2 What Is Science?

The wrong view of science betrays itself in the craving to be right; for it is not his possession of knowledge, of irrefutable truth, that makes the man of science, but his persistent and recklessly critical quest for truth.

Sir Karl Popper, *The Logic of Scientific Discovery*

So I left him, saying to myself as I went away: Well, although I do not suppose that either of us knows anything really beautiful and good, I am better off than he is—for he knows nothing, and thinks that he knows. I neither know nor think that I know. In this latter particular, then, I seem to have slightly the advantage of him.

Socrates, in Plato's *Apology*

Test everything. Keep what is good.

Saint Paul, First Letter to the Thessalonians

OVERVIEW

- Comparative politics is the subfield of political science that focuses primarily on politics within countries. In Chapter 3 we define and examine the nature of politics. In this chapter we define and examine the nature of science.
- Science is a strategy for understanding and explaining the social and natural world that emphasizes the use of statements that can be examined to see whether they are wrong.
- Scientific explanations should explain previously puzzling facts, be logically consistent, and produce (many) potentially falsifiable predictions.
- All scientific statements are tentative. We accept some statements as provisionally true when they have withstood vigorous attempts at refutation more successfully than competing statements.

INTRODUCTION

Consider the following five statements. What do they all have in common?

1. Science is a collection of facts that tell us what we know about the world.
2. A scientific theory is one that has been proven.
3. "The sun revolves around the earth" is not a scientific statement.
4. If my theory is correct, then I should observe that rich countries are more likely to be democracies. I do observe that rich countries are more likely to be democracies. Therefore, my theory is correct.
5. Politics cannot be studied in a scientific manner.

The common element in these statements is that they are all, in some sense, wrong. Science is not a collection of facts that tell us what we know about the world. Scientific theories cannot be proven; thus, a scientific theory is not one that has been proven. The statement that the sun revolves around the earth is a scientific statement (even though it is false). The argument outlined in statement 4 is invalid and, therefore, I cannot conclude that my theory is correct. And finally, politics can be studied in a scientific manner. We suspect that many of you will have thought that at least some of these statements were correct. To know why all of these statements about science are wrong, you will need to continue reading this chapter.

Science certainly has its detractors, largely because of what was experienced in the twentieth century. Some horrendous things were either done in the name of science or "justified" on scientific grounds or, at a minimum, made possible by science. Although we should never close our eyes to the harm that is sometimes done with science, we believe that it is as much a mistake to blame science for what some scientists have done in its name as it is to blame religion for what some believers have done in its name.

But what is science? First and foremost, science is a method; however, it is also a culture. The quotations at the start of this chapter are meant to capture what we might call the "culture" of science. Some of the negative views of science come from what people perceive the culture of science to be—cold, calculating, self-assured, and arrogant. We believe, however, that at its best, the culture of science displays the characteristics encouraged by the otherwise very different thinkers who are quoted. The scientific method is, at its very core, a critical method, and those reflective individuals who use it are much more likely to be humbled than emboldened. Sir Karl Popper ([1959] 2003) reminds us that science is not a static set of beliefs to be conserved and that all knowledge is tentative. Socrates reminds us that an acute awareness of our own ignorance is always the first step toward knowledge. Saint Paul offers hope that our willingness to test all of our ideas will leave us something good to hang onto. As we'll demonstrate in this chapter, science isn't about certainty, it isn't about the orderly collection of facts, and it isn't about invoking authority to protect our ideas from uncomfortable evidence. Instead, science is about asking tough questions and providing answers that invite criticism. Science is about recognizing the limits of our knowledge without lapsing into irresponsible cynicism. And science is about using the best logic, methods, and evidence available to provide answers today, even though we recognize that they may be overturned tomorrow.

Comparative politics is a subfield of political science. But what exactly is political science? Well, it is the study of politics in a scientific way. How's that for a tautology? It is easy to see that, as it stands, this definition is not particularly informative. For example, what is politics? And what is science? In the next chapter we answer the first of these questions and seek to demarcate politics from other forms of social phenomena. In this chapter, though, we focus on the second question—what is science? Our goal is to provide an answer that resembles the way most practicing scientists would answer this question.

THE COMPARATIVE METHOD

A common method employed today by comparative political scientists to learn about the world is known as the *comparative method.* It is also known as Mill's methods because it is based on a formal set of rules outlined by John Stuart Mill in his 1843 book, *A System of Logic.* Mill actually outlined two different methods. One is called the *Method of Agreement;* the other is called the *Method of Difference.* Political scientists who employ these methods collect observations of the world and then use these observations to develop general laws and theories about why certain political phenomena occur.[1] In employing these methods, the goal is to identify the causes of political events. Before we evaluate Mill's Method of Agreement and his Method of Difference in detail, we should first define what we mean by the word *cause.* For the moment, let us restrict ourselves to two relatively straightforward conceptions of causation: necessary and sufficient conditions.

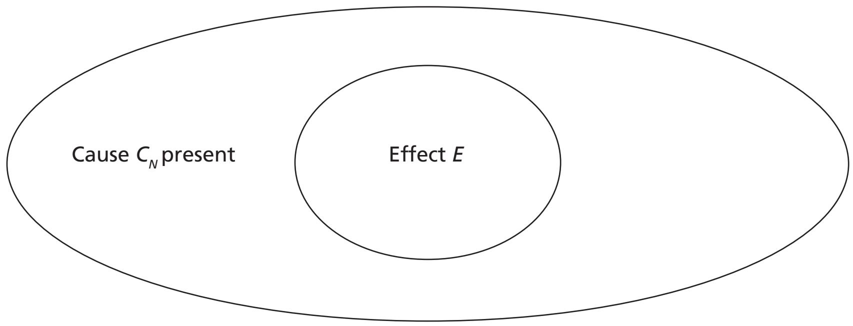
The **comparative method,** also known as Mill's methods, involves the systematic search for the necessary and sufficient causes of political phenomena. The comparative method comprises the Method of Agreement and the Method of Difference.

Necessary and Sufficient Conditions

A *necessary condition* is a circumstance in whose absence the event in question cannot occur. In other words, the effect (E) never happens unless the purported necessary condition or cause (C_N) is present: "If E, then C_N" or "If no C_N, then no E." Barrington Moore's ([1966] 1993) magisterial 559-page *Social Origins of Dictatorship and Democracy* can be summarized, somewhat simplistically, with the following necessary condition: "no bourgeoisie, no democracy." This necessary condition captures Moore's claim that without a strong urban class, there will be no stable democracy, and if there is a stable democracy, there must be a strong urban class. Because some of you, like us, think better visually, we provide a visual representation of a necessary condition in Figure 2.1. As you can see, the claim that C_N is a necessary condition for effect E to occur is logically equivalent to the claim that occurrences of E form a subset of the instances where C_N is present. Note that C_N can occur without the effect E occurring—this is because C_N is only a necessary, but not a sufficient, condition for E. As another example, oxygen is a necessary, but not a sufficient, condition for fire. Take oxygen

1. For example, Weber ([1930] 1992) employs Mill's methods to explain the rise of capitalism; Moore ([1966] 1993), to determine why some countries are democracies but others are dictatorships; Skocpol (1979), to examine social revolutions; Katznelson (1985), to analyze the variation in the organizational patterns of the working class in the United States and the United Kingdom; and Kalyvas (1996), to explain the rise of Christian democracy in Western Europe.

FIGURE 2.1 **A Visual Representation of a Necessary Cause**



away and there will be no fire, but add oxygen to a given situation and there may or may not be fire, depending on other circumstances.

A *sufficient condition* is a circumstance in whose presence the event in question must occur. In other words, the sufficient condition or cause (C_S) never occurs without the effect (E) also happening; that is, "If C_S, then E" or "If no E, then no C_S." As an example, fire is a sufficient condition for smoke. If there is a fire, there will be smoke. And if there is no smoke, there can be no fire. Figure 2.2 provides a visual representation of a sufficient condition. It is easy to see that the claim that C_S is a sufficient condition for E to occur is logically equivalent to the claim that occurrences of the sufficient condition C_S form a subset of the instances where effect E occurs. Note that effect E can occur even when condition C_S is not present—this is because C_S is a sufficient, but not a necessary, condition for E. Put differently, there may be causes of E other than C_S. A second example might illustrate the point. Jumping is a sufficient, but not a necessary, condition for leaving the ground. Jumping will always cause us to leave the ground; however, the fact that we are not on the ground does not automatically mean that we jumped—there are many other ways of leaving the ground.

FIGURE 2.2 **A Visual Representation of a Sufficient Cause**

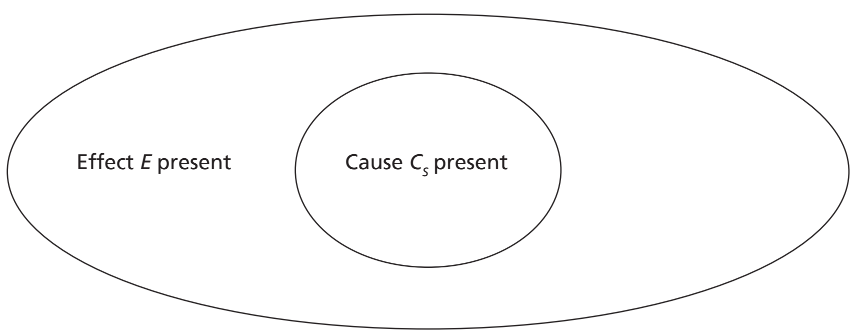
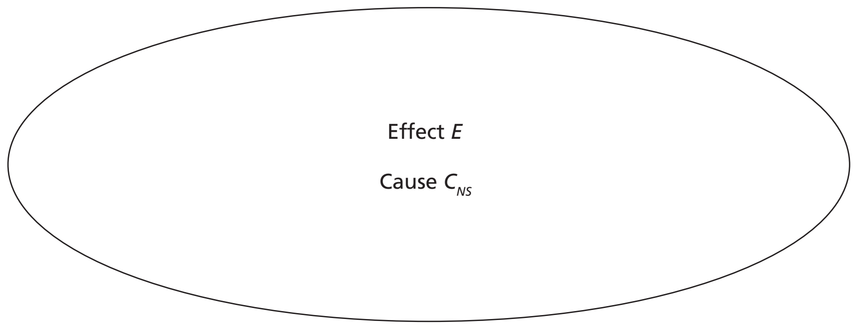


FIGURE 2.3 **A Visual Representation of a Necessary and Sufficient Cause**



A *necessary and sufficient condition* is a circumstance in whose absence the event in question will not occur and in whose presence the event in question must occur. A statement about necessary and sufficient conditions is equivalent to an "if and only if" statement. In other words, the effect (*E*) occurs *if and only if* the necessary and sufficient condition (C_{NS}) is present: "If C_{NS}, then *E*" and "If no C_{NS}, then no *E*" or "If *E,* then C_{NS}" and "If no *E,* then no C_{NS}." Figure 2.3 provides a visual representation of a necessary and sufficient condition. The claim that C_{NS} is a necessary and sufficient condition for *E* to occur is logically equivalent to the claim that occurrences of C_{NS} are a subset of *E* and that occurrences of *E* are a subset of C_{NS}. In other words, you cannot get one without the other. Visually, this means that there are no subsets where effect *E* occurs without cause C_{NS} or vice versa.

A **necessary condition** is a circumstance in whose absence the event in question cannot occur. A **sufficient condition** is a circumstance in whose presence the event in question must occur. A **necessary and sufficient condition** is a circumstance in whose absence the event in question will not occur and in whose presence the event in question must occur.

The systematic search for "necessary," "sufficient," and "necessary and sufficient" conditions has come to be known as Mill's methods or simply the comparative method. Having defined what we mean by a cause, we can now turn our attention to Mill's methods of agreement and difference.

Mill's Method of Agreement

As an illustration of Mill's Method of Agreement, suppose we want to explain the occurrence of democracy. Common sense might suggest that if we want to know what causes democracy, we should study democracies.[2] We could observe two contemporary democracies and take note of their features. For example, we might compare the United Kingdom and Belgium, as we do in Table 2.1. Both the United Kingdom and Belgium "agree" in regard to

2. As we will see, the kind of sense needed to do good science often turns out to be very "uncommon."

TABLE 2.1 Mill's Method of Agreement I

Country	Democracy	Ethnically homogeneous	Multiparty system	Parliamentary system
United Kingdom	Yes	Yes	No	Yes
Belgium	Yes	No	Yes	Yes

the outcome to be explained—they are both democracies. This is why Mill calls the method being employed here the Method of Agreement.

What, if anything, can we infer from this comparison? Well, we observe that the United Kingdom has a relatively homogeneous population and a two-party parliamentary system. We also observe that Belgium has a relatively heterogeneous population and a multiparty parliamentary system.[3] Assuming that the classification of our observations is correct, we can conclude that ethnic homogeneity is not a necessary condition for democracy. This is because Belgium is a democracy despite being ethnically diverse. We can also conclude that having a multiparty system is not a necessary condition for democracy, because the United Kingdom is a democracy even though it has only two parties. Thus, we have used Mill's Method of Agreement to eliminate two of the three potential causes. Does this mean that we can now conclude that having a parliamentary system is the cause of democracy? It certainly looks that way from Table 2.1. After all, Belgium and the United Kingdom are both democracies and they both have parliamentary systems.

Before we can declare success and put a lot of comparative politics scholars out of work, however, we should look more carefully at Mill's Method of Agreement. Mill ([1874] 1986, 280) wrote:

> If two or more instances of the phenomenon under investigation have only one circumstance in common, the circumstance in which alone all the instances agree, is the cause (or effect) of the given phenomenon.

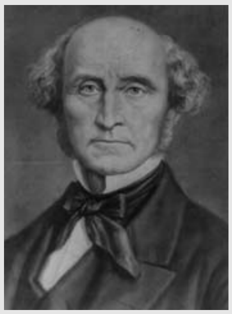
Mill's logic is unassailable given the way he has defined a "cause." The key phrase to note from a practical standpoint, however, is that our observations of the world should have "only one circumstance in common." In other words, we must be entirely sure that the two observations have nothing else in common that might cause democracy other than the hypothesized cause (a parliamentary system in this case).

Therefore, before we can place much confidence in the statement "[i]f a country adopts a parliamentary system, then it will be a democracy," we must eliminate all other factors that

3. Belgium's population is fairly evenly split between Dutch-speaking Flemish and French-speaking Walloons. There is also a sizable German-speaking population in the east of the country and a nontrivial number of non-European immigrants.

Box 2.1

JOHN STUART MILL
(May 20, 1806–May 8, 1873)


An undated portrait of John Stuart Mill

John Stuart Mill was born in London, England, the oldest son of a Scottish philosopher. He was educated by his father with the assistance of one of the most famous philosophers of the day, Jeremy Bentham. Mill's education was quite rigorous and he was deliberately shielded from contact with children other than his siblings. By the age of eight he was fluent in Latin and Greek. By the time he was thirteen, Mill had been introduced to Euclidean geometry, algebra, and political economy. The rigor of his academic studies eventually took its toll and he suffered a nervous breakdown when he was twenty-one.

At various points in his life, Mill worked for the British East India Company and was elected to the British House of Commons, where he became the first member of Parliament to advocate for a woman's right to vote. Mill produced many influential works of political philosophy. In *On Liberty* (1859), Mill set out the nature and limits of the power that can be exercised by society over the individual. It was here that he famously argued that people should be free to do whatever they liked so long as it did not harm others. It was in his most famous book, *A System of Logic* (1843), that he laid out his rules for the scientific method. Among his other famous works are *Utilitarianism* (1861), in which he argued for the philosophy of utilitarianism proposed by Bentham, and *The Subjection of Women* (1869), in which he claimed that the continuing oppression of women was an impediment to the progress of humanity.

might be considered relevant to the establishment of democracy. Until such a time, all we can do is continue to try to eliminate possible necessary conditions. Note that those factors that cannot be eliminated must be retained as potential necessary conditions. Thus, all we can really conclude on the basis of our two observations is that parliamentary rule may be a necessary condition for democracy—in other words, it's still in the running as a potential cause.

But let's dig a little deeper. Can you think of another possible cause of democracy? For some time now, scholars have suspected a causal connection between the wealth of a country and whether that country will be a democracy. We address this potential relationship in some detail in Chapter 6 of this book. But ask yourself right now, how might you test this claim? Scholars using Mill's Method of Agreement would suggest going back out into the "real world" to observe whether Belgium and the United Kingdom are wealthy or not. It turns out that both countries are wealthy. This new information is shown in Table 2.2.

Since Belgium and the United Kingdom are both wealthy democracies, it now seems that wealth might be a necessary condition for democracy. But note that this violates Mill's stipulation that a cause must be unique—recall that there must be "only one circumstance in common." This means that either wealth or a parliamentary form of government cannot be

Table 2.2 Mill's Method of Agreement II

Country	Democracy	Wealth	Ethnically homogeneous	Multiparty system	Parliamentary system
United Kingdom	Yes	Yes	Yes	No	Yes
Belgium	Yes	Yes	No	Yes	Yes

the cause of democracy.[4] How can we determine which is the "real" cause? The answer is that we can't with just these two observations. So, it's back out into the real world for us to do some more observing.

What type of observation would allow us to determine whether wealth or a parliamentary form of government is a necessary condition for democracy? Clearly, we would need to observe either a wealthy democracy that is not parliamentary or a parliamentary democracy that is not wealthy. Suppose that the next country we observe happens to be the United States. Like the United Kingdom, the United States is a wealthy democracy. In contrast to the United Kingdom, though, the United States has a presidential system of government. We can now add our new observation to the two observations that we already have. We do this in Table 2.3.

What can we now infer from these three observations? Remember that a necessary condition is one in whose absence the event in question cannot occur. This means that we can eliminate any factor that is absent when the outcome being explained is present. In other words, we can eliminate any of the potential necessary causes of democracy in Table 2.3 that are absent when the country is a democracy. Thus, the conditions present in the United Kingdom demonstrate that a multiparty system is not necessary for democracy. Those in Belgium demonstrate that ethnic homogeneity is not necessary for democracy. Finally, con-

Table 2.3 Mill's Method of Agreement III

Country	Democracy	Wealth	Ethnically homogeneous	Multiparty system	Parliamentary system
United Kingdom	Yes	Yes	Yes	No	Yes
Belgium	Yes	Yes	No	Yes	Yes
United States	Yes	Yes	Yes	No	No

4. It might be the case that neither wealth nor a parliamentary form of government causes democracy. We cannot be sure because we may not have eliminated all of the other possible causes of democracy. But let's ignore this for now.

ditions in the United States demonstrate that a parliamentary system is not necessary for democracy. Wealth alone survives as a potential necessary condition for democracy in our three cases.

It may be that wealth is the cause we are looking for. Still, we cannot emphasize enough that we can be confident in this only to the extent that we have identified all of the potential causes. In addition, we can say only that wealth may be necessary for democracy; Mill's Method of Agreement does not allow us to determine whether wealth is sufficient for democracy. Ask yourself what type of observation would allow you to determine whether wealth was a sufficient condition for democracy? Well, you would need to look for wealthy countries that are not democracies. If you found such a country, you would know that wealth is not sufficient for democracy. Thus, to evaluate whether wealth is sufficient for democracy, we need to examine non-democracies as well as democracies. This obviously cannot be done with Mill's Method of Agreement, however, because the outcome to be explained would not "agree" for all of the cases. It turns out that we can evaluate claims about sufficient (and necessary) causes using Mill's Method of Difference.

Mill's Method of Difference

Mill's Method of Difference compares cases that "differ" in regard to the outcome to be explained. Mill ([1874] 1986, 280) wrote:

> If an instance in which the phenomenon under investigation occurs, and an instance in which it does not occur, have every circumstance in common save one, that one occurring only in the former; the circumstance in which alone the two instances differ, is the effect, or the cause, or an indispensable part of the cause, of the phenomenon.

In other words, the analyst employing this method takes cases that differ in their outcome. She then tries to reject potential conditions for the difference in outcomes by eliminating those conditions that do not vary in exactly the same way as the outcome. If there is one and only one condition that cannot be eliminated by this process, then, Mill's Method of Difference states, this condition must be the cause of the outcome.

> The **Method of Agreement** compares cases that "agree" in regard to the outcome to be explained. The **Method of Difference** compares cases that "differ" in regard to the outcome to be explained.

Now that we know how the Method of Difference works, let's return to our question about whether wealth is a sufficient cause for democracy. To evaluate this claim we must go back out into the real world to observe some non-democracies.[5] Imagine that the first non-democracy that we observe is Mexico prior to 1990. Mexico in this period had a presidential system dominated by a single party. It was also relatively wealthy and ethnically homogeneous. Suppose that we compare Mexico prior to 1990 with the United States. We do this in Table 2.4.

5. Here's an example of science depending on uncommon sense. Note the somewhat surprising implication that if you want to know what is sufficient to produce democracy, you must study non-democracies.

TABLE 2.4 Mill's Method of Difference

Country	Democracy	Wealth	Ethnically homogeneous	Multiparty system	Parliamentary system
United States	Yes	Yes	Yes	No	No
Mexico	No	Yes	Yes	No	No

What can we learn from this comparison? Remember that a sufficient condition requires that if the condition is present, then the outcome or effect should also be present. This means that we can eliminate from consideration any condition that is present when democracy is absent. The case of Mexico prior to 1990 tells us that wealth is not a sufficient condition for democracy, because it is wealthy but not a democracy. It also indicates that ethnic homogeneity is not a sufficient condition for democracy, because it is homogeneous and yet it is not a democracy. The Mexican case can shed no light on whether having multiple parties or a parliamentary system is a sufficient condition for democracy.

Not only does Mill's Method of Difference allow us to determine sufficient conditions, but it also allows us to find out if the conditions are necessary for democracy. In this sense, it is "stronger" than the Method of Agreement. For example, the United States case indicates that having multiple parties or a parliamentary system is not necessary for democracy. This is because the United States is a democracy even though it has only two parties and a presidential system. The information shown in Table 2.4 indicates that ethnic homogeneity, like wealth, may be necessary for democracy. Note, though, that the conclusion from the comparison of the United States and Mexico that ethnic homogeneity may be a necessary condition for democracy contradicts the conclusion drawn from our earlier comparison of the United Kingdom and Belgium that ethnic homogeneity was not a necessary condition for democracy. This point highlights an important limitation when one draws inferences from Mill's methods based on a small number of observations—the conclusions drawn may be extremely sensitive to the set of cases observed. As our examples illustrate, comparing the United Kingdom and Belgium would lead to a very different conclusion about the effect of ethnic homogeneity on whether a country will be a democracy than comparing the United States and Mexico prior to 1990. This is just one of the problems associated with drawing inferences using Mill's methods. Before we explore other problems in more detail, let's imagine that we had observed all four cases described above. The four cases are shown in Table 2.5.

From this set of four observations, we can make the following conclusions. Be sure you understand where each conclusion comes from.

- Wealth is not a sufficient condition for democracy in light of the Mexican case. It may, however, be a necessary condition.
- Ethnic homogeneity is not necessary for democracy in light of the Belgian case. Nor is it sufficient for democracy because of the Mexican case.

TABLE 2.5 Combining Mill's Methods of Agreement and Difference

Country	Democracy	Wealth	Ethnically homogeneous	Multiparty system	Parliamentary system
United Kingdom	Yes	Yes	Yes	No	Yes
Belgium	Yes	Yes	No	Yes	Yes
United States	Yes	Yes	Yes	No	No
Mexico	No	Yes	Yes	No	No

Note: Mill refers to the combination of the Method of Agreement and the Method of Difference as the Indirect Method of Difference or the Joint Method of Agreement and Difference.

- Multipartism is not a necessary condition for democracy in light of the United Kingdom and United States cases. Multipartism may, however, be sufficient for democracy according to the Belgian case.
- A parliamentary system is not necessary for democracy in light of the United States case. It may, however, be a sufficient condition based on the Belgium and United Kingdom cases.

Note that our four observations allow us to rule out only ethnic homogeneity as a cause for democracy; that is, ethnic homogeneity is neither necessary nor sufficient for democracy. Mill's methods cannot determine whether multipartism or a parliamentary system is a sufficient condition for democracy or not based on these four observations. Note also that it is difficult to know if wealth as an apparent necessity for democracy is meaningful, because we have not observed any cases in which wealth is absent. This reveals an interesting aspect of Mill's methods. Although they are often presented as a useful tool when the phenomenon under study is relatively rare, once the number of potential causes expands, the number of cases logically required to isolate their individual effects can get very large rather quickly.[6]

A Critique of Mill's Methods

As we noted earlier, Mill's methods are widely employed in comparative political science. Indeed, they form the basis of the popular "most similar systems" and "most different systems" research designs (Przeworski and Teune 1970; Lijphart 1971, 1975; Collier 1993).[7] We suspect that you will have come across numerous studies using Mill-like methods in many

6. Skocpol (1979) argues that she must rely on Mill's methods because the subject she wishes to study (social revolutions) is historically rare. Ragin (1987) actually defines the comparative method as a technique to be used when the number of instances under study is sufficiently small that a scholar can study the full universe of observations rather than a sample.

7. Somewhat confusingly, the most similar systems design is the equivalent of Mill's Method of Difference. It requires that the analyst find cases that are identical to each other except in regard to the outcome to be explained and one key condition. The most different systems design is equivalent to Mill's Method of Agreement. It requires the analyst to choose cases that are as different as possible except in regard to the outcome to be explained and one key condition.

of your classes in political science, economics, sociology, anthropology, or history. Despite their prevalence, though, we now turn to what we consider a compelling critique of these methods (Lieberson 1991, 1994; Sekhon 2004). In order to draw valid inferences from Mill's methods of agreement and difference, several very special assumptions must be met.

The causal process must be deterministic.
There can be no interaction effects.
There can be only one cause of the outcome.
All of the possible causes must be identified.
All the instances of the phenomena that could ever occur have been observed by us *or* all the unobserved instances (including future instances) must be just like the instances we have observed.

We believe that these assumptions are almost impossible to satisfy in the social sciences. Nonetheless, some "researchers seem to be unaware or unconvinced of these methodological difficulties, even though Mill himself clearly described many of their limitations" (Sekhon 2004, 281).[8] Moreover, most introductory books on comparative politics seem to ignore these methodological issues and continue to advocate the use of Mill's methods. Given that we seem to be challenging a certain view of how the study of comparative politics should be conducted, let us briefly examine whether these assumptions really are necessary for drawing valid inferences and what consequences they have for research in the social sciences.

A **deterministic cause** is one that always produces a specific outcome. A **probabilistic cause** is one that influences the probability of a specific outcome.

A *deterministic* cause is one in which a cause always leads to a specific outcome. That the assumption that causes must be deterministic logically follows from the fact that both the Method of Agreement and the Method of Difference employ a process of elimination. The Method of Agreement is based on the argument that whatever can be eliminated is not a cause of the outcome being explained, whereas the Method of Difference is based on the argument that what cannot be eliminated is the cause of the outcome being explained. Scholars employing Mill's methods recognize (and often appear to laud) their deterministic nature.[9] For example, Theda Skocpol (1984, 378) states: "Comparative historical analyses proceed through logical juxtapositions of aspects of small numbers of cases. They attempt to identify invariant causal configurations that necessarily (rather than probably) combine to account for outcomes of interest." The problem with deterministic causal processes, though, is that a single "disconfirming" observation can force the analyst to eliminate *X* as a cause of *Y* no matter how many other "confirming" observations she has found.

We believe that it is much more appropriate to view the social world in probabilistic terms than in deterministic ones. Up to this point, we have defined *cause* in terms of sufficiency and

8. Mill ([1874] 1986, 275) states that "in the sciences which deal with phenomena in which artificial experiments are impossible (as in the case of astronomy), or in which they have a very limited range (as in mental philosophy, *social science,* and even physiology), induction from direct experience is practiced at a disadvantage *in most cases equivalent to impracticability*" (italics added).

9. Mill also recognized that his methods are deterministic ([1874] 1986, 271, 373).

necessity; that is, "If C_S, then E" (C is sufficient for E) or "If no C_N, then no E" (C is necessary for E). In practice, though, it is often advisable to restrict ourselves to simply saying that the presence of C increases the probability or likelihood of E rather than that C always produces E. As we'll see, this is the case even if we truly believe that the causal process is deterministic. So why is thinking about causal processes in a probabilistic way better?

First, thinking in probabilistic terms helps us take account of the fact that we may have measured some or all of our cases incorrectly. Measurement error is common in the social sciences and may cause us to incorrectly eliminate (or fail to eliminate) a potential cause for the outcome we seek to explain.[10] This suggests that we should not claim that wealth always causes (or does not cause) democracy based on empirical evidence—our instruments for measuring wealth and democracy are imperfect, and the indicators that we choose to capture wealth may not perfectly fit the concept of wealth that we hope to capture with them. Given the likelihood of some measurement error, we believe that all we can really claim is that wealth increases (decreases, or has no effect on) the probability that a country will be democratic.

Second, thinking in probabilistic terms may be necessary because the phenomenon under study is inherently probabilistic. For example, what if you are trying to predict the behavior of someone who uses the roll of a die to determine his behavior? What if you are trying to predict the movement of subatomic particles? What if an outcome depends on the smooth operation of voting machines in Florida? Given that outcomes in the social sciences are nearly always the result of decisions made by human beings, we believe that it is preferable to think of their causes as being probabilistic rather than deterministic.[11] In sum, the first reason for thinking probabilistically has to do with the limits of our knowledge, whereas the second has to do with the nature of our subject matter.[12]

The second assumption required for drawing valid inferences from Mill's methods is that there can be no interaction effects—all of the causal factors must be independent of each other. An *interaction effect* is when two (or more) conditions jointly cause the outcome. Recall that we used Mill's methods to infer that ethnic homogeneity is neither a necessary nor a sufficient condition for democracy based on the cases in Table 2.5. Can Mill's methods, however, rule out the possibility that ethnic homogeneity and a two-party system are both necessary for democracy? The answer is that they cannot.[13] Mill himself recognized that interactions of this sort are widespread in the social world and admitted that his methods were inappropriate for identifying them. He

> An **interaction effect** occurs when the effect of one variable depends on the value of another variable.

10. We address measurement issues in more detail in Chapter 5. As that discussion suggests, we rarely measure our observations perfectly. Moreover, there is often great controversy about what particular measurement process is most appropriate.

11. It is probably wise to think probabilistically even if one's research is in the natural sciences. The discoveries in the field of quantum physics, such as Heisenberg's uncertainty principle, make this particularly clear.

12. Several techniques have been proposed to extend Mill's methods to take account of probabilistic causes (Hildebrand, Laing, and Rosenthal 1977; Braumoeller and Goertz 2000). These techniques, however, all require that there be only one cause (Clark, Gilligan, and Golder 2006).

13. The information in Table 2-5 cannot rule out the possibility that ethnic homogeneity in combination with a two-party parliamentary system causes democracy based on the United Kingdom case or that ethnic heterogeneity in combination with a multiparty system causes democracy based on the Belgian case.

believed that "if so little can be done by the experimental method to determine the conditions of an effect of many combined causes, in the case of medical science; still less is this method applicable . . . to the phenomena of politics and history" (Mill [1874] 1986, 324). It turns out that there are techniques for extending Mill's methods to include complex combinations of individual causal factors (Ragin 1987). Several important difficulties arise with these techniques, however. First, the number of cases required to evaluate the many combinations of causal factors (which increase geometrically) becomes large very quickly. Second, all of the combinations of causal factors required to test one's claims may not actually exist as real world observations. As a result, these extensions are often impractical.

The third assumption underlying Mill's methods is that there can be only one cause. Mill himself indicates this when he says that the Method of Agreement requires cases to "have only one circumstance in common" and that the Method of Difference requires cases to "have every circumstance in common save one." The inability of Mill's methods to deal with multiple causes is illustrated with an example adapted from Lieberson (1994). Consider first the information shown in Table 2.6. Scholars employing the Method of Agreement would conclude that wealth, ethnic homogeneity, and a multiparty system are not necessary for democracy. They cannot, however, rule out the possibility that one or more of these variables are sufficient to cause democracy. As a result, the Method of Agreement cannot handle the possibility of multiple causes.

Is the Method of Difference any better? Imagine that we now add two new observations of non-democracies to our previous four observations. This new set of observations is shown in Table 2.7. As you can see, the Method of Difference cannot determine whether one or more of the conditions—wealth, multipartism, parliamentary system—are sufficient conditions for democracy either. In sum, Mill's methods require that there be only one possible cause of the outcome of interest if scholars are to draw valid inferences.

The fourth assumption is that we have identified all of the possible causes. Recall how our conclusions changed when we added wealth as a potential cause in Table 2.2. Although we were studying the exact same two observations (Belgium and the United Kingdom), our conclusions changed dramatically just because we turned our attention to a new causal fac-

TABLE 2.6 Mill's Method of Agreement Revisited

Country	Democracy	Wealth	Ethnically homogeneous	Multiparty system
A	Yes	Yes	No	No
B	Yes	No	Yes	No
C	Yes	No	Yes	Yes
D	Yes	No	No	Yes

TABLE 2.7 An Example of Mill's Method of Difference

Country	Democracy	Wealth	Ethnically homogeneous	Multiparty system
A	Yes	Yes	No	No
B	Yes	No	Yes	No
C	Yes	No	Yes	Yes
D	Yes	No	No	Yes
E	No	No	No	Yes
F	No	No	No	Yes

tor. When wealth was omitted, we thought that parliamentary systems caused democracy. Once we added wealth as a potential cause, however, we could not determine whether it was wealth or parliamentary systems that led to democracy. The point here is that we can reach conclusions that have logical force using Mill's methods only if we assume that we have identified all the relevant factors. To convince ourselves that we have done so we must examine a great number of alternative causal factors. To do this, we must examine many cases in order to isolate the independent effect of these alternative causal factors.

Finally, even if we are convinced that the causal process is deterministic, that there are no interaction effects, that there is only one cause, and that we have identified all the possible causes, we are still justified in inferring that a factor is a necessary or sufficient cause only if we accept either (a) that the cases we have observed are all the instances of the phenomena or (b) that all unobserved instances (including future instances) of the phenomena are just like the instances we have already observed. The problem is that we might well draw an inference after N observations that must be discarded after $N + 1$ observations. We saw this earlier when our conclusions about the causal role of wealth changed with the addition of Mexico to our set of observations. Before we added Mexico, we concluded that wealth was a sufficient condition for democracy; afterward, we concluded that wealth was not a sufficient condition. Who's to say that any of our remaining conclusions would not need to be altered in light of as yet unobserved cases? Drawing inferences from observed cases to unobserved cases is problematic.

What are the strengths and weaknesses of the comparative method? A key strength is that it allows us to test whether something is a necessary, sufficient, or necessary and sufficient condition. But it can do so only when many fairly restrictive assumptions are met. If one or more of these assumptions are not met, then we cannot draw valid inferences from the application of Mill's methods. This problem is exacerbated by the fact that the comparative method does not provide us with any help in determining when these assumptions will be met. In our view, at least one of these assumptions is likely to be violated in almost any social science application. This is perhaps why Mill ([1874] 1986, 324) so clearly warned scholars not to employ his methods for examining the political world. As he put it,

> Nothing can be more ludicrous than the sort of parodies on experimental reasoning which one is accustomed to meet with, not in popular discussion only, but in grave treatises, when the affairs of nations are the theme. "How," it is asked, "can an institution be bad, when the country has prospered under it?" "How can such or such causes have contributed to the prosperity of one country, when another has prospered without them?" Whoever makes use of an argument of this kind, not intending to deceive, should be sent back to learn the elements of some one of the more easy physical sciences.

These reservations are sufficiently worrisome on their own that analysts should be reluctant to accept uncritically claims based on the application of Mill's methods. A more fundamental problem is at issue here, however. Even if the analyst could get around the problems listed above, she would have established only that certain phenomena occur together; she would not have provided an explanation of the outcome in question. That is, Mill's methods are empirical methods—they tell us what happens, not why the phenomena occur together. Put differently, all they say is that *Y* happened when *X* was present; this is roughly equivalent to saying that the sun came up because the rooster crowed. An essential missing ingredient is a sense of process, a story about why *Y* appears to happen when *X* happens. The story about the process that produces the outcomes we see is what scientists call a *theory,* and these stories cannot necessarily be reduced to a set of circumstances that covary with the outcome we wish to explain.

Later in this chapter we discuss the role of theory in the scientific process. First, however, we show that scholars employing Mill's methods would confront a problem even if the cause of a phenomenon was no deeper or more complicated than the factors that covary with it. This problem applies to the analyst who runs millions of regressions on large data sets looking for patterns that might explain her outcome of interest as well as it does to scholars who apply the comparative method to a few cases. Next we address this problem head on by examining when an argument is valid and when it is invalid.

AN INTRODUCTION TO LOGIC

Throughout our lives we are confronted by people trying to convince us of certain things through arguments. Politicians make arguments as to why we should vote for their party rather than the party of their opponents. National leaders provide arguments for why certain policies should be implemented or abandoned. Lawyers make arguments as to why certain individuals should be found guilty or innocent. Professors make arguments as to why students should spend more time in the library and in class rather than at parties. It is important for you to know when these arguments are logically valid and when they are not. If you cannot distinguish between a valid and an invalid argument, other people will be able to manipulate and exploit you. You will be one of life's suckers. In this section, we give you some tools to determine whether an argument is valid or not.

Valid and Invalid Arguments

What is an argument? An *argument* is a set of logically connected statements, typically in the form of a set of *premises* and a *conclusion*. An argument is *valid* when accepting its premises compels us to accept its conclusions. An argument is *invalid* if, when we accept the premises of an argument, we are free to accept or reject its conclusions. One way to represent an argument is in the form of a *categorical syllogism* that consists of a major premise, a minor premise, and a conclusion. The major premise is typically presented as a conditional statement such as, "If *P*, then *Q*." The "if" part of the conditional statement (in this case "If *P*") is called the "antecedent," whereas the "then" part of it (in this case "then *Q*") is called the "consequent." An example of a conditional statement is: "If a country is wealthy [antecedent], then it will be a democracy [consequent]." The minor premise consists of a claim about either the antecedent or the consequent in the conditional statement (major premise). The conclusion is a claim that is thought to be supported by the premises.

An **argument** is a set of logically connected statements, typically in the form of a set of premises and a conclusion. A **premise** is a statement that is presumed to be true within the context of an argument leading to a conclusion. A **conclusion** in an argument is a claim that is thought to be supported by the premises.
A **valid argument** is one in which, if you accept the premises, then you are compelled to accept the conclusion. An **invalid argument** is one in which, if you accept the premises, then you are free to accept or reject the conclusion.
A **categorical syllogism** is an argument that consists of a major premise, a minor premise, and a conclusion.

Four types of conditional argument can be represented with a syllogism—arguments that affirm or deny the antecedent and those that affirm or deny the consequent. Which of these four types of argument are valid and which are invalid? Recall that a valid argument is one such that if you accept that the premises are true, then you are compelled to accept the conclusion as true. Let's start by considering what happens when we affirm the antecedent. An example is shown in Table 2.8.

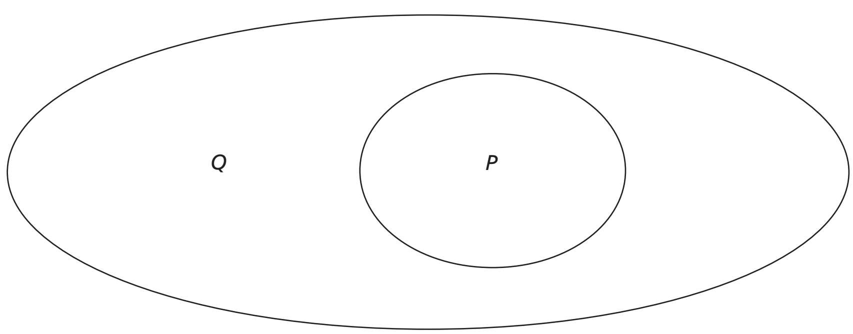
TABLE 2.8 Affirming the Antecedent: A Valid Argument

	General form	Specific example
Major premise	If *P*, then *Q*	If a country is wealthy, then it will be a democracy
Minor premise	*P*	The country is wealthy.
Conclusion	Therefore, *Q*.	Therefore, the country will be a democracy.

The major premise states, "If *P* is true, then *Q* must be true." The minor premise says that "*P* is true." Together, these premises compel us to accept that the conclusion is true. As a result, the argument is valid. In other words, the major premise states, "If a country is wealthy (antecedent), then it will be a democracy (consequent)." The minor premise says, "The observed country is wealthy." It logically follows from this that the observed country must be a democracy. To see why this type of argument is valid, consider the general form of this argument in set-theoretic form. This is shown in Figure 2.4. The major premise indicates that the set of cases where *P* occurs is a subset of the cases where *Q* occurs.[14] The minor premise maintains that *P* does occur. Figure 2.4 clearly shows that if the case in question is in *P*, as the minor premise affirms, then the case must also be in *Q*. Thus, the argument is valid—we are compelled to conclude *Q*.

Now let's consider what happens when we deny the antecedent. An example is shown in Table 2.9. Once again, the major premise can be represented in set-theoretic terms by Figure 2.4. The difference from the previous example is that the minor premise now asserts that *P* is not the case; that is, it denies the antecedent. If we accept this, does it necessarily follow that *Q* is not the case, as the conclusion maintains? Figure 2.4 clearly illustrates that even if our case is not in *P*, it could still be in *Q*. As a result, it does not logically follow from observing "not *P*" that *Q* is not the case. Therefore, this is an invalid argument. This is because we can contradict the conclusion (not *Q*) without running into a contradiction with either the major premise or the minor premise. Since a valid argument compels us to accept its conclusion given that its premises are true, this is sufficient to demonstrate that arguments that deny the antecedent are invalid.

FIGURE 2.4 Major Premise: If *P*, then *Q*



14. Earlier in the chapter we would have said that the major premise indicates that *P* is sufficient for *Q*.

TABLE 2.9 Denying the Antecedent: A Invalid Argument

	General form	Specific example
Major premise	If *P,* then *Q*	If a country is wealthy, then it will be a democracy
Minor premise	Not *P*	The country is not wealthy.
Conclusion	Therefore, not *Q.*	Therefore, the country will not be a democracy.

In the context of our running example, does it follow from the fact that the observed country is not wealthy that it will not be a democracy? Intuitively, we can imagine that there may be other reasons why a country is a democracy even though it is not wealthy. Indeed, one example of a nonwealthy democracy is India. An important point here, though, is that the argument is invalid, not because we can come up with an example of a real democracy that is not wealthy, but rather because we are not compelled to accept the conclusion based on the truthfulness of the major and minor premises. It may be confusing for readers that there is no direct connection between the factual accuracy of an argument's conclusion and the validity of the argument itself—a valid argument can have a conclusion that is factually false and an invalid argument can have a conclusion that is factually true. If we restrict our attention only to whether the argument is valid as it applies to our democracy example, we must ask, "Does the major premise claim that wealth is the only reason why a country will be a democracy?" The answer is clearly no. The major premise states only what will happen if a country is wealthy. It makes no claim as to what might happen if a country is not wealthy. It is for this reason, and this reason alone, that the argument is invalid.

Now let's consider what happens when we affirm the consequent. An example is shown in Table 2.10. As before, the major premise can be represented in set-theoretic terms by Figure 2.4. The difference this time is that the minor premise now asserts that *Q* is the case; that is, it affirms the consequent. If we accept that the premises are true, are we compelled to accept the conclusion that *P* is the case? Figure 2.4 clearly illustrates that the fact that our case is in *Q* does not necessarily mean that it is also in *P*. As a result, the argument is invalid—we are not compelled to accept the conclusion based on the premises.

In the context of our running example, an argument that affirms the consequent confuses necessity and sufficiency. The major premise does not maintain that wealth is the only cause

TABLE 2.10 Affirming the Consequent: An Invalid Argument

	General form	Specific example
Major premise	If *P,* then *Q*	If a country is wealthy, then it will be a democracy
Minor premise	*Q*	The country is a democracy.
Conclusion	Therefore, *P.*	Therefore, the country is wealthy.

TABLE 2.11 Denying the Consequent: A Valid Argument

	General form	Specific example
Major premise	If *P*, then *Q*	If a country is wealthy, then it will be a democracy
Minor premise	Not *Q*	The country is not a democracy.
Conclusion	Therefore, not *P*.	Therefore, the country is not wealthy.

of a country's democracy. Consequently, we cannot make a valid inference from the fact that a country is a democracy to the claim that the country must be wealthy—it may be wealthy or it may not be. Recall that to show that an argument is invalid, it is not necessary to show that its conclusion is false, we have to show only that it doesn't have to be true.

Finally, let's consider what happens when we deny the consequent. An example is shown in Table 2.11. As always, the major premise can be represented in set-theoretic terms by Figure 2.4. The difference this time is that the minor premise now denies that *Q* is the case; that is, it denies the consequent. If we accept that the premises are true, are we compelled to accept the conclusion that "not *P*" is the case? Figure 2.4 clearly shows that the fact that our case is not in *Q* necessarily means that it is not in *P*. As a result, the argument is valid—we are compelled to accept the conclusion based on the premises. In the context of our running example, the major premise indicates that all wealthy countries are democracies and the minor premise states that the country is not a democratic one. If these premises are both true, then it logically follows that our country cannot be wealthy.

Our brief foray into the study of logic indicates that if complex arguments can be broken down into categorical syllogisms, then it is possible to classify all arguments into one of four types according to whether they affirm or deny the consequent or antecedent. Two of these arguments are valid but the other two are invalid. Specifically, affirming the antecedent and denying the consequent are valid arguments—if you accept the major and minor premises, you are compelled to accept the conclusion. In contrast, denying the antecedent and affirming the consequent are invalid arguments—if you accept the major and minor premises, you are not compelled to accept the conclusion. These results are summarized in Table 2.12.

TABLE 2.12 What Types of Conditional Arguments Are Valid?

	Antecedent	Consequent
Affirm	Valid	Invalid
Deny	Invalid	Valid

Testing Theories

We believe that it is important for you to be able to distinguish between valid and invalid arguments so that you are not manipulated or exploited by others. This brief introduction to logic, however, is also important because it tells us something about the way scientists test their theories and explanations. Suppose we want to explain why wealthy countries are much more likely to be democracies than poor countries. One possible explanation for why this might be the case is given in the following statements:[15]

1. Living in an autocracy is risky—if you are one of the autocrat's friends you will do extremely well; but if you are not, you will do extremely poorly.
2. Living in a democracy is less risky—democratic leaders have to spread the goodies (and the pain) around more evenly. This means that you are less likely to do extremely well or extremely poorly in a democracy.
3. Wealthy people are less likely to take risks than poor people because they have more to lose. This means that countries with lots of wealthy people are more likely to be democracies than autocracies.

This short explanation provides reasons why rich countries might be more likely to be democracies than poor countries. How good is this explanation, though? Does this argument have any testable implications? One implication is that rich democracies should live longer than poor democracies. This is because people in rich democracies should be less likely to take the "risk" of becoming a dictatorship; in contrast, people in poor democracies might wonder what they have to lose.

How can we use observations of the real world to evaluate our proposed explanation? It is often the case that the implications of an explanation are more readily observable than the elements of the explanation itself. Consider the example we are using. Although it may be possible to compare the distribution of good and bad outcomes in autocracies and democracies, the claims that people differ in their propensity to take risks and that this propensity is related to their level of income are difficult to observe. This is because the propensity to take risks is an internal and psychological attribute of individuals.[16] For similar reasons, scholars typically evaluate their explanations by observing the real world to see if the implications of their explanations appear to be true based on the assumption, "If my theory is true, then its implications will be true." If we take this to be our major premise and the truth or falsity of the theory's implications as the minor premise, then we might be able to use observations to draw inferences about our theory or explanation.

15. This is a simplified version of an argument presented by Przeworski (2005). It is discussed more fully in Chapter 6.

16. Although an individual's propensity to take risks is difficult to observe, experimental social scientists are doing clever work to make progress on this front. For a summary of this work, see the relevant chapters in Davis and Holt (1993), Kagel and Roth (1995), and Camerer (2003).

Suppose our theory's implications were borne out by our observation that wealthy democracies do live longer than poor democracies. Can we conclude that our theory is true? If we were to do so, we would be engaging in reasoning that affirmed the consequent. This fact is shown more clearly in Table 2.13. However, as you know by now, affirming the consequent is an invalid form of argument. The major premise only says that if the theory is correct, then the implications should be observed. It never says that the only way for these implications to be produced is if the theory is correct. In other words, processes other than those described in our theory may produce the observation that wealthy countries live longer than poor countries. Put differently, the mere fact of observing the predicted implication does not allow us to categorically accept or reject our theory.

Suppose now that our observations did not bear out our theory's implications, that we did not observe that wealthy democracies live longer than poor democracies. Can we conclude that our theory is incorrect? If we were to do so, we would be engaging in reasoning that denies the consequent. This fact is shown more clearly in Table 2.14. As you know by now, denying the consequent is a valid form of argument. In other words, by accepting the premises, we are compelled to accept the conclusion that our theory is not correct.

If we compare the two previous examples, we can see an important asymmetry as regards the logical claims that can be made on the basis of "confirming" and "disconfirming" observations. When an implication of our theory is confirmed, the most we can say is that the theory may be correct. This is because neither of the two possible conclusions—our theory is correct or our theory is not correct—contradicts our major and minor premises. In other words, we cannot say that our theory is correct or verified. In contrast, if we find that an implication of a theory is inconsistent with observation, then we are compelled by logic to accept that the theory is false—this is the only conclusion that is consistent with our observation. Thus, although we can know that a theory must be incorrect in light of a disconfirming case, all that we can say in light of a confirming case is that a theory may be correct (it may also be wrong). What does this mean? It means that we are logically justified in having more confidence when we reject a theory than when we do not.

TABLE 2.13 Affirming the Consequent: An Invalid Argument

General form	Example	Specific example
If *P*, then *Q*	If our theory is correct, then we should observe some implication *I*.	If our theory is correct, then we should observe that wealthy democracies live longer than poor democracies.
Q	We observe Implication *I*.	Wealthy democracies live longer than poor democracies.
Therefore, *P*.	Therefore, our theory *T* is correct.	Therefore, our theory is correct.

TABLE 2.14 Denying the Consequent: A Valid Argument

General form	Example	Specific example
If *I,* then *Q*	If our theory is correct, then we should observe some implication *I.*	If our theory is correct, then we should observe that wealthy democracies live longer than poor democracies.
Not *Q*	We do not observe Implication *I.*	Wealthy democracies do not live longer than poor democracies.
Therefore, not *P.*	Therefore, our theory *T* is incorrect.	Therefore, our theory is incorrect.

This, in turn, implies that the knowledge encapsulated in theories that have not been rejected remains tentative and can never be proven for sure—scientific theories can never be proven. Even if we are utterly convinced that our major and minor premises are true, all that we can logically conclude from a confirming instance is that the theory has not yet been falsified.

This asymmetry between confirming and disconfirming cases led the philosopher of science Sir Karl Popper ([1959] 2003, 280–281) to conclude:

> The old scientific ideal of *episteme*—of absolutely certain, demonstrable knowledge—has proved to be an idol. The demand for scientific objectivity makes it inevitable that every scientific statement must remain *tentative for ever.* . . . With the idol of certainty . . . there falls one of the defenses of obscurantism which bar the way to scientific advance. For the worship of this idol hampers not only the boldness of our questions, but also the rigor and integrity of our tests. The wrong view of science betrays itself in the craving to be right; for it is not his *possession* of knowledge, of irrefutable truth, that makes the man of science, but his persistent and recklessly critical *quest* for truth.

The Comparative Method Revisited

It is important to recognize that the asymmetry between confirmation and falsification has important implications for the method we use to build knowledge. When scholars use Mill's methods, they go out into the real world to collect observations and look for patterns in the data. Those factors that cannot be eliminated as potential causes by Mill's methods become our explanation. Each new case that exhibits the same pattern in the data confirms or verifies our conclusion. We have already seen that one problem with Mill's methods is that many assumptions have to be satisfied before valid inferences can be drawn. This problem is complicated by that fact that the approach itself does not provide us with much guidance in determining if those assumptions are satisfied in any particular case.

It should be clear by now that Mill's methods pose yet another problem. Because they start with observations, they rely entirely on the process of affirming the consequent. If we identify causes only after we have observed the data, as Mill's methods require, we have no chance of ever coming across disconfirming observations. This is because our "theory" is essentially just a restatement of the patterns in our observations.[17] This is a real problem, whether the researcher is employing Mill's methods on a small number of cases or analyzing large data sets looking for patterns. No matter how many cases these researchers observe that appear to exhibit the predicted pattern, they are never logically justified in claiming that their conclusions have been confirmed or verified.

You might wonder whether there is any way to avoid these problems. The answer is yes. Imagine that we start with a set of implications derived from a theory and then observe some facts. In other words, let's start with the theory and then observe the world rather than the other way around. It is now at least possible for our observations to contradict our theory. If it turns out that our observations are consistent with our theory, then we can have a greater measure of confidence in our theory because it withstood the very real chance of being falsified. Even now, though, it is important to recognize that we still can never say that our theory is verified or confirmed. If our observations are inconsistent with our theory, then we can draw valid inferences about the truthfulness of our theory—we can conclude that it is wrong. This approach to doing science is called *falsificationism.* Falsificationism forms the basis for the view of science employed in this book. It is to this view of science that we now turn.

Falsificationism is an approach to science in which scientists generate testable hypotheses from theories designed to explain phenomena of interest. It emphasizes that scientific theories are constantly called into question and that their merit lies only in how well they stand up to rigorous testing.

SCIENCE AND FALSIFICATIONISM

In the previous section, we argued that the comparative method is deeply flawed. We hope that this is not taken as evidence that we believe that the whole scientific endeavor is inherently flawed and that we should look elsewhere for an understanding of the world. We truly believe that science is the best way to learn about the world and that it can fruitfully be applied to the study of politics. But let us be clear about what our view of science is.

What Is Science?

Is science simply a body of knowledge or a collection of facts, as many of us learn in high school? There was a time when scientists may have given this as the most common answer, but this response is fundamentally unsatisfactory. If this answer were correct, then many of the claims about how the universe worked, such as those developed through Newtonian physics, would now have to be called unscientific, because they have been replaced by claims based on

17. This suggests that the comparative method is, at most, suitable only for developing theories and not testing them.

more recent theories, such as Einstein's theory of relativity. Moreover, if science were simply a collection of statements about how the world works, then we would not be able to appeal to science to justify our knowledge of the world without falling into the following circular reasoning:

"Science is a collection of statements about how the world works."
"*How do we know if these statements are accurate?*"
"Well, of course they're accurate! They're scientific!"

The body of knowledge that we call "scientific" may well be a product of science, but it is not science itself. Rather, science is a method for provisionally understanding the world. The reason for saying "provisionally" will become clear in a moment. Science is one answer to the central question in epistemology (the study of knowledge): "How do we know what we know?" The scientist's answer to that question is, "Because we have subjected our ideas to the scientific method." Science, as Karl Popper indicates in one of the epigraphs at the start of this chapter, is the quest for knowledge. At this point, you might say that there are many ways to seek knowledge. Does this mean that meditation, reading scripture, and gazing at sunsets are all scientific activities? Although we agree that these are all ways of seeking knowledge, none of them is scientific. Science is a particular quest for knowledge. To use Popper's phrase, it is the "recklessly critical" pursuit of knowledge, in which the scientist continually subjects her ideas to the cold light of logic and evidence.

Although science is not the only route to knowledge, it may be unique in its emphasis on self-criticism. Scientists, like other scholars, can derive their propositions from an infinite number of sources. For example, Gregory Derry (1999) tells the story of how August Kekulé made an extremely important scientific breakthrough while hallucinating—half asleep—in front of the fireplace in his laboratory one night. He had spent days struggling to understand the spatial arrangement of atoms in a benzene molecule. In a state of mental and physical exhaustion, his answer appeared to him as he "saw" swirls of atoms joined in a particular formation dancing among the embers of his fireplace. In a flash of inspiration, he saw how the pieces of the puzzle he had been struggling with fit together. This inspired understanding of the physical properties of organic compounds did not become a part of science that night. It did so only after the implications of his vision had withstood the critical and sober onslaught that came with the light of day. Thus, although flashes of insight come to all manner of beings, science begins only when one asks, "If that is true, what else ought to be true?" And it ends—if ever—when researchers are satisfied that they have taken every reasonable pain to show that the implications of the insight are false and have failed to do so.

So, science is the quest for knowledge that relies on criticism. The thing that allows for criticism is the possibility that our claims, theories, hypotheses, and the like could be wrong. Thus, what distinguishes science from nonscience is that scientific statements are *falsifiable*—there must be some imaginable observation that could falsify or refute it. This does not mean that the scientific statement will ever be falsified, just that there must be a possibility that it could

> Scientific statements are **falsifiable.** This means that they are potentially testable—there must be some imaginable observation that could falsify or refute it.

be falsified. Only if a statement is potentially testable is it scientific. We deliberately say "potentially testable" because a statement does not have to have been tested to be scientific; all that is required is that we can conceive of a way to test it.[18]

What sorts of statements are not falsifiable? Tautologies are not falsifiable because they are true by definition. For example, the statement "Strong states are able to overcome special interests in order to implement policies that are best for the nation" is a tautology. This statement may be true, but unless we can think of a way to identify a strong state without referring to its ability to overcome special interests, then it is just a definition and is, therefore, unscientific. Other hypotheses are not falsifiable, not because they are tautological, but because they refer to inherently unobservable phenomena. For example, the claims "God exists" or "God created the world" are not falsifiable because they cannot be tested; as a result, they are unscientific. Note that these claims may well be true, but it is important to recognize that science has nothing to do with the truth or falsity of statements. All that is required for a statement to be scientific is that it is falsifiable. It should be clear from this that we are not claiming that nonscience is nonsense or lacks meaning—this would clearly be a mistake. Non-falsifiable statements like "God exists" may very well be true and have important and meaningful consequences—our claim is simply that they do not form a part of science. Having defined science as a critical method for learning about the world, we can now evaluate the basic elements of the scientific method in more detail.

A **tautology** is a statement that is true by definition.

The Scientific Method

Although there is no *scientific method* clearly written down that is followed by all scientists, it is possible to characterize its basic features in the following manner.

The **scientific method** describes the process by which scientists learn about the world.

Step 1: Question

The first step in the scientific process is to observe the world and come up with a question or puzzle. The very need for a theory or explanation begins when we observe something that is so unexpected or surprising that we ask, "Why did that occur?" Note that the surprise that greets such an observation, and that makes the observation a puzzle worth exploring, implies that the observation does not match some prior expectation or theory that we held about how the world works. Thus, we always have a preexisting theory or expectation when we observe the world; if we did not have one, we could never be surprised and there would be no puzzles.

18. Indeed, a statement can be scientific even if we do not currently have the data or the technical equipment to test it. Our upcoming discussion of Einstein's special theory of relativity illustrates this point quite clearly.

Step 2: Theory or Model

Once we have observed something puzzling, the next step is to come up with a theory or model to explain it. In what follows, we will talk of theories, models, and explanations interchangeably. Scientists use the word *theory* to describe a set of logically consistent statements that tell us why the things that we observe occur. It is important that these statements be logically consistent, otherwise we have no way of determining what their empirical predictions will be and, hence, no way to test them. Put differently, theories that are logically inconsistent should not, indeed cannot, be tested, because we have no way of knowing what observations would truly falsify them.

> A **theory** is a set of logically consistent statements that tell us why the things that we observe occur. A theory is sometimes referred to as a model or an explanation.

Most philosophers of science assume that all phenomena occur as a result of some recurring process. The principle of the *uniformity of nature* asserts that nature's operating mechanisms are unchanging in the sense that if *X* causes *Y* today, then it will also cause *Y* tomorrow and the next day and so on.[19] If it does not, then we should not consider *X* a cause. Be careful to note that the principle of uniformity is not a statement that nature is unchanging, only that the laws of nature do not change (although our understanding of those laws will likely change over time). This is an important principle, because if this principle is rejected, we must accept the possibility that things "just happen." That is, we must accept that things happen for no reason. Casual observation of the sometimes-maddening world around us suggests that this may, indeed, be true, but it is the job of scientists to attempt to impose order on the apparent chaos around them.[20] In the social world, this process often begins by dividing the behavior we observe into systematic and unsystematic components. The social scientist then focuses her attention on explaining only the systematic components.[21]

> The principle of the **uniformity of nature** asserts that nature's operating mechanisms are unchanging in the sense that if *X* causes *Y* today, then it will also cause *Y* tomorrow and the next day and so on.

So, what should theories or models look like? It is useful to think of our starting puzzle or observation as the end result of some previously unknown process (Lave and March 1975).[22] We can then speculate about what (hidden) processes might have produced such a result. In effect, we try to imagine a prior world that, if it had existed, would have produced

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19. For a layman's discussion of the uniformity of nature, see Stephen Jay Gould's book (1985) *The Flamingo's Smile: Reflections in Natural History.*

20. Indeed, at least one paradigm for understanding the world embraces *chaos* as its starting point. See James Gleick's book (1987) *Chaos: Making a New Science* for a compelling introduction to chaos theory aimed at the nonspecialist.

21. This suggests that you should be wary of anyone who tells you that you need to know everything before you can know anything.

22. Note that thinking in terms of a process takes us away from the strictly correlational models used by scholars trying to apply the comparative method and brings us closer to a more commonsensical notion of an explanation. It also encourages the development of interesting implications via counterfactuals like, "What would happen if we changed a part of the causal process?"

the otherwise puzzling observation before us. This prior world then becomes our model explaining the observation.

Notice that this process of imagining prior worlds is one place—but surely not the only one—where imagination and creativity enter the scientific process. What scientists do to stimulate this creative process is itself not part of the scientific method. Essentially, anything goes. Nobel Prize-winning physicist Richard Feynman, who himself spent a lot time hanging out in bars, drawing "exotic" dancers and playing Brazilian hand drums, describes science as "imagination in a straightjacket"—it is imagination constrained by what we already know about the world (Feynman 1967). Consequently, he suggests that there is no point engaging in flights of fancy about things that we know cannot exist (like antigravity machines). Whatever means we use to stimulate speculation about a prior world, if we can show through logical deduction that if that prior world existed, it would have produced the puzzling observation we started with, then we have a theory, or model. Note that we only have "a" theory; we do not necessarily have "the" theory. This is why we continually subject our theories to tests.

The model that we end up with will be a simplified picture of the world. It will be something that helps us understand how some aspect of the world works and helps us explain it to others. Because a model is a simplified picture of the world, it is always going to leave lots of things out. Much of the art of modeling is in deciding what to leave out and what to keep in. A good model contains only what is needed to explain the phenomenon that puzzles us and nothing else. If we made our models too complex, we would have no way of knowing which elements were crucial for explaining our puzzling observation that we started with and which were superfluous. The purpose of a model is not to describe the world but to explain it, so descriptive accuracy is not a core value in model building.[23] Details are important only to the extent that they are relevant to what we are trying to explain. For example, if we are interested in explaining an aircraft's response to turbulence, it is not important whether our model of the aircraft includes LCD screens on the back of the passengers' seats.[24] In fact, such irrelevant details can easily distract our attention from the question at hand. Another benefit of simple models is that they invite falsification because they make it very clear what we should not observe. The more amendments and conditions placed on an explanation, the easier it is for scholars to dismiss apparently contradictory evidence. We now know from our earlier discussion that we learn more when a theory is falsified; this may be another reason for keeping our models simple.

Step 3: Implications (Hypotheses)

Once we have a model, the third step in the scientific process is to deduce implications from the model other than those that we set out to explain. Why do we say "other than those that

23. As the late Dutch economist Henri Theil (1971) once said, "models should be used, not believed." In other words, a model is a tool to be used to create knowledge; it is not a repository of descriptive knowledge.

24. Of course, if we were explaining our children's choice of airlines, this might well be a crucial detail.

we set out to explain"? Well, presumably the model will provide a logical explanation for the puzzling observation that we started with; after all, that is what it was designed to do. In other words, there is no way that a model can ever be falsified if only the observations that were employed to develop the model in the first place are used to test it. To actually test the model and allow for the possibility that it will be falsified, we will have to find other implications that can be deduced from it. We must ask ourselves "If the prior world that we created to explain the phenomena that we originally found puzzling really did exist, what else ought to exist? What else should we be able to observe?" As before, there is often room for incredible imagination here, because the complete list of logical implications of a model is seldom self-evident.

Good models are those that produce many different implications. This is so because each prediction represents another opportunity for the model to fail and, therefore, makes the model easier to falsify. This is good because if the model fails to be falsified, we gain more confidence in its usefulness. Fertile models—models with many implications—are also desirable because they encourage the synthesis of knowledge by encouraging us to see connections between ostensibly disparate events. Good models also produce surprising implications—they tell us something we would not know in the absence of the model. Models are not particularly useful if they tell us only what we already know. Surprise, however, is best appreciated in small doses. If every implication of a model is surprising, then either everything we thought about the world is wrong, or the model is.

Step 4: Observe the World (Test Hypotheses)

The fourth step is to examine whether the implications of the model are consistent with observation. Remember that the goal is not to dogmatically uphold the implications or defend them in order to prove how right they are. On the contrary, we should try our best to falsify them, because it is only after a theory has withstood these attempts to overthrow it that we can reasonably start to have confidence in it. Although as many of the model's implications as possible should be tested, testing those that are most likely to be falsified is particularly important. Always submit a model to the harshest test that you can devise.

It is standard practice to stop and ask if other models—models that describe altogether different processes—might also explain the phenomena of interest. When this is the case (and it almost always is), it is incumbent upon the scientist to compare the implications of those other models with the implications of her own model. Although it is always the case that competing models have some of the same implications (otherwise they could not explain the same observations to begin with), it is typically the case that they will differ in some of their implications (otherwise they are not different models). The trick for a researcher is to identify these points of conflict between the different models and identify the relevant observations in the real world that would help her decide between them. This is what scientists refer to as a *critical test.* Ultimately, if a critical test is possible, observation will prove decisive

> A **critical test** is one that allows the analyst to use observation to distinguish between two or more competing explanations of the same phenomenon.

in choosing between the models. This is because we know that there is only one world and the creative scientist has managed to get competing theories to say contradictory things about it—only one of the models can be consistent with the real world.

Step 5: Evaluation

If we observe the implications deduced from our theory, we simply say that our theory has been corroborated. As we showed earlier, we cannot say that our theory has been verified or proven.[25] This is why we earlier called science a method for "provisionally" understanding the world. Our theory may or may not be true. All we know is that it has not been falsified so far; we cannot rule out that it will not be falsified the next time it is tested. As you can see, the scientific method is an inherently critical method when it is "successful" (when a theory's predictions seem to be borne out), because it is precisely under these circumstances that it is most cautious in the claims that it makes.

Although we cannot ever prove our theories, we can claim that some theories are better corroborated than others. As a result, we can have more confidence in their conclusions. One might think that a theory that has been subjected to multiple tests is better corroborated than one that has not been subjected to many tests at all. However, this is not always the case. If we keep testing the same implication over and over again, it is not clear how much an additional test actually adds to the degree to which the theory is corroborated. What really matters is not so much how many times a theory has been corroborated, but the severity of the tests to which it has been subjected. This, in turn, will depend on the degree to which the theory is falsifiable. Again, this is why we like our models to be simple and have multiple implications. In general, we will have more confidence in a theory that has survived a few harsh tests than a theory that has survived many easy ones. This is why scientists often talk about the world as if it were black and white rather than gray. Bold statements should not be interpreted as scientific hubris but rather as attempts to invite criticism—they are easier to falsify.

What happens if we do not observe the implications deduced from our theory? Can we conclude that our theory is incorrect based on one observation? The answer is probably not. It is entirely possible that we have not observed and measured the world without error. Moreover, if we believe that human behavior is inherently probabilistic, then we might not want to reject theories on the basis of a single observation. In a world in which our tests are potentially fallible, we should not relegate a theory to the dustbin of intellectual history the minute one of its implications is shown to be false. Instead, we must weigh the number, severity, and quality of the tests that the theory's implications are subjected to and make a judgment. And most important, this judgment should be made with an eye toward what would replace the theory should we decide to discard it. This is why some scientists say that it takes a theory to kill a theory.

25. Many scientists, however, slip into the language of verification when reporting their results. Instead of simply saying that their test has failed to falsify their hypotheses or is consistent with their theory, they will claim that the test has shown that their theory is correct. For example, they might claim that their test shows that wealth causes democracies to live longer when, in fact, all they can conclude is that they were unable to falsify the claim that wealth causes democracies to live longer.

Box 2.2

AN EXAMPLE OF THE SCIENTIFIC PROCESS

The Case of Smart Female Athletes

Because student athletes often miss classes to compete out of state, they frequently submit a letter from the athletic director asking for cooperation from their professors. Over the years a certain professor has noticed through casual observation that women engaged in athletic competition frequently perform better academically than the average student. It is puzzling why female athletes would perform better in spite of missing classes. Can you think of a model—a process—that might produce such a puzzling observation?

You might start with the following conjecture:

- Female athletes are smart.

This is an explanation, but it is not a particularly good one. For example, it comes very close to simply restating the observation to be explained. One thing that could improve the explanation is to make it more general. This might lead you to a new explanation:

- Athletes are smart.

This model is certainly more general (but not necessarily more correct). Still, there are at least two problems with this model as things stand. First, it has no sense of process; it basically says that athletes share some inherent quality of smartness that leads them to perform better academically. In effect, this only pushes the phenomenon to be explained back one step, that is, we now need to know why athletes are smart. Second, the model comes close to being a tautology. It essentially says that athletes perform better academically because they are defined as being smart. This is problematic, as we saw earlier, because tautologies are not falsifiable—they cannot be tested and, hence, they are not part of the scientific endeavor.

This might lead you to look for a new explanation or model that includes some sort of process that makes female athletes appear smart. You might come up with the following model:

- Being a good athlete requires a lot of hard work; performing well academically in college requires a lot of work. Students who develop a strong work ethic in athletics are able to translate this to their studies.

This is a much more satisfying model because it provides a process or mechanism explaining why female athletes might be more academically successful than other students. An appealing feature of the model is that the logic of the argument applies not only to female athletes but to any athlete. Indeed, it applies to any person involved in an activity that rewards hard work. Thus, we might generalize this model by removing the specific reference to athletes:

- **Work Ethic Theory:** Some activities provide a clear, immediate, and tangible reward to hard work—in fact, they may provide an external stimulus to work hard (coaches shouting through bullhorns, manipulating rewards and punishments based on effort, and so on). Individuals who engage in these activities develop a habit of working hard and so will be successful in other areas of life as well.

At this point, you should stop and ask yourself whether there are any alternative explanations for why female athletes are successful. Can you think of any? One alternative explanation is the following:

- **Excellence Theory:** Everyone wants to feel successful but some people go long periods without success and become discouraged. Those individuals that experience success in one area of their life (perhaps based on talent, rather than hard work) develop a "taste" for it and devise strategies to be successful in other parts of their life. Anyone who achieves success in nonacademic areas, such as athletics, will be more motivated to succeed in class.

Another alternative explanation is the following:

- **Gender Theory:** In many social and academic settings, women are treated differently from men. This differential treatment often leads women to draw inferences that certain activities are "not for them." Because many athletic endeavors are gender specific, they provide an environment for women to develop their potential free from the stultifying effects of gender bias. The resulting sense of efficacy and autonomy encourages success when these women return to gendered environments like the classroom.

We now have three different or competing models, all of which explain the puzzling observation that we started with. But how can one evaluate which model is best? One way is to test some of the implications that can be derived from these theories. In particular, we would like to find some new question(s) to which the three models give different answers. In other words, we would like to conduct a critical test that would allow us to choose among the alternative reasonable models.

We might start by wondering whether being an athlete helps the academic performance of women more than men. Whereas the Work Ethic Theory and the Excellence Theory both predict that being an athlete will help men and women equally, the Gender Theory predicts that female athletes will perform better than nonathletic women, but that male athletes will have no advantage over nonathletic men. Thus, collecting information on how well male and female athletes perform in class relative to male and female nonathletes, respectively, would allow us to distinguish between the Gender Theory and the other theories.

But how can we distinguish between the Excellence Theory and the Work Ethic Theory? One difficulty frequently encountered when trying to devise critical tests is that alternative theories do not always produce clearly differentiated predictions. For example, we just saw that the Excellence Theory and the Work Ethic Theory both predict that athletics will help men and women academically. It turns out that these two theories have other predictions in common as well. The Excellence Theory clearly suggests that success in any nonacademic area of life is likely to encourage academic success. In other words, the Excellence Theory predicts that academic success will be associated with success in other areas of life. The problem is that success in many of these nonacademic areas may require hard work.

As a result, if we observe, for instance, accomplished musicians performing well in our political science classes, it will be difficult to discern whether this is because they learned the value of hard work in music and transferred it to political science (Work Ethic Theory) or because they developed a "taste" for success as musicians that then inspired success in political science (Excellence Theory). In effect, the Excellence Theory and the Work Ethic Theory both predict that academic success will be associated with success in other areas of life.

If we want to distinguish between the Work Ethic Theory and the Excellence Theory, we need to imagine observations in which they produce different expectations. Sometimes, this requires further development of a theory. For example, we might expand the Excellence Theory to say that those people who develop a taste for excellence also develop a more competitive spirit. If this is true, then the Excellence Theory would predict that student athletes are likely to be more competitive and will perform better than other students even when playing relatively frivolous board games. Since even the most driven athletes are not likely to devote time to training for board games, the Work Ethic theory predicts that athletes will perform the same as nonathletes in such trivial pursuits. Thus, we could look at the performance of athletes and nonathletes at board games to distinguish between the Excellence Theory and the Work Ethic Theory.

The three critical tests that we have come up with and their predictions are listed in Table 2.15. All that is now required is to collect the appropriate data and decide which model, if any, is best.

It is worth noting that there is considerable overlap between the predictions of our three theories. This is often the case in political science settings as well. The crucial point is not that each theory should yield a complete set of unique predictions, but that our theories should have sufficiently many distinct predictions that we can use observation to help us make decisions about which theories to embrace, however tentatively. Table 2-15 lists just some of the predictions that might help us to distinguish between the three theories outlined above. Can you think of any more?

TABLE 2.15 Three Critical Tests

	Theory		
Question	**Gender**	**Excellence**	**Work ethic**
Will athletics help women more than men?	Yes	No	No
Is academic success associated with success in other areas of life?	No	Yes	Yes
Are female athletes more successful at board games than women who are not athletes?	Yes	Yes	No

Having described the scientific method, we would like to briefly dispel certain myths that have developed about science. Some of these myths have been promoted by opponents to the scientific project, but others, unfortunately, have been sustained by scientists themselves.

Myths about Science

The first myth is that science proves things and leads to certain and verifiable truth. This is not the best way to think about science. It should be clear by now from our discussion that the best science can hope to offer are tentative statements about what seems reasonable in light of the best available logic and evidence. It may be frustrating for students to realize this, but science can speak with more confidence about what we do not know than what we do know. In this sense, the process of scientific accumulation can be thought of as the evolution of our ignorance. We use the scientific method because it is the best tool available to interrogate our beliefs about the (political) world. If we hold onto any beliefs about the (political) world, it is because, after we have subjected them to the most stringent tests we can come up with, they remain the most plausible explanations for the phenomena that concern us.

The second myth is that science can be done only when experimental manipulation is possible. This is clearly false. For theories to be scientific, they need only be falsifiable. There is no claim that tests of these theories need to be carried out in the experimental setting. Many of the natural sciences engage in research that is not susceptible to manipulation. For example, all research on extinct animals such as dinosaurs must be conducted without the aid of experimental manipulation because the subjects are long dead. In fact, there is also no claim that a theory must be tested before it can be called scientific. Einstein presented a special theory of relativity in 1905 that stated, among other things, that space had to be curved, or warped. It took fourteen years before his theory was tested with the help of a solar eclipse. No scientist would claim that Einstein's theory was unscientific until it was tested. Put simply, scientific theories must be potentially testable, but this does not mean that they stop being scientific if they are yet to be actually tested.

The third myth is that science is value-neutral. It is important to remember that the pursuit of knowledge about the world is closely entangled with attempts by people to change the world. This poses difficulties for social scientists. For example, the people we study may read what we write and act upon it. For that reason, we have to be very clear about the limits of our knowledge and not encourage others to act upon knowledge that is not highly corroborated. And although we should not resist the conclusions of our research because we had hoped that the world worked differently, there is nothing wrong with raising the evidentiary bar before accepting results that could lead to policies we would deeply regret if we found out later that we were wrong.

The fourth myth, that politics cannot be studied in a scientific manner, can easily be dispelled by now. Our description of the scientific method clearly shows that this myth is false. The study of politics generates falsifiable hypotheses and hence generates scientific statements. These theories of politics can be tested just like any other scientific theory. We will further demonstrate that politics can be studied in a scientific manner in the remaining chapters of this book. The fact, though, that our subjects can read our work and change their behavior makes our job quite a bit harder than if we were working in one of the natural sciences.

CONCLUSION

In this chapter we have argued that it is useful to think about politics in a scientific manner. We have also tried to offer a clear view of what most practicing scientists have in mind when they use the word *science*. It is a fairly minimalist view. What unites all scientists is the idea that one ought to present one's ideas in a way that invites refutation (Popper 1962). It is incumbent upon the scientist to answer the question "What ought I to observe if what I claim to be true about the world is false?" This view of science recognizes that scientific knowledge is tentative and should be objective. Although it is certainly likely that our prejudices and biases motivate our work and will creep into our conclusions, the goal of science is to present our conclusions in a way that will make it easy for others to determine whether it is reasonable for people who do not share those prejudices and biases to view our conclusions as reasonable.

KEY CONCEPTS

argument, *33*
categorical syllogism, *33*
comparative method, *19*
conclusion (in an argument), *33*
critical test, *45*
deterministic cause, *28*
falsifiable, *41*
falsificationism, *40*
interaction effect, *29*
invalid argument, *33*
method of agreement, *25*
method of disagreement, *25*
necessary and sufficient condition, *21*
necessary condition, *21*
premise, *33*
probabilistic cause, *28*
scientific method, *42*
sufficient condition, *21*
tautology, *42*
theory, *43*
uniformity of nature, *43*
valid argument, *33*

ED: text ms has difference not dis-agreement

PROBLEMS

The four categories of problems that follow address some of the more important concepts and methods introduced in this chapter.

Logic: Valid and Invalid Arguments

1. Consider the following argument.

Major Premise: If a country has a strong economy, the government will be popular.
Minor Premise: The government is not popular.
Conclusion: Therefore, the country does not have a strong economy.

a. Is this a valid or invalid argument?

b. What form of categorical syllogism is this (affirming the antecedent/consequent or denying the antecedent/consequent)?

2. Consider the following argument.

Major Premise: If the president commits a criminal act, then he can be impeached.
Minor Premise: The president does not commit a criminal act.
Conclusion: Therefore, the president cannot be impeached.

a. Is this a valid or invalid argument?
b. What form of categorical syllogism is this?

3. Consider the following argument.

Major Premise: If a country employs proportional representation electoral rules, it will have many parties.
Minor Premise: The country does not employ proportional representation electoral rules.
Conclusion: Therefore, the country does not have many parties.

a. Is this a valid or invalid argument?
b. What form of categorical syllogism is this?

4. Consider the following argument.

Major Premise: If theory *T* is correct, all rich countries will be democracies.
Minor Premise: All rich countries are democracies.
Conclusion: Therefore, theory *T* is correct.

a. Is this a valid or invalid argument?
b. What form of categorical syllogism is this?
c. If you wanted to demonstrate that theory *T* is wrong, what would you have to observe?

Scientific Statements

5. A statement is scientific if it is falsifiable. Which of the following statements are scientific?

- Smoking increases the probability of getting cancer.
- A square is a shape with four sides of equal length.
- The sun revolves around the earth.
- It always rains in England during the winter.
- Education spending increases under left-wing governments.
- Iceland is a country.
- Religious faith assures a person a place in the afterlife.
- Democracies are less likely to go to war than dictatorships.

6. Some statements are nonscientific because they are tautologies and some because they refer to inherently nonobservable phenomena. Come up with an example of both types of nonscientific statement.

7. Sometimes it is hard to know whether a statement is scientific or not. Much depends on how we define certain terms. Consider the following statement.

- If the USA Patriot Act is successfully implemented, then the United States will not be attacked.

Whether this statement is falsifiable depends on how we define "successfully implemented." On the one hand, if we define successful implementation as not being attacked, then this statement becomes tautological or true by definition—no observation could falsify it. On the other hand, if we define successful implementation as actually passing the Patriot Act in Congress, then this statement becomes scientific—it could be falsified by an attack on the United States.

Consider the following statement.

- All mainstream U.S. senators agree that the House bill is unacceptable.
  a. Is this statement scientific if "mainstream" is defined in terms of the acceptability of the House bill?
  b. Is this statement scientific if "mainstream" is defined in terms of the ideology of the senators?

Now consider the following statement.

- All good students get high grades.
  a. Is this statement scientific if "good" is defined in terms of a student's grade?
  b. Is this statement scientific if "good" is defined in terms of a student's enthusiasm?

Necessary and Sufficient Conditions

8. Consider the following statements. After looking at the structure of each statement, would you say that the conditions shown in boldface type are necessary or sufficient to produce the effects shown?

- If a person contracts measles, then she was **exposed to the measles virus.**
- If a **democracy is wealthy,** then it will stay a democracy.
- A country cannot maintain a democratic form of government unless **it has a culture that promotes civic participation.**
- Countries have many parties only **when they employ proportional electoral rules.**
- Countries always have few parties **when they employ majoritarian electoral rules.**

Model Building in the Scientific Method

9. It has frequently been observed that students coming into a lecture hall tend to fill up the rear of the hall first (Lave and March 1975; Schelling 1978). Here are two possible explanations, or models, that predict this kind of behavior.

Minimum Effort Theory: People try to minimize effort; having entered at the rear of the hall, they sit there rather than walk to the front.

"Coolness" Theory: General student norms say that it is not cool to be deeply involved in school work. Sitting in front would display interest in the class, whereas sitting in the rear displays detachment.

a. Make up two facts (that is, derive two specific predictions) that, if they were true, would tend to support the Minimum Effort Theory. Do the same thing for the "Coolness" Theory.
b. Make up a critical fact or experiment (specific prediction) that, if it were true, would tend to support one theory and contradict the other.
c. Propose a third theory to explain student seating results and explain how you might test it against the other two theories.

10. It has frequently been observed that democracies do not go to war with each other. This has come to be known as the Democratic Peace.
    a. Make up two theories or models that would account for this observation.
    b. Generate a total of three interesting predictions from the two models and identify from which model they were derived.
    c. Find some critical fact/situation/observation/prediction that will distinguish between the two models. Be explicit about how it simultaneously confirms one model and contradicts the other.

11. A casual look around the world reveals that some governments treat their citizens better than other governments do.
    a. Make up two theories or models that would account for this observation.
    b. Generate a total of three interesting predictions from the two models and identify from which model they were derived.
    c. Find some critical fact/situation/observation/prediction that will distinguish between the two models. Be explicit about how it simultaneously confirms one model and contradicts the other.