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What Is Science?

Learning Objectives

1.1 Describe how sciences differ from other ways of knowing

1.2 Discuss how the scientific approach was developed

1.3 Explain how to study behavior and experience

Science is above all a human activity. One obvious meaning of this statement is that people perform science. Another equally accurate meaning is that all people perform science in some form. After all, the methods of science are simple extensions of the ways all people learn about their world. Science in many ways is similar to the way we have been learning about the world since we were infants. We learn through interacting with our world. Consequently, each of you knows this aspect of science well because you have been using it in one form or another since you first began toddling about and discovering the world. You probably know much more about the scientific method than you think you do.

Watch a young child. When something catches his or her eye, the child must examine it, study it, observe it, have fun with it. Next, the child wants to interact with it, touch it, feel it, and move it around. From passive observations and active interactions, the child slowly learns about the world. Some interactions are fun: "If I tip the glass, I get to see the milk form pretty pictures on the floor." Others are not so much fun: "If I touch the red circles on the stove, my fingers hurt!" From each interaction, the child learns a little more about the world.

Like the child, scientists are exploring the unknown—and sometimes the known—features of the world. All basic research strategies are based on one simple notion: *To discover what the world is like, we must experience it.* To have an idea about the nature of the world is not enough. Instead, like the child, scientists experience the world to determine whether their ideas accurately reflect reality. Direct experience is an essential tool because it alone allows us to bridge the gap between our ideas and reality.

However, there is another aspect to science and to critical thinking itself that many people do not think about. This is the aspect of *doubt*. One way in which we doubt is to question the common wisdom—whether it holds that the world is flat or that all our behavior is learned—and to seek different models of the world. Likewise, when we consume information, we still want to know how to question what we are being told. In science we use doubt to question our research and ask whether factors other than the ones that we originally considered might have influenced our results. As an informed consumer, we also want to know how to evaluate what we are being told. By doing this we come to see that science is a combination of interaction with the world and logic. Thus, as we will discuss throughout this book, science is more than just watching; it is rare that data actually speak for themselves.

In general, there is no single scientific method, any more than there is one art or one education or one religion, yet there is a general process called *science*. This process consists of experiencing the world and then drawing general conclusions from observations. Sometimes these conclusions or facts are descriptive and can be represented by numbers. For example, we say that the moon is 238,000 miles from the Earth or that the average human heart rate is 72 beats per minute. Other times these facts are more general and can describe a relationship or a process. For example, we say that it is more difficult to learn a second language after puberty than before, or that as we age we hear fewer high-frequency sounds. Whatever the topic, the known information about a particular subject is called *scientific knowledge*.

Much of our scientific knowledge is based on a history of research in a particular area. How we perform research is what this book is all about. Many conceptions of scientific research picture a man or a woman in a white lab coat, laboriously writing down numbers, and later milling about in a cluttered office trying to make theoretical sense out of these findings. This conception may be partly accurate, but it is not a total picture of science. A scientist, like all of us, is human; and as we shall see, this fact contributes to both the promises and problems of doing science.

In this book, we stress this aspect of science, which becomes apparent when the available facts are viewed in light of human value. It is this aspect of value that allows us to see one set of numbers as more relevant or potentially more useful than another. This combining of fact and value results in a humanistic approach to scientific understanding. Scientific understanding helps us to see the *how* and *why* of the world and thereby to understand nature in a fuller perspective. In many cases, this understanding raises new questions, which in turn can be answered by using science to examine the world. In other cases, these new facts can be applied in real-life settings (technology) and make life easier for everyone. Thus, at its best, science begins and ends in human experience.

In the introduction to this book, we described three actors in the drama of science: the scientist, the research participant, and the informed consumer. In our study of behavior and experience, it is the scientist who experiences the world and then formulates general facts or conclusions that describe it. The participant is the one who is studied in an experiment. In some cases, these roles are simple; in others, such as the study of human consciousness, the situation is more complex because we must use our own consciousness to study consciousness. Finally, the informed consumer provides the perspective, the concerns for value, and the relationship of science and its facts to other aspects of human life. By the end of this book, we want you to understand the perspective experienced in each of these roles.

Science as a Way of Knowing

All of us at times fall into the trap of viewing science as the best way, or even the only way, to study behavior and experience. If you find this happening to you, beware! Although our culture emphasizes science as an important way of knowing, it is not the only way, and like all ways of knowing, it has certain limitations in its methods. To emphasize this, we offer science as merely one way of examining human processes. There are others; art, philosophy, religion, music, and literature are all fruitful ways or channels through which we can express new ideas about human behavior and experience. Psychology has drawn on many of these traditions and will surely continue to do so.

Having a fruitful source of ideas, whether it is our literary, spiritual, scientific, or artistic traditions, is an important part of understanding behavior and experience. However, a second and perhaps even more important aspect of learning about psychological science is the process of determining whether a new idea is accurate. In contrast to other ways of knowing, science offers not only a fertile source of new ideas but also a powerful method for evaluating the ideas we have about reality. That is to say, science helps us to know if our ideas about the world are wrong.

For example, suppose someone tells you to buy a new exercise machine, or a well-known spiritual leader says that if you meditate twice a day you will be happier, or someone tells you that if you eat only a low-carbohydrate diet you will be healthier and live longer. These are instances in which you are confronted with ideas that may have an important impact on your life. Because some time and effort are involved in these examples, and given the track record of some exercise specialists, spiritual teachers, and fad diets, you may be hesitant to change your habits unless you know it will be worthwhile. So you are faced with the task of evaluating the suggestions and deciding whether these ideas are right for you. How do you become an informed consumer? How do you decide which of these changes you should make in your life?

In the remainder of this section, we examine several ways people decide whether to accept new ideas about the world. For a more detailed discussion of these ways of accepting belief, see the work of American philosopher Charles Peirce (Cohen & Nagel, 1934; Kerlinger, 1973, 1986). We are obviously biased and believe that the best way to respond to new ideas, especially for society at large, is to use science to evaluate these new ideas and then use the results of this research to help make a decision.

Tenacity

Peirce uses the term *tenacity* to refer to the acceptance of a belief based on the idea that "we have always known it to be this way." People at various times have said, "You use only 10% of your brain," or "You can't teach an old dog new tricks," or "We don't need science." These statements are presented over and over again and accepted as true, yet they are rarely examined and evaluated. This is an all-too-common method of accepting information. Television advertising and political campaigns use this technique when they present a single phrase or slogan repeatedly. Even an empty phrase repeated often enough can become accepted as true. As has been said, if you tell people something often enough, they will believe it.

As a way of learning about the world, there are two problems with this tenacity. First, the statement may be just an empty phrase, and its accuracy may never have been evaluated. The statement may gain wide acceptance through its familiarity alone. Second, tenacity offers no means for correcting erroneous ideas. That is, once a belief is widely accepted solely on the basis of tenacity, it is difficult to change. Social psychologists have shown that once a person accepts a belief without data to support it, the person often will make up a reason for accepting the belief as true. In fact, the person may even refuse to accept new information that contradicts this belief. In the case of the diet example, a decision to begin a certain diet simply because it is said to be beneficial would be acceptance based on tenacity. Accepting ideas about experience and behavior simply because they are familiar to us or widely believed by others is an extension of the childish behavior of the 3-year-old who copies the words and behaviors of others. For the child this is an efficient beginning for learning about the world, but for the rest of us it is limiting.

Authority

A second way we may accept a new idea is when an authority figure tells us it is so. Acceptance based on authority is simple because we only have to repeat and live by what we are told. In many cases, referring to an authority, especially in areas about which we know nothing, is useful and beneficial. When we were young, our parents often used the method of authority for directing our behavior. In the past, health care and education were based almost exclusively on authority. If a famous physician or educator said something was true, almost everyone believed it to be true. Even today, we often rely on the judgment of an authority when we consult physicians, psychologists, scientists, or consultants. Likewise, religious training often relies on the authority of religious leaders and elders for establishing correct religious procedures.

Although authority brings with it a stability that allows for consistency, it is not without problems. The major problem of accepting authority as having sole access to truth is that authority can be incorrect and thus send people in the wrong directions. For example, as long as everyone accepted the view that the Earth was the center of the universe, no one thought to study the orbit of the Earth and the other planets. Consequently, it is important to examine the basis of the authority's claims. Are these claims based on opinion, tradition, revelation, or direct experience? How valid are the sources of this information? In the meditation example, if you decided to meditate simply because a well-known spiritual leader advised it, you would be basing your decision solely on the authority of this person.

Reason

Reason and logic are the basic methods of philosophy. Reason often takes the form of a logical syllogism such as "All men can't count; Dick is a man; therefore, Dick can't count." We all use reason every day as we try to solve problems and understand relationships. As useful as it is to be reasonable, however, reason alone will not always produce the appropriate answer. Why?

One potential problem in the reasoned approach is that our original assumption must be correct. If the original assumption is incorrect or at odds with the world in which we live, then logic cannot help us. For example, the syllogism that concluded that Dick can't count is logically valid even though it is based on the absurd premise that all men can't count. Much of traditional economic theory was based on the assumption that a given person would always put his or her own interests first, the so-called "rational man." However, recent research in social psychology and behavioral economics presents a more complicated picture in which humans do not behave rationally when dealing with money or helping others. That is, they reason psychologically rather than logically from a rational basis. The good news is that we will often help others when there is no apparent gain for ourselves. If you ask someone to help you move a box, they will usually do it although they obtain no real gain for their time. Thus, the weakness of using reason alone is that we have no way to determine the accuracy of our assumptions. We can have situations in which our logic is impeccable, but because our original assumption is inaccurate, the conclusion is silly.

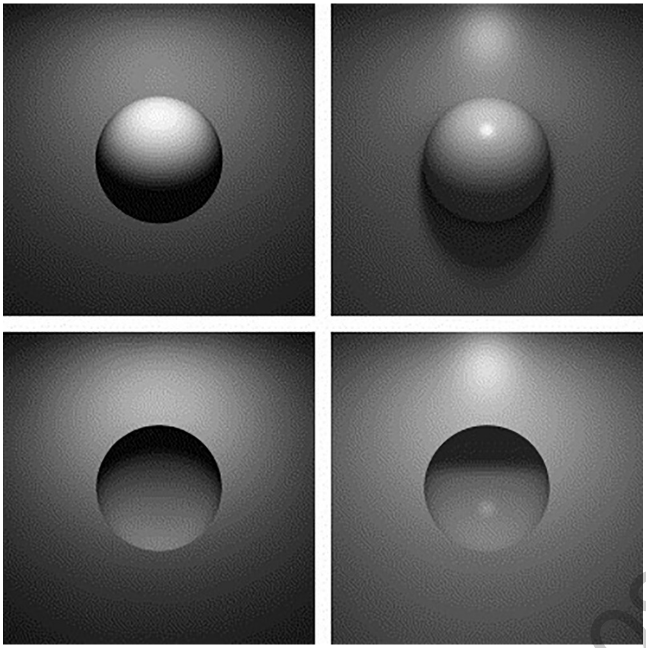
Common Sense

Common sense may offer an improvement over acceptance based on tenacity, authority, or reason because it appeals to direct experience. Common sense is based on our own past experiences and our perceptions of the world. However, our experiences and perceptions of the world may be quite limited. For example, you may think that children who did not play in mud and dirt would have more health problems than those who did not. However, research has shown the opposite to be true (Stein et al., 2016). Playing in the dirt influences your immune system, which reduces the chances of having asthma and allergies. Likewise, our common sense tells us that the quicker we can intervene with someone who experienced trauma, the better the results will be. Although such procedures are well received by most workers, the overall evidence suggests that it is not effective in reducing future PTSD (Rose, Bisson, Churchill, & Wessely, 2002). Thus, many international organizations such as the Red Cross no longer require debriefing for all workers. However, they offer services for those who seek them.

Another part of our common sense may be based on our human origins. For example, if you see a shadow on a circle near the top, you will see the circle as concave (going away from you), whereas if it is on the bottom, it is seen as convex (coming toward you). This is how we experience shadows in the real world. This is shown in Figure 1.1. Turn the page upside down to see the orientation change.

There can also be a bias in the way we think. Piattelli-Palmarini (1994) suggests that just as there are optical illusions, there are also cognitive illusions that lead us to be certain but wrong in our answers. Furthermore, research in social psychology

FIGURE 1.1 ● The Shadow on the Circle Determines Whether it is Seen as Convex or Concave.



Source: Liu & Todd (2004)

has shown that we make different psychological attributions depending on whether we observe or participate in a given situation. If we are asked to explain why someone made a bad grade, we tend to make internal attributions, such as "She's not a good student" or "He isn't smart." However, if we received a bad grade on a test, we would tend to make external attributions, such as "I had three tests that day" or "The test was unfair."

Whereas common sense may help us deal with the routine aspects of daily life, it may also form a wall and prevent us from understanding new areas. This can be a problem, particularly when we enter realms outside our everyday experience. For example, people considered Albert Einstein's suggestion that time was relative and could be different for different people to be contrary to common sense.

Likewise, it was considered contrary to common sense when Sigmund Freud suggested that we did not always know our own motivations or when B. F. Skinner suggested that the concept of free will was inapplicable to the behavior of most individuals. Bandura (1982) argues that many of what we consider significant events in our lives (whom we marry, where we go to college, where we work, and so on) are often the results of brief chance encounters and clearly not under our control.

We might also assume that the stable process is the healthier one. However, research using nonlinear (chaos) analysis has suggested, for example, that the patterns of a healthy heart are erratic and those of a pathological heart can be regular (Goldberger & Rigney, 1991). Likewise, those with diabetes show less complex blood sugar readings than those without (Costa, Henriques, Munshi, Segal, & Goldberger, 2014). Although common sense may make us think that health is associated with regularity, research suggests this is not always the case.

Science

We end our discussion of the ways people accept new ideas by discussing science. Philosopher of science Alfred North Whitehead (1925) suggested that there are two methods for what he called the "purification of ideas" and that these methods are combined in the scientific method. An idea is evaluated or corrected through (1) dispassionately observing by means of our bodily senses (for example, vision, hearing, and touch) and (2) using reason to compare various theoretical conceptualizations based on experience.

The first method is a direct extension of the commonsense approach just described. Unlike a given person's common sense, however, science is open to *anyone's* direct experience. Presumably, any person with normal sensory capacities could verify any observation made by a scientist. To aid people in repeating the observations of others, some scientists (see Bridgman, 1927) have emphasized the importance of *operational definitions* in research. As you will see in Chapter 2, operational definitions direct *how* observations are to be made and what is to be observed and measured.

The second method is a direct application of the principles of logic. In this case, however, logic is combined with experience to rule out any assumptions that do not accurately reflect the scientific experiment. This blend of direct sensory experience and reason gives science a self-corrective nature that is not found in other ways of accepting ideas about the world. One important technique is replication, in which a procedure is repeated under similar conditions. For example, if an experiment is found to give similar results in different labs and even in different parts of the world, this lends support to the conclusions. Thus, you never want to take a single study as completely defining a result (Shrout & Rodgers, 2018).

This means that scientific conclusions are never taken as final but are always open to reinterpretation as new evidence becomes available. In other words, the method of science includes a feedback component by which conclusions about the world can be refined over time. It is the refining of ideas through both experimentation and reason that allows science to be a fruitful method for knowing about the world.

Historically, the methods of modern science can be traced to the 17th century. The work of Sir Isaac Newton generally is credited as representing the beginning of modern science that greatly influenced Europe at that time (Feingold & Svorenčík, 2020). Newton suggested four rules: the law of parsimony, the assumption that there exists a unity to the physical universe in which we live, the possibility of generalizing from experiments, and the acceptance of empirical data over opinion. In many ways, these rules are as applicable today as they were when they were written more than 300 years ago.

Alan Kazdin (2003b) begins his discussion of the key characteristics of psychological science with parsimony, or the idea that we should consider simpler explanations over complicated ones. A second key characteristic is that we consider rival alternative explanations of our findings. Throughout this book, we consider a variety of ways in which environmental or other factors may have influenced research findings. Third, replication is central to doing good science. If a scientific finding reflects the world in which we live, we would expect, as Newton suggested, that the results from similar experiments performed in different labs around the world would be similar. A fourth characteristic of science is that we consider our results with great care and apply appropriate logic to the situation. Overall, the scientific approach helps us to draw valid inferences from our research in describing the world.

Pseudoscience and Superstition

Our goals in this book are to help you think critically as a scientist and to be an informed consumer. We do this in the context of science. We emphasize ways to evaluate information and come to valid conclusions. However, as humans, we have a long history of relying on magic and superstition as ways to guide our decisions. In fact, in the next section we will tell you about a king some 2,500 years ago who based his war plans on what an oracle told him would happen in the future. Even today some hotels do not have a 13th floor, since this is seen by some to be unlucky. Many individuals and sports teams have rituals that they think will help them win. Some people carry lucky charms or wear certain clothes to important meetings because they think this will help them succeed. We are told to blow out all the candles on our birthday cakes and not to walk under ladders. Even our newspapers have daily horoscopes to tell us what types of activities to engage in that day.

Why we give extra significance to a common event like seeing a black cat is an interesting question. Most likely it is part of our long evolutionary history. We may emotionally believe that something is true and hate the thought of giving up that particular idea or belief. This is made even more complicated by the way that, as research shows, when we believe something to be true, we tend to look only for supporting evidence and to dismiss any contradiction to our belief as an exception. We love to share information with each other, often without even thinking (Wardle, 2019). We are also willing to spread misinformation, especially if it starts with a seed of truth (O'Connar & Weatherall, 2019). Without a method to test our ideas, we will never know the validity of our conclusions.

We also want to warn you that a variety of individuals make claims in the name of science that are not actually based on rigorous scientific procedures. Often these are individuals who want to sell you something. You see this every day in terms of certain video commercials as well as claims on the Internet. Some of these claims have made their way into popular books and even have been reported as true in the mass media. For example, the idea that you can learn while you sleep was a popular one during parts of the 20th century. This idea found its way into a variety of movies and novels and was even spoofed on an episode of *The Simpsons*. *The Simpsons* had it correct, since various scientific research studies have not been able to find evidence supporting the claim of learning during sleep. However, even today you can go on the Web and buy materials that claim to help you learn languages, study for exams, and improve a variety of abilities while you sleep. All of these items are supposed to be based on scientific research, or at least that is what the websites claim.

This phenomenon of presenting information as if it is based on science when it is not is referred to as *pseudoscience*. In this sense, *pseudo* means false. Thus, pseudoscience is false science. Often claims of pseudoscience are based on testimonials that present only one side and have not been evaluated by others studying similar phenomena using valid scientific methods. For this reason, scientists pay particular attention to research that has been evaluated by other scientists before it is published. This process is called *peer review,* and journals that follow this procedure are called *peer-reviewed journals*. One characteristic of pseudoscience is that it is not found in peer-reviewed journals. As we continue throughout the book, we will help you to identify pseudoscience and to develop some of the skills of critical thinking to evaluate its claims. Overall, we want to help you think like a psychological scientist.

HELPFUL HINTS AND EXERCISES

IDENTIFYING PSEUDOSCIENCE

As you read media reports about new scientific findings, you can ask yourself such questions as:

- Where did the original information some from (e.g., was it just based on someone's opinion, even if a famous person)?
- Was the information published in a scientific journal?
- Was the journal peer-reviewed?

You can also ask questions in terms of is this the best group of participants to study, could other factors be involved, and how would you have conducted a better study?

In the rest of this book, you will also learn other questions to ask in terms of factors that can make findings invalid.

Just because something is not based on science does not mean that we should not consider it. Many of us love to read science fiction and other types of fantasy literature. Such writing makes us consider possibilities and other ways of thinking about our world. As we will see in this book, scientists are always considering alternative explanations and sometimes ideas that are crazy. However, considering that something could be true does not mean that it has scientific support. Thus, we need a means for testing our ideas. We particularly need ways of knowing if we are wrong, which is one of the important aspects of science we will present in this book.

✓ CONCEPT CHECK 1.1

As you read your morning newsfeed, you see that a famous scientist has said that cancer will be cured in the next year. If you believe this statement, is your belief based on scientific reasoning?

The Scientific Approach

In this chapter we examine the scientific approach through various informal illustrations, examples, and stories. In Chapter 2 we discuss more formally the methods of natural observation and experimentation. Among other things, we emphasize that a major characteristic of science is a reliance on information that is *verifiable through experience*. That is, it must be possible for different people in different places and at different times using a similar method to produce the same results.

Once you know the methods of science and have used them in a variety of situations, you will be in a position to evaluate science as a method of knowing about the world that includes the behavior and experience of yourself and others. More important, you will be able to become a psychological scientist. First, however, let's begin to understand what science is by looking at three early efforts to understand the world. Although these efforts attempted to be systematic, today we would call them pre-experimental or quasi-experimental. That is, in none of these procedures was an actual experiment conducted. Our purpose is to focus on the way the problem was solved—particularly the efforts to be systematic—and what errors were made. You might also recall instances from your own life when you attempted to solve problems in similar ways.

Early Approaches

The first example concerns extrasensory perception (ESP). According to the historian Herodotus (trans. 1942), Croesus, who was king of Lydia from 560 to 546 BC, became concerned with the increasing power of the Persian army because Lydia was located between Persia and Greece. King Croesus knew the Persian army to be strong and therefore did not want to attack unless it was certain he would win. He needed someone who could foretell the future. As an enlightened consumer, Croesus wanted to know that the information he received was true. To determine this, he constructed a test of the oracles who were said to foretell the future best. Croesus's assistants were to go out into Greece and Libya where famous oracles lived. The assistants were to visit each oracle on a specific day and at a specific time and ask, "What is the king doing at this moment?" Because the king told no one what he was actually doing at that moment, he reasoned that only a true oracle, one capable of extrasensory perception, could answer correctly. The assistants all returned to the king and reported their answers. Only one oracle, the oracle at Delphi, gave the correct answer. In fact, according to Herodotus, this oracle answered the question before it was even asked. (The king had been making lamb stew.)

Although the king had the beginnings of a scientific approach to experience, he had not learned the role of chance in science or the nature of the language of science. Trusting his research, the king honored the oracle and asked the important political question of whether he should go to battle against the Persian army. The oracle replied that in such a contest a mighty empire would be destroyed. This was all the king needed to assemble his armies and attack. When the battle was over, a mighty empire had been destroyed as the oracle had predicted; the problem for the king was that the empire destroyed was his own, and he was taken prisoner.

The king, like many others after him, failed to realize that a single correct answer may not be sufficient to allow us to draw valid conclusions. Likewise, the king did not realize that the language of prediction must be precise in directing our attention toward possible outcomes. Let's look at another attempt to understand the world, this one dating back almost 2,000 years.

In the second century AD, Galen, a well-known physician, described a woman who complained of insomnia (Mesulam & Perry, 1972). The problem was to determine the factors that led to the insomnia. Galen first decided that the problem was not mainly physical. Following this determination, he began to notice the woman's condition during his examinations. It happened that during one examination, a person returning from the theater mentioned the name of a certain dancer named Pylades. At this point Galen observed an increase in the woman's pulse rate, along with a change in her facial color and expression. What did Galen do next? To answer his questions about what was affecting the woman, he began to experiment. In his own words,

> The next day, I told one of my following that when I went to visit the woman he was to arrive a little later and mention that Morphus was dancing that day. When this was done the patient's pulse was in no way changed. And likewise, on the following day, while I was attending her, the name of the third dancer was mentioned, and in like fashion the pulse was hardly affected at all. I investigated the matter for a fourth time in the evening. Studying the pulse and seeing that it was excited and irregular when mention was made that Pylades was dancing, I concluded that the lady was in love with Pylades, and in the days following, this conclusion was confirmed exactly. (Galen, trans. 1827)

Galen went past observation and began to ask, "I wonder what will happen if I do this?" He performed what we now would call a *single-case experiment* (see Chapter 13). Notice that Galen checked to determine that it was not the name of just any dancer that produced a change in pulse rate or even just a man's name. He sought to discover what factors brought on an irregular pulse by examining a number of alternatives. From this investigation, he concluded that only the name of one particular man, repeated on different occasions, produced the effect.

Consider a story that took place in Europe about 150 years ago. A physician named Ignaz Semmelweis faced a serious problem when he noticed that previously healthy women who had just given birth to healthy children were dying. The women died of a condition that included fever, chills, and seizures. Although numerous theories were offered—which attributed the deaths to such causes as bad diet, unhealthy water, and even the smell of certain flowers—Semmelweis knew that other women in the same hospital who ate the same food, drank the same water, and smelled the same flowers did not die. Consequently, he reasoned, it was not the food, water, or flowers that caused the deaths. Yet the fact remained that women who had just given birth died of the mysterious condition.

Semmelweis became aware of a crucial clue when he learned that an assistant who had accidentally cut his hand during an autopsy later died after displaying the same symptoms as the mothers. What was the connection between the death of the assistant and the deaths of the mothers? Was there any connection at all? Semmelweis reasoned that the autopsy laboratory where the assistant had worked might be the cause of the mysterious deaths. To evaluate this notion, he traveled to other hospitals and recorded what physicians did just before delivering babies. From these observations, he learned that when the physicians who delivered the babies came directly from a pathology lecture in which diseased tissues were handled or from performing an autopsy, the death rate was highest. Semmelweis suggested that it was the physicians who were transferring the diseases from the pathological tissue to the healthy mothers, just as the assistant had accidentally infected himself with the knife cut.

The physicians of the day were outraged at the suggestion that they were the cause of the women's deaths. But Semmelweis found further evidence by demonstrating that in hospitals where some births were assisted by midwives rather than physicians, the mothers assisted by midwives survived at a much higher rate. In a rather striking, though not totally controlled, experiment, Semmelweis is said to have placed himself at the door to the delivery ward and forced all physicians who entered to wash their hands first. The number of deaths decreased dramatically. Although not everyone accepted Semmelweis's findings, these data spoke for themselves, and modern medical practice has been shaped by this event (Glasser, 1976).

These three stories—of Croesus, Galen, and Semmelweis—show the beginnings of a scientific approach to human problems. Croesus faced the problem of how to evaluate information offered by various oracles. To do this, he devised a test: an evaluation of the sources to decide which one he would use to direct his behavior. But we do not consult oracles today, you might argue. True, but we do develop far-reaching social programs and treatments. For example, is *Sesame Street* a useful means for teaching disadvantaged children? In psychotherapy, would you gain more by just talking with your favorite professor than by going to a clinical psychologist? If you want to avoid heart attacks, should you change your diet, run 4 miles a day, meditate, or just do nothing? To answer these questions, we, like Croesus, need to perform evaluation research, and the methods of science offer us one approach.

Croesus's experience also reminds us of two potential pitfalls to knowing about the world. These are the roles of chance in the events we observe and the need for unambiguous statements. Croesus's single question to the oracle might have been answered correctly by a lucky guess. To decrease the chance of a lucky guess, Croesus might have asked the oracles several questions. In essence, such a safeguard would have constituted a replication (repeating a procedure under similar conditions) of his experiment. Today, simple replication of a new finding is a powerful way to decrease the likelihood that it is a fluke. Croesus also surely recognized, in retrospect, that he had misinterpreted the oracle's ambiguous answer about the battle. To minimize the chances of ambiguities, scientists carefully and systematically define their words as precisely as possible.

Galen wanted to learn why a particular woman did not sleep. To do this, he first observed the woman; that is, he just spent some time with her and noticed what happened. Once he realized that the woman's heart reacted to a dancer's name, he began to test his observations. At this point, Galen moved to a more sophisticated process than Croesus's simple consultation with the oracle. Galen sought evidence of a causal relationship by examining the woman directly. In doing this, he anticipated a major shift in how we seek to know about the world.

Croesus, by contrast, sought his answers from authority. The authorities of his time were the gods, who spoke through the oracles. A more empirical approach would have been for Croesus to develop a system of spies and scouts to provide information about the Persians' strength based on direct experience. Galen went beyond the ungrounded opinions or guesses of available authorities and relied on his direct experience. Galen's appeal to direct experience reflects an alternative approach to knowing and in a real way reflects an alternative level of consciousness, toward which modern science continues to evolve. Indeed, for several generations now, science has been rebuilding our knowledge and understanding of the world on the basis of direct experience.

The choice of basing our actions on evidence from experience or on unfounded opinion probably has been with us in some form for thousands of years and currently confronts each of us countless times every day. Yet basing one's actions on direct experience of the world sometimes appears time-consuming and more difficult than simply consulting some expert or acting on a hunch. In the long run, because our actions invariably take place in the world, the wiser alternative is to base actions on experiential knowledge of the real situation. Mere opinions of others provide a convenient answer, but in the long run, as Croesus found out, reality prevails.

In the third story, Semmelweis had a different problem to solve. To determine why some previously healthy women were dying after giving birth, he examined a number of factors. *He observed the patients with a definite purpose in mind.* He asked, "How are these women being treated that is different from the way other patients are treated?" That is, he sought to determine what was unique to these patients. Was it diet? Flowers? Doctors?

Then an unexpected event occurred; an autopsy assistant died of the same symptoms. This gave him the clue that led to the solution of the problem. This example shows that science is not only a method that scientists engage in to solve problems and learn about the world but also a procedure that allows for unexpected events to play a part, whether in the form of accident or human error. One of the rich aspects of science includes unpredictability, serendipity, and what is often called luck. However, luck can work either way, as Croesus found out.

Notice how Semmelweis used logic and simple common sense to design his tests so that his observations would lead to a better understanding of the problem. Semmelweis was trying to understand what was related to the mothers' deaths. For example, because the laboratory assistant died with similar symptoms, Semmelweis reasoned that perhaps he died from the same cause. Semmelweis's observation that more deaths occurred when doctors delivered babies after handling diseased tissue led him to reason that perhaps the cause was somehow related to the diseased tissue. In other cases he tried to rule out *factors that were not responsible* for the deaths. For instance, because patients who did not die ate the same food and drank the same water as those who died, Semmelweis reasoned that the food and water were not possible causes and could be eliminated from further consideration.

There was nothing particularly extraordinary about any of these conclusions. In fact, they reflect the simple common sense that we all possess. What was exceptional was that Semmelweis saw relationships that others overlooked. When simple common sense and reason are combined with direct sensory experience, a desire to understand reality, and the courage to accept new facts, science emerges as a powerful means of asking and answering questions about reality.

Our final comment on Semmelweis's work is that his desire to know and understand led to the development of a series of investigations that approached the problem from several directions. Once he had gained the clue from the death of the assistant, he set out to answer his question through a series of observations. First, he observed that the new mothers in his hospital were not treated differently from other women; that is, he observed that they were not given different food or flowers or treated by different doctors. Second, he allowed himself to prefer a possible connection between the death of an assistant and the deaths of the mothers. Third, he went to other hospitals to determine whether his ideas or hypotheses were limited to his hospital or whether they were true for other hospitals as well. Fourth, he concluded that the problem was that the physicians handled diseased tissue and then delivered babies without washing their hands, even though this conclusion was unpopular. Fifth, he performed an indirect test of his theory by comparing the difference in death rates of women assisted by physicians who had handled diseased tissue and those assisted by midwives who had not. Sixth, he began a direct test of his theory by insisting that physicians wash their hands as they came into the delivery ward. The power of Semmelweis's procedure was not in any one test of his ideas because it is almost impossible for any single procedure to answer all questions. Semmelweis was successful because he began with a problem and followed it through to the end by means of a series of observations.

Before you think that what Semmelweis did was a historical event and has nothing to do with our time, you might want to read an article published in the *New England Journal of Medicine* in 1998. The story began in an intensive care unit (ICU) in New England in which newborn babies were getting sick from an unusual form of yeast infection. When experts were called in to investigate, they began to suspect that the yeast infection came from dogs. Of course, there are no dogs in a newborn ICU, so how did the yeast infection get to the unit and, once there, how did it spread from child to child? The experts' best guess was that it got to the unit from one or more pet owners. Now, how do you think it spread? You got it!

The nurses and doctors on the unit spread the infection when they did not wash their hands thoroughly. There is one additional piece of information you may want to know, especially if you are planning to do research in this type of situation. When asked, two thirds of the professionals said that they scrubbed between patients 100% of the time. However, when the experts watched the staff at work, they discovered that these professionals washed their hands between handling newborns only about one third of the time. As we will see later in this book, verbal reports and observed behaviors may not always go together. Thus, scientific approaches often use multiple measures for gaining more complete information concerning a topic.

By the way, in a later study, different signs were placed above the sanitary gel dispensers (Grant & Hofmann, 2011). One said, "Hand hygiene prevents you from catching diseases," and the other said, "Hand hygiene prevents patients from catching diseases." Results showed that changing a single word in messages motivated meaningful changes in behavior: The hand hygiene of health care professionals increased significantly when they were reminded of the implications for patients but not when they were reminded of the implications for themselves. Surprisingly, lack of hand washing compliance is also seen in areas of high infection rates worldwide (Alshammari, Reynolds, Verhougstraete, & O'Rourke, 2018).

Overview

Let's pause for a moment and review what we have covered so far. In the preceding sections, we described the scientific approach to problem solving. We began with children learning about the world by interacting with it. In particular, we suggested that such interaction leads to a notion of science as a way of knowing through experience. We characterized science as a process for drawing conclusions that describe the world. We discussed science not as a sacred entity to be worshipped but as a simple extension of the way all of us—not just children—learn about the world.

We then gave an overview of science by relating the stories of Croesus, Galen, and Semmelweis. We pointed out the manner in which aspects of these stories anticipated important issues in present-day science. These correspondences included the need for unambiguous statements, the need for discovering what does not affect the behavior as well as what does affect the behavior, and the importance of a series of tests or research studies for developing a solution to the problem. Science combines experience, reason, and the desire to answer questions about our conceptions of reality. To accomplish this goal, scientists create theories to help explain their experiences. As we will see later, evaluating ideas and theories is also a large part of what science is all about. Furthermore, the approach to solving problems that we call science is not new but represents a way of solving problems that we all use to some extent every day.

✓ CONCEPT CHECK 1.2

"The major reason why Semmelweis's approach was superior to that of Croesus is that we know ESP not to be real—no one can foretell the future." Do you agree?

Studying Behavior and Experience

In the preceding discussion, we emphasized that scientists view themselves as using sensory experience to evaluate their ideas concerning the world. This appeal to experience and experimentation as opposed to authority is crucial for two reasons. First, it represents a genuine attempt to pause and observe the external world. Second, reliance on sensory experience means that not only scientists but also any other person with normal sensory capacities and training can observe the particular behavior under study. The ability of anyone to use his or her own senses to verify the raw data of any scientist provides a strong and essential safeguard that our observations of the world remain as free as possible of the unintended or intended biases of any particular scientist. The process of relying on sensory experience to verify our ideas about reality is called empiricism. **Empiricism** has been an important approach in the history of psychology. Of course, pure empiricism can lead us to erroneous conclusions, but combined with the scientific method, it has been a productive approach for psychology.

It also should be pointed out that in our study of behavior and experience, we study our topics on a variety of levels. At times, we discuss at a cognitive level, as when we consider how people think or solve certain problems. At other times, we may move to the physiological level and consider how a particular neurotransmitter is involved in memory, emotion, or schizophrenia. At still other times, we may examine behavior from an extremely broad perspective as we ask how a group of people (society or culture) behaves and experiences a particular event, such as an earthquake or a nuclear reactor accident. As we point out throughout the book, answering a particular research question may lead to one type of research approach rather than another. It is part of your job to ask which type of research approach will give you the most useful information for the question you are asking. Helping you understand how to choose an appropriate research approach is part of the goal of this book.

Throughout the book we also want to help you understand what science will not do for you. For example, it will not give you the final answers to all questions of importance to humans. Science will give you a method for understanding the reality in which we live. It is also important to understand that the answers we receive from science depend on the perspective from which they are asked; there exist various levels of analysis. Although we assume and have assumed for at least the past 100 years that the fundamental processes on each level—cultural, cognitive, emotional, physiological, molecular, genetic—can be explained scientifically, it is a mistake to assume that information from one level can explain completely the worlds of behavior and experience on another level.

We are dealing with two worlds in our study of behavior and experience. One is the objective, physical world in which anyone can observe appearance and *behavior*. The other is the subjective world of personal psychological *experience*, which is completely private. Science—whether it is biology, physics, chemistry, psychology, sociology, or zoology—focuses on the objective world of appearances and behavior. In the behavior of people, molecules, internal organs, or electrons, what scientists observe and measure are observable objects in the real world. Psychology has continued this tradition, and many studies that you perform and read about consist of the observation and measurement of behavior. However, because the subject matter of psychology focuses in part on humans, psychology is faced with a greater challenge. Not only can we observe humans behaving, but we also can ask them about their inner experiences: their thoughts, feelings, and sensations. Furthermore, because we share the same array of psychological processes, we also can observe our own behavior and experiences. This is described further in the box, Four Ways of Studying Psychological Processes.

FOUR WAYS OF STUDYING PSYCHOLOGICAL PROCESSES

This diversity of understanding behavior and experience offers us a challenge. The challenge is to explore and understand scientifically the behaviors as well as the experiences of ourselves and others. E. F. Schumacher (1977) emphasized this diversity when he pointed out that using experience and behavior to study psychological processes in ourselves and others leads to four possible fields of knowledge. For our purposes, we consider these as four possible ways of studying psychological processes. They are summarized in Table 1.1.

TABLE 1.1 ● Ways of Studying Psychological Processes

		Process Under Study	
		Inner Experience	Outer Appearance (Behavior)
Focus of Study	"I" (self)	1	3
	"You" (others)	2	4

In Table 1.1 cell 1 represents that with which we are all immediately acquainted. This is our private experience of being who we are and living in our world. It is a largely unshared, subjective experience open to no one but ourselves. However, as we suggest later, it may be possible to explore this space scientifically and systematically. For example, Irwin and Whitehead (1991) asked whether the methods of psychophysics could be applied to the experience of pain to give us a more objective measurement of an individual's subjective experience.

Cell 2 represents the inner world of all beings other than ourselves. Of course, we have no direct experience of the subjective world of others. But we can ask such intriguing yet unanswerable questions as, "What does it feel like to be you?" "Do my cats experience the world as I do?" "Do you and I both see a red apple as the same color?" Some researchers in psychology try to understand how other people perceive the world and how those people might represent their perceptions internally (compare Shepard, 1983; Simon, 1978). Such a researcher is interested in the experience of other people as they deal with their world cognitively.

For example, Simon and others have sought to describe how expert and novice chess players decide on making a particular move. They found that a chess expert does not plan ahead any further than a novice does. This is only one of the many observations cognitive scientists have made as they try to understand how we experience and process the world around us. In seeking to understand how someone experiences the world, clinical and personality researchers have studied the types of associations that one has to different categories of knowledge, as well as the manner in which certain groups (for example, schizophrenics) experience the world. Physiological psychologists also consider questions from cell 2 when they ask whether the nervous system of a cat produces a view of reality different from that produced by the nervous system of a human.

Cell 3 represents our outward behavior: "How do I appear in the eyes of others?" Some aspects of psychology, such as psychotherapy, may focus on helping people learn about how others perceive them. We could also ask, "How am I represented in the sensory system of nonhuman organisms?"

Cell 4 represents the behaviors of other people or animals that anyone can directly observe, measure, or objectify. Included are physiological responses such as heart rate or electroencephalogram (EEG) measures or brain mapping (fMRI), as well as self-report responses, as in a memory experiment. This cell has been the traditional domain of psychological research throughout the 20th century.

We can use the four ways of studying psychological processes presented in Table 1.1 to ask how we might conduct a science of behavior and experience. In cell 1 we ask, "How do I study my own inner experience?" In cell 2 we ask, "How do I study your inner experience?" In cell 3 we ask, "How do I study my own behavior in terms of how others see me?" In cell 4, the one we focus on most in this book, we ask, "How do I study your behavior?"

Behavior: A Road Into the Subjective Experience of Research Participants

Sometimes we want to ask questions that are difficult for participants in scientific experiments to answer directly. For example, we cannot just ask an animal (other than humans) directly whether it is color-blind or what particular color it sees. However, we can create situations in which an animal would display different behavior in the presence or absence of a particular color. We discuss this and other approaches later in this section. There are also cognitive, emotional, and out-of-awareness processes that are difficult to identify even in humans. For example, how can you explain an image you have in your head? How do we know when someone is dreaming?

At times, we are able to answer such questions through the use of marker variables. A **marker variable** is an event that occurs along with the process we are studying. For example, Aserinsky and Kleitman (1953) discovered that dreaming was often accompanied by rapid movements of the eyes. If you wake a person when they are in rapid eye movement (REM) sleep, they are more likely to report they are dreaming than if you wake them in other stages of sleep. In neuropsychology research we may want to know whether people can perceive certain forms or patterns after damage to a particular part of the brain that leaves them without personal awareness of what they have seen. For example, such people may be able to recognize that they have seen a face but not that the face was of a person they had known. It is possible to use psychophysiological markers in such cases, particularly electrodermal activity, to demonstrate that a person with brain damage is physiologically able even with the absence of conscious recognition to differentiate between faces from his or her past and unknown faces.

There is even a phenomenon called *blindsight,* in which people who are normally blind and say they see nothing can correctly identify the locations of particular patterns in experimental situations (Celeghin et al., 2018; de Gelder, 2010). Surprising as it may seem, Kolb and Braum (1995) used a similar blindsight procedure with normal-sighted people to suggest that information can guide behavior without entering subjective awareness. If this is true, then this suggests that we can be influenced by experiences but not be aware of them, as well as be aware of how experiences influence our decisions. But how can we study this?

At Oxford University in England, Navindra Persaud, Peter McLeod, and Alan Cowey (2007) had been studying an individual with blindsight. They asked him to make a bet on whether he had seen a stimulus or not. Thus, he had to perform two tasks. The first was to say whether a pattern on the computer screen was present or not. The second was to bet on how certain he was. What these researchers discovered was even though he was correct about the presence of a stimulus 70% of the time, he was correct in his bet only 50% of the time. This suggested that although he could process the stimuli, he was not aware of them or otherwise he would have been more correct in his bets.

To follow up on this, these researchers asked college students to play a card game called the Iowa gambling task. The goal of the game is to win as much money as possible. At the beginning of the game, the students were given $400. Then the participants picked a card from one of four stacks of cards. When they turned the card over, the card told them whether they had won or lost money. They did this 100 times. Before the participants turned a card over, they could place a bet of either $10 or $20. The participants could choose from any of the four stacks.

Unknown to them, two of the stacks of cards were set up to result in the participants winning on average, and the other two stacks to result in greater losses. A variety of studies showed that after about 40 cards, participants began to choose mainly from the two stacks that resulted in positive outcomes. However, it was only after about 70 trials that the participants begin to optimize their betting. This suggested to these researchers that unconscious learning comes before conscious awareness, and that betting can be a way to measure the beginning of awareness in a task (Lustig & Haider, 2019; Persaud, McLeod, & Cowey, 2007).

What if we want to study what appear to be nontraditional claims? For example, Cytowic (2018) was interested in studying the process of *synesthesia:* perceiving with a different sense than would usually be the case. He studied people who said they saw colors when music was played or perceived weight when tasting an intense flavor. How you go about researching difficult processes may be different in each case, but it will still rely on inference, or drawing conclusions based on theoretical and experimental situations.

Assume that you want to know whether an animal sees colors. You cannot directly experience what the animal experiences in the presence of color; you must find a method for asking the animal. You must accept that you can never scientifically answer the question directly, but you can answer it indirectly. That is, you begin by reasoning how the animal's behavior would be different in the presence and in the absence of color. You can create a situation in which being able to experience color is necessary for the animal to solve a certain problem.

One way this problem has been approached is through the use of a conditioning paradigm using a Skinner box or similar apparatus. The Skinner box was designed for use with small animals such as rats or pigeons. It contains a lever on one wall near a food dish. Most Skinner boxes are electronically automated so that a single press or a certain number of presses on the lever cause food to be dropped into the dish. For example, you could program the food-delivery system in such a manner that the animal would receive food each time the lever was pressed when a light of a particular color (for example, green) was on. When either a light of another color (for example, blue) or no light was on, the animal would not receive food for pressing the lever. How do you think the animal would respond if it could see colors? How would it respond if it could not see colors?

Imagine yourself as this animal, and you will see how we could use the animal's behavior to tell us whether it can distinguish green from blue. If, as an animal, you could see colors, then you would soon learn to press the lever only when the green light was on and not to press the lever when either the blue light or no light was on. What if you could not see colors? When would you press the lever? You would probably learn quickly not to press the lever when no light was on. But what about when there was a green or blue light on? If you could not see colors, you would never distinguish between the blue and the green light. Thus, you would probably guess whenever either light was on.

If we made systematic recordings of your lever pressing over a period of time, we would be able to infer whether you could distinguish a blue light from a green one. We might then set up other discrimination problems (red versus blue, yellow versus green, and so forth). From this information, we could infer whether you could see colors. In our approach to solving this problem, we could use two techniques for inferring the experience of our research participants.

The first would be to create a situation in which different experiences give rise to different behaviors. The second would be to imagine oneself as the research participant and role-play the responses to gain an experimental perspective. Of course, this second technique is difficult to use when the organism (for example, a bat or a dolphin) has a nervous system sensitive to entirely different stimuli. Also, we must avoid the mistake of assuming that other organisms (or even other humans) think, feel, and act in the same manner as we do.

The scientific study of experience rests on the assumption that a person's behavior is a manifestation of what he or she is experiencing. This assumption is made whether we are studying how animals see colors or how a baby distinguishes his or her parents from other adults. (How might you conduct this experiment?) If we are studying human emotions, we may assume that aggressive, attacking behaviors are related in some way to an experience of anger in our research participants.

In a similar way, if we are studying factors that facilitate the experience of joy in preschool children, we might take increased laughter as evidence that joyful experiences have taken place. In these cases, we use the behavior of our research participants (aggressive attacks and laughter) to study their subjective experiences (anger and joy). Seen in this light, *behavior and experience are two sides of the same coin*. In the case of anger, for example, the research participant's feeling of anger is the internal and unseen experiential aspect, and the research participant's aggressive attacks are the external and observable behavioral aspects. In a preceding section, we saw how Galen inferred his patient's love for Pylades when he observed her behavioral—in this case, physiological—reactions to hearing Pylades's name.

The use of objective behavior to study subjective experience is by no means new. We are all good at reading the psychological states of people from their behavior. If your professor walks into class with a scowl, you immediately assume that he or she is experiencing some sort of negative emotion. In science, however, we would go a step further and test our assumption.

For example, MacLeod, Mathews, and Tata (1986; see also MacLeod, Grafton, & Notebeart, 2019) were interested in whether anxious people tended to pick out either socially or physically threatening words (such as *failure* or *cancer*) when presented with both threatening and nonthreatening words. In more technical terms, was there a processing bias for encoding emotionally threatening information?

In an intriguing study, these researchers asked research participants to watch a computer screen on which both threatening and nonthreatening words were presented quickly. During the study, a dot would appear on the screen, and the research participants were instructed to press a button as fast as possible when they saw the dot. At times, the dot appeared at the location just occupied by a threatening word, and at other times in the location occupied by a nonthreatening word. It was reasoned that if the research participants' reaction times were shorter in the case of the threatening words than the nonthreatening words, then it could be inferred that the research participants were directing their gaze to the threatening words. That is, by measuring the reaction time from the appearance of the dot to the time the individual pressed the button, these researchers were able to infer the manner in which emotionally threatening words are processed. From the results of the study, the authors concluded that in comparison to nonanxious people, anxious people shift their attention toward emotionally threatening words.

It should be stressed that the use of objective behavior and appearances to study phenomena that cannot be observed directly, such as subjective experience, is not unique to psychology; it is a common feature of all sciences. For example, in physics we discuss the construct *gravity,* yet we never see gravity. Instead, we observe the movement of objects toward the earth and make inferences about gravity. Nor do we study magnetism directly, but we do observe the movements of iron filings, iron bars, charged particles, and various types of gauges, and we make inferences about magnetism.

In the same way, Semmelweis never saw a physician carrying germs into the delivery room; indeed, at that time germs could not even be seen. Yet using indirect evidence, Semmelweis was able to pinpoint the unobservable but very real cause of the mothers' deaths. A construct is a concept used in a particular theoretical manner that ties together a number of observations. In a nutshell, many major constructs of science—such as gravity, time, evolution, electricity, genetic transmission, learning, and even life itself—are discussed and examined indirectly through their manifestations in the physical world. Thus, in science we use the observation of physical events to make inferences about not only the physical world but also the unseen processes that underlie it.

✓ CONCEPT CHECK 1.3

You read in a newspaper that dogs can hear tones that humans cannot hear. How might you design an experiment to test this?

The People Who Perform Science

As we said at the beginning of the chapter, science is a human activity; only people perform it, and all people perform it in one form or another. It is important to remember that all people means *all* people. This reality is not portrayed accurately in the movies and on television. Typically, a white man in a white lab coat is shown, and often not a very interesting one at that. However, this is only part of the truth. Men and women of all races are scientists. Not only is it true today, but it also has always been the case. You may not know that in one of his last public speeches, Martin Luther King discussed the contribution of behavioral scientists in the civil rights movement (King, 1968).

Historically, every great culture has an important history of scientific achievements, whether it is in mathematics, physics, chemistry, or the social sciences. It is clear that all people of the world are represented in the history of science. However, some people are more visible than others, and sometimes we do not even see the people who are there. For example, you may have heard of the Ladd-Franklin theory of color vision and assumed it to be the work of Mr. Ladd and Mr. Franklin when in fact it was the work of Ms. Christine Ladd-Franklin in the early 1900s (Furumoto, 1992; Scarborough & Furumoto, 1987).

It is important to remember that women have been an integral part of psychology since its beginning as a science more than 100 years ago. In fact, even from the beginning, psychology has had a larger percentage of women than any other scientific discipline (Furumoto & Scarborough, 1986). Although we say this, we know that some students in our classes still do not believe that they can become psychological scientists because of their race or gender. We hope that those who believe this way will reconsider this assumption or at least gather data to test their hypothesis. To this end, there are websites directed at sharing information for minority students interested in a career in science (for example, http://www.sciencemag.org/careers/2015/04/minority-phd-students-where-do-they-go). There are also websites directed at women in science (for example, http://www.awis.org/).

Another meaning of the statement that science is a human activity is that we perform science with the support of and in communication with other scientists. Because a group of people shares our search and values, it is possible for scientists to work together as a larger body of searchers after truth. Sometimes scientists communicate with each other harmoniously, and new discoveries and formulations are the result of the work of many different people. At other times, the opposite is the case. As if in a race, the individual scientist, hoping to be the first to make a discovery, competes against other scientists and even against scientists as a group.

Remember, performing science is just one role or activity of scientists. Scientists are people, and as people they do what people everywhere do. They love and hate. They have good ideas, and they have bad ideas. They have thoughts and feelings. Some may want attention and fame, and others may want to be left alone. Scientists feel lonely and sad as well as happy and gregarious. Science is not a means for avoiding what is human within us, although some scientists try to use science in this way. Science is merely a systematic way of using experience to test our ideas about the world.

Although we will emphasize psychological science in this book, it is important to realize that many of you may choose occupations other than psychology. However, in many of these jobs understanding research will be a critical factor. For example, a toy company may want to know which toys children like best or an advertising agent may want to know which ads are most effective. Or you may be in a management position and need to know how to evaluate research or polling. All of these positions will require the information we are presenting in this book.

At times in our history, we have forgotten that scientists are human. We have thought of scientists as *objective,* without feeling, and oblivious to the human condition in general and to what is going on around them in particular. To be sure, there have been such instances, but in these cases it is the failure of the witness and not of the scientist or the research participant that is the basis of the problem. When we discuss ethics, we develop this idea further.

In the final analysis, the human sensitivity of scientists adds life and spirit to the scientific enterprise. Thus, what is unique about science is not the people who are scientists but their methods and the relationships between the people who practice science with these methods.

Key Terms

empiricism 17

marker variable 20

Concepts

1. Nature of science
   A. Roles of scientist, research participant, and informed consumer (witness)
2. Ways of accepting knowledge
   A. Tenacity
   B. Authority
   C. Reason
   D. Common sense
   E. Science
3. The scientific approach
   A. Verifiable through experience
4. Examples of early approaches to science
   A. Croesus and the establishment of criteria for evaluation
   B. Galen and the examination of alternative factors
   C. Semmelweis and the development of a series of studies
5. Studying behavior and experience
   A. Empiricism
   B. Studying experience through behavior
   C. Use of constructs
6. The nature of scientists
   A. Science is performed by people.
   B. All people perform some type of science.
   C. Science requires the support of and communication with others.

Summary

1. The purpose of this chapter is to introduce you to science as an approach to learning about ourselves and our world. As a problem-solving approach, science offers an important means of evaluating ideas.

2. People have used a variety of ways of accepting or rejecting ideas throughout history. Basing our approach on the work of Charles Peirce, we discussed the strengths and weaknesses of five of these (tenacity, authority, reason, common sense, and science). We also discussed pseudoscience and superstition.

3. Science is useful for evaluating ideas because it is self-corrective; that is, results from experiments offer a feedback mechanism to help clarify ideas.

4. For thousands of years, people have tried to understand their world better. We looked at three historical events to help clarify the scientific approach. The stories of Croesus, Galen, and Semmelweis pointed to the need for unambiguous statements, the need for testing factors that do and do not affect behavior, and the importance of a carefully designed series of observations. In sum, science combines experience, reason, and a desire to answer questions about reality.

5. Psychology is interested in the study of outer appearances (behavior) as well as inner experiences. Using a schema presented by Schumacher, we asked how we might study the behavior and experience of ourselves and others.

6. There are times when researchers want to know about the internal processing of an organism but either cannot or, as we discuss in later chapters, do not want to ask directly. Because we can assume that an organism's behavior is related to its experience, we can ask such questions as, "Does a cat see colors?" or "Can babies tell the difference between their parents and other adults?" In this manner, we use behavior to make inferences concerning the inner worlds of various organisms.

Review Questions

1. What are the ways of accepting or rejecting ideas, as suggested by Peirce?
2. What is pseudoscience?
3. How is science self-corrective?
4. What was progressive about Croesus's approach to the oracles?
5. How was Galen's approach scientific?
6. How did Semmelweis approach the problem of mothers dying soon after childbirth?
7. Give some examples of what would be included in a discussion of behavior and experience and how modern psychology approaches these areas.
8. Describe an experiment that would show whether an animal is color-blind.

Discussion Questions and Projects

Questions in this section are based on ideas presented in the text and require you to use what you have learned or to draw from your own experience. Some of the questions are designed to stimulate discussion; they have no single right answer.

1. While watching television, pick out five commercials and notice the way in which they try to convince you that their products are good. Which of Peirce's ways of knowing do they suggest? (*Hint:* Some of the suggestions may be nonverbal; for instance, the use of a famous person suggests knowledge through authority.)
2. Discuss the statement "Science is above all a human activity."
3. Discuss how the roles of scientist, research participant, and witness are exemplified and portrayed in our society. What different disciplines in a college or university are devoted to each of these roles?
4. It was suggested that science is a self-corrective process. What are the advantages and disadvantages of a self-corrective system?
5. Develop an experiment that would determine whether someone who was unable to speak could experience emotions.
6. Name some constructs that cannot be seen but are important in our everyday lives.

7. Discuss how you might study your own behavior. For example, how would you determine whether you practiced your guitar better in the morning or at night? How could you determine the effects of extra sleep on your school work and on your feelings in general? What could you do to get your professor to tell better jokes?

8. A researcher was looking for the reasons why people fail in college. To help answer this question, the researcher took a group of students who flunked out of college and a group of students who got good grades. Both groups were given a test of self-esteem. It was found that the group that flunked out had lower self-esteem than the group that did not. From this the researcher concluded that low self-esteem is one of the causes of failure in college. Comment on this conclusion.

✓ Answers to Concept Checks

1.1 Although it is possible that cancer could be cured in the next year, the basis of your acceptance was authority, not science. Accepting what a famous person says, whether he or she is a scientist, the president, or a 6-year-old child, is a reliance on authority, not science. Science requires that the information be evaluated through observation and reason according to an established procedure. As you will see, we could accept the statement that a particular type of cancer would be affected by a particular treatment as a hypothesis to be tested. After the test, we could make a scientific statement about the hypothesis.

1.2 One major reason why Semmelweis's approach was superior was that he sought to determine not only what *did* influence an event but also what *did not*. That is, he sought to determine which factors were not related to the deaths of the mothers as well as the one that was. Another important reason was that he used a series of observations to test his question. Whether ESP is real is in no way related to why Semmelweis's approach was more productive than that of Croesus.

1.3 An easy way to test this hypothesis is to observe the dog's reaction to the tones. If you want to determine which tones the dog can or cannot hear, then you can pair each tone with a cue for receiving food. You will need to make sure that the dog does not use any of its other senses to obtain the food. For example, you will not want the dog to be able to see you producing the tones.