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Approaches to Knowing

Almost every moment of our waking lives we are confronted with situations that require us to make choices. Shall we obey the strident summons of the morning alarm or turn off the infernal machine in favor of another forty winks? Should we go to the aid of a friend who is in the throes of an emotional "down" even though doing so means breaking other commitments we have made? Should we buy the latest recording of our favorite musical group even though it precipitates a temporary financial crisis? How many times a day do questions like this race through our thoughts? How often are we required to assess situations, make decisions, predict actions, and draw conclusions? Some questions lead to emotional issues. How old is the earth? When and how did humans evolve? What curriculum should be taught in public school? What is the basis for observed racial differences?

Whether we are scientists or not, the ways in which we carry out these activities are of profound significance. They determine the quality of our decisions, the accuracy of our understanding, and ultimately, the quality of our lives. In the hustle and bustle of daily living, we are rarely aware of the assumptions we make as we seek solutions to problems. Nor do we take much time to reflect on the variety of approaches we take. At times we are intuitive, relying on a hunch or some vague feeling. At other times we examine questions in a rational manner. On yet other occasions we become empirical, basing our actions on our prior experiences or on the experiences of others. Often we rely on authority, looking toward experts to fill gaps in our own backgrounds. Let's take a closer look at these approaches to knowing.

Let's assume that you believe that watching violence on television leads children to be more violent in their behavior. Where does this belief come from? How did you acquire this knowledge? Perhaps your parents, minister, or teacher told you this. Perhaps when you were younger you noticed that your own behavior and the behavior of children you played with seemed more violent after watching certain TV shows. Perhaps you have reasoned that because part of a person's development is based on learning by watching others, watching others display violent behavior will undoubtedly lead to more frequent violent behavior in the observer. Perhaps you have read about research studies in a textbook or scientific journal that propose such a conclusion. Finally, and perhaps more realistically, your belief may be based on an integration of information from several sources.

The primary goal of science is to acquire new knowledge. In science, we are interested in making new observations, verifying prior observations, discovering laws, deriving predictions, and improving our understanding of ourselves and the world around us. To these ends, we are interested in improving theories that explain and predict behavior, developing better analytical and measurement methods, and providing a broader database (information) for future development. Science is based primarily on an empirical approach to gathering information—an approach that relies on **systematic observation.** Before discussing empiricism, let's examine three other important sources of information in our lives.

Authority

One source of knowledge is that derived from authority figures. Religious leaders, teachers, parents, and judges may dictate the truth as they believe it. Or truth may be found in authoritative works such as the Bible or an encyclopedia. In the case of the Bible, the method of authority is described as dogmatic (fixed and unbending); if knowledge from the source is wrong, then we would be misled and the search for the truth hindered. Likewise, people often view a text like an encyclopedia as the truth when, in fact, some information is likely incorrect (such as historical accounts of events based on biased viewpoints). Although science as a discipline is not based on authority, scientists as people do, on occasion, rely on authority. In the past, some scientists have believed so firmly in their theories that they asserted, dogmatically, that they were true. When false, these beliefs resulted in faulty knowledge and hindered the development of these disciplines.

For example, a Russian geneticist and agronomist by the name of Lysenko was involved with the science and economics of crop production. Based on faulty research, Lysenko announced that crop characteristics resulting from environmental changes could be transmitted genetically. Because this view of genetics was compatible with the political doctrine of Soviet Russia, his position was forced upon all geneticists conducting research within the Soviet Union. Lysenko's view was later repudiated, but not before it considerably set back the science of agriculture in Russia. Ivan Pavlov also noted that each generation of dogs conditioned faster than the preceding generation. This was also accepted within the Soviet Union as evidence of the genetic transmission of acquired traits—in this case, learning. The truth of the matter is that the dogs were conditioning faster because the researchers were getting better at their trade, so to speak. Improved conditioning techniques and better control over extraneous variables, rather than genetic coding, were responsible for the generational improvement. Thus, Soviet genetic research suffered from several decades of allegiance to an erroneous theory.

The point can be made more clearly by contrasting creationism with science. Creationists argue that creation science is scientific and should be taught in the schools along with evolution. Is it scientific? Let's take a look.

In traditional science, observations, measurement, and discoveries are repeatedly tested before they are accepted as factual. Also, the findings and interpretations are always provisional and contingent upon additional tests. Scientists question their data with a healthy skepticism and are open to accepting changes in their conclusions if warranted by new evidence. They accept change; they encourage creative ideas, with the focus being on a better understanding of nature. Theories and laws that survive repeated testing are retained; those that do not are modified or discarded. For example, theories such as evolution and gravity have withstood repeated testing from many different scientific disciplines. However, even though they are accepted today, they are still undergoing further testing.

In contrast, creationism asks that we believe on faith and not focus on evidence. For creationists, appeals to authority take precedence over evidence. The conclusions of creationism are fixed and do not change when presented with findings contradictory to their tenets. From a creationist perspective, authoritative conclusions come first and then evidence is sought to support them. Obviously their procedures contrast sharply with those of traditional sciences. In science, new ideas are welcomed. They are particularly exciting when they question the validity of current conclusions and theories—especially when they increase the understanding of our world.

Our physical health, our economic health, our environmental health, and future benefits to humankind depend on our scientific progress. They depend on enhancing our understanding of the world in which we live. To date, science has an excellent track record in approaching these ends.

Another point should be made regarding creationism. Many creationists spend time trying to discredit the theory of evolution. Their argument is essentially that evolution theory is wrong (despite the powerful evidence in its favor). They then draw the improper conclusion that because evolution is wrong, creationism must be right.

Personal Experience

Some individuals (such as writers and artists) have insights derived from experiences and observations unique to them. They attempt to communicate their insights and intuitions to others through writing and works of art. They try to communicate, through their work, general truths with which those familiar with their work can identify. To illustrate, who has read Shakespeare's *As You Like It* and failed to respond to the lines, "All the world's a stage, and all the men and women merely players. They have their exits and their entrances; and one man in his time plays many parts"? Though not all of us make our personal insights public, it is certainly true that much of our own knowledge is based on our own experiences. However, we must be careful. Our own experiences can lead to faulty beliefs. For example, you may have an unpleasant experience with a member of an ethnic minority group and conclude that all individuals of that ethnic background have similar flaws. Such overgeneralization is common and can result in faulty beliefs (in this case, prejudice).

Rationalism

In wearing the hat of **rationalism,** we emphasize reasoning and logic rather than experience. Reasoning and logic can be very powerful methods in the search for knowledge and understanding. They play an important role in the formation of theories and the formation of hypotheses to test those theories. For example, a theory of depression proposes that it is related to below-normal activity of a particular brain chemical called serotonin. Reasoning and logic would therefore suggest that a drug that increases serotonin activity might be an effective antidepressant. We now have a hypothesis for an experiment. (In fact, many antidepressant drugs currently on the market, including Paxil, Prozac, and Zoloft, increase the activity of serotonin in the brain.)

Although rationalism can be useful in the advancement of knowledge, it has drawbacks when used in isolation as the only approach. With rationalism, propositions are not empirically tested, but are accepted as self evident. Thus, if we accept the proposition that males have better math skills than females, it follows that an engineering firm should give preference to hiring male rather than female job applicants. Although the conclusion may be logical, the original proposition may not be based on empirical evidence and may, in fact, be incorrect. The rational approach will often deny the relevance of observation and experience in a search for universal truths, pointing out that our senses are faulty and incomplete.

Empiricism

Unlike rationalism, which tends to seek universal truths, the goals of **empiricism** are more modest. The empiricist stresses the importance of observation as the basis for understanding our past and present and predicting the future. Reasoning, personal experience, and authority are not enough for the empiricist. For empiricists, experiencing events through stimulation of our senses (seeing, hearing, touching) is required. Recognizing the fallibility of experience, the empiricist does not search for universal or absolute truth. Statistics and probability, which are tools for dealing with uncertainty, are key weapons in the arsenal of the scientist.

All four approaches to knowledge are important, and we use them all. Scientists emphasize the rational and empirical approaches, but also make use of authority and personal experience on occasion. Figure 3.1 summarizes the four approaches to knowing.

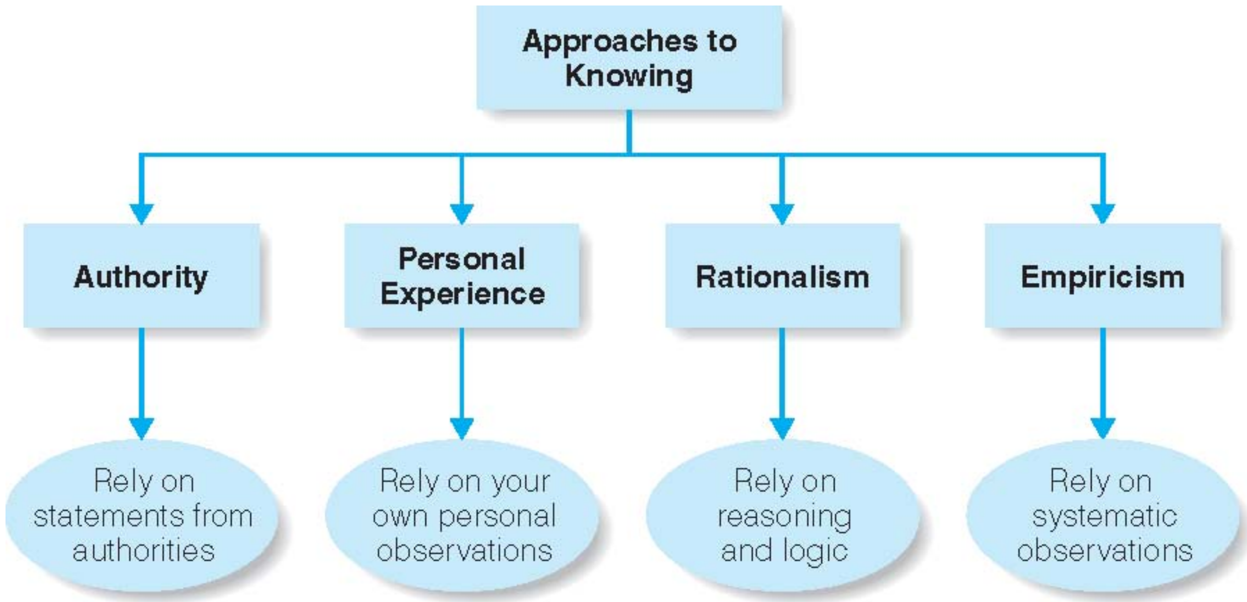

Figure 3.1 Approaches to knowing.

Defining Science

Psychology is a science. But what is science? Most people, including scientists, find it difficult to answer this question because there is no simple, straightforward definition. We might try to break the ice by defining science as an organized body of knowledge that has been collected by use of the scientific method. We should then state what we mean by the scientific method, being careful to state the assumptions and goals fundamental to science. Therefore, to define the term *science* adequately, we must state the goals that are sought, the assumptions that are made, and the characteristics of the method.

Goals of Science

Most scientists, but not all, are interested in three goals: *understanding*, *prediction,* and *control.* Of these three goals, two of them, understanding and prediction, are sought by all scientists. The third goal, control, is sought only by those scientists who can manipulate the phenomena they study. One of the most rigorous and precise disciplines in terms of prediction is astronomy, but it is unlikely that astronomers will ever acquire sufficient control over their subject matter to manipulate events.

Sometimes *description* and *explanation* are used synonymously with *understanding* when stating the goals of science. Although there is a similarity of meaning among the three concepts, there are also subtle differences. Description of things and events appears first. We must know the “what” of what we are studying. It is important to give an accurate description, identifying the factors and conditions that exist and also the extent to which they exist. As the description becomes more complete—as we identify more factors or conditions affecting the events we are studying—the better our understanding of the event becomes. A complete description of the event would constitute an explanation. We would then be able to state clearly and accurately the conditions under which a phenomenon occurs.

Some have argued that prediction is the ultimate goal that sciences seek. To a degree, we know that we understand (at some level) an event when we can predict the occurrence of that event. Prediction may also permit a substantial amount of control. When events can be predicted accurately, preparation in anticipation of the event can occur. However, we should be careful not to fully equate prediction with understanding. Based on past experience, we may correctly predict that some people with severe depression will evidence a remission of symptoms following electroconvulsive shock. However, we may have little understanding of why this is so.

Considerable research has taken place in countries throughout the world regarding natural disasters such as earthquakes, hurricanes, droughts, and epidemics. Imagine, in terms of human welfare, the impact of acquiring an understanding sufficient to predict these natural disasters. Timely preparation of those threatened could save lives and dramatically reduce injuries and human suffering. But the next step—achieving control of the environmental conditions leading to these events—would permit us to alter the time, place, and intensity of their occurrence or prevent them altogether. The prospect of control over disordered behavior is also exciting to contemplate. When sufficient knowledge is acquired, perhaps we will be able to eliminate or reduce the symptoms of many psychological and physiological disorders, maximize a sense of well-being, enhance memory and learning, or eliminate AIDS.

Ultimately, science seeks to explain, through the development of theory, the phenomena that exist in the universe. Scientists try to arrive at general statements that link together the basic events being studied. If this is accomplished, understanding, prediction, and control follow.

Assumptions of Science

All scientists make two fundamental assumptions. One is **determinism**—the assumption that all events in the universe, including behavior, are lawful or orderly. The second assumption is that this lawfulness is discoverable. Notice that the first assumption does not necessarily imply the second assumption. In other words, we can assume that behavior is lawful without presuming that we will discover this lawfulness.

To say that behavior is lawful is to say that behavior is a function of antecedent events. More loosely, we could say that there is a cause–effect relationship between the past and the present, a continuity between before and after. According to this view, behavior is orderly and lawful; individuals do not behave randomly or capriciously. Even behavior that appears to be random is assumed to follow some underlying lawfulness.

The assumption that behavior is lawful is justified by everyday experiences. Every time we place ourselves behind the steering wheel of a car, we implicitly assume that the behavior of hundreds of other motorists on the road will be orderly. They will not suddenly veer off the road into our path, brake without cause, or try to crash into us. Similarly, when traveling by air, we assume the pilots will take a course that minimizes air turbulence and maximizes the comfort of passengers. We feel assured that they will not commit any act on a whim, such as doing loop-the-loops at 30,000 feet.

The assumption of lawfulness is very important for several reasons. One major reason is that it determines our own behavior as scientists. If we were to assume that behavior is free of causes or determiners, it would not make much sense for us to study it. By definition, if an individual’s behavior is free of causes, then there is no lawfulness. There is no pattern to it, no connection with the past. It simply would not make good sense to study a phenomenon assumed to be unlawful. However, even if the assumption of lawfulness is correct, we should not be deluded into believing that it will result in precise predictions of human behavior. We must realize the enormous variability in behavior that results from the enormous number of variables that have affected a person up until a particular moment in life. These variables include genetic composition and every experience that the person has ever had. Understanding all of these variables and their complex interactions in order to make precise predictions would seem to be an unattainable goal. However, our predictions in the behavioral sciences have certainly become better over the years, and scientists believe that the trend will continue as behavioral science continues to develop.

One effort to better understand the variability in events is chaos theory—a relatively new concept that has been applied to science, including the behavioral sciences. **Chaos theory** is an attempt to understand complex, nonlinear, dynamic systems by using mathematical modeling. The theory attempts to explain the overall behavior of a system without attempting to predict detailed states at any given moment in time.

Chaos theory is often misunderstood to imply that there are systems that are not deterministic. This is not true. In fact, the theory assumes determinism but concedes that perfect predictability may not be achievable because of the immense number of variables simultaneously interacting to affect the system. Thus, you can imagine that our behavior and thoughts at this moment are determined by an immense number of natural events, including our genetic makeup, all of our past experiences, our present state of physiology, and the current environmental conditions. Although such determinism is imaginable, it is impossible to imagine a complete understanding of all these variables and their interactions that would lead us to perfect predictions of our behaviors and thoughts. However, we might note that just because something has not yet been done does not mean that it cannot be done.

It is important to note that these assumptions of science are not thought of as true or false, provable or unprovable. As scientists, we make certain assumptions to see where they take us in terms of achieving our goals. If we achieve our goals of prediction, control, and understanding, we feel more confident about the assumptions we have made. But we do not assert that we have proved determinism or that free will does not exist. These assumptions may be thought of as the rules of the games in which scientists engage. We stick by these rules as long as they prove to be useful. When no longer useful, we discard them and adopt others that promise to carry us further in our quest for understanding.

The history of science is replete with instances in which major advances occurred only when one set of assumptions was replaced by a different set. Many refer to this as a paradigm shift. To illustrate, we presently regard astronomy as one of the most accurate sciences. However, a few centuries ago, astronomy was in chaos. Astronomers labored under the assumption that the sun revolves around the earth (Ptolemy). Even though this assumption nicely corresponded with everyday experiences (the sun *does* look as if it revolves around the earth; the earth *does not* appear to be moving), little progress was made in astronomy until it was discarded. Many conflicting observations simply could not be resolved within the Ptolemaic framework. Ironically, astronomy emerged as a vibrant science only when it adopted an assumption that ran counter to casual observation. Copernicus posed the startling hypothesis that the earth revolves around the sun. Only with this assumption did many confusing observations about the behavior of the stars and the planets become coherent. The Copernican assumption ultimately prevailed because it proved more useful in predicting and understanding celestial events.

The Scientific Method

Dreams are a fascinating topic in behavioral science. Some believe, as Sigmund Freud did, that dreams are highly meaningful and full of symbolism that requires interpretation. Others believe that dreams are simply a physiological by-product of the physiological activity of the brain during stage REM sleep. Because of the strong visual content of most dreams, scientists long suspected that the visual centers in the brain would be activated during human dreaming. However, there was no practical method for such localized recording of human brain activity while a person was in a dream state. Thus, the state of technology precluded an answer to the scientific question. However, in more recent years, with the advent of PET scans and functional MRIs, scientists have been able to demonstrate the activity in the visual centers of the brain during dream sleep.

Unanswerable questions of yesterday are the facts of today, and the unanswerable questions of today will be the facts of the future.

There are a couple of lessons to be learned from this example. Not all events are subject to scientific inquiry. Some are inaccessible because of technological limitations, as was the case with brain activity during dreaming. Others are inaccessible because there is no **empirical referent** to the presumed event (such as ghosts or evil spirits). By *empirical* we mean that it is capable of being experienced—that the event will stimulate one or more of our many senses. We must be able to feel it, taste it, see it, smell it, or hear it, or we must be able to sense a record it makes. In other words, an event must be observable or measurable, either directly or indirectly. For example, no one has seen a subatomic particle, but some scientists have seen and measured a trace it leaves on a photographic plate. No one has ever seen gravity, but its effects are observable and measurable all around us. Similarly, in psychology the construct of learning is never observed directly, but is measured in terms of its effects on some aspect of behavior.

To say that an event must have an empirical referent implies that the event is a public one, not a private one. It also implies that the observations are objective and not subjective. As noted, there are events that cannot be studied because they do not have an empirical referent. For example, the question “Is there a God?” cannot be answered scientifically. The subject matter is not empirical and therefore cannot be subjected to scientific study. Questions such as this require faith on the part of the believer, and this faith is derived from authority figures and related authoritative texts (such as clergy or the Bible) . However, a related question can be asked that would allow us to study religious beliefs. We could ask, “What are the effects of religious beliefs on behavior?” We could study these effects scientifically because the presence or absence of religious beliefs in a person can be determined empirically (through verbal reports or questionnaires, for example), and the effects of these beliefs on behavior can also be determined. Both the beliefs and the behavior are directly or indirectly measurable. They are empirical events.

In addition to the requirement that events must be observable, science also requires that observations be *repeatable* and that science itself be *self-correcting*. The requirement that observations must be repeatable permits one investigator to verify the work of another. Insisting on repeatability allows the self-correcting feature, another essential requirement for science, to operate. The scientific method is perhaps the only one that has a built-in self-correcting procedure. Because events are empirical and repeatable, research conducted in one place can generally be repeated in any other part of the world to either confirm or cast doubt on the reliability of published findings.

Students are sometimes distressed to learn that an event must be repeatable if it is to be studied scientifically. What about unique events? Aren’t they as important, and shouldn’t they be studied? My birth is unique! My death will be unique! As a person, I am unique! Indeed, all people are unique and important. How can scientists ignore these unique events?

In a word, they do not. Scientists are well aware of the problem. The solution is to deal with classes of events. Although your birth is unique, births in general are not. The same is usually true for other unique events. We study the class of events—births, deaths, personality, and so on—and then bring our understanding to bear on particular events. On occasion, however, some important events (such as particular alignments of planets in the solar system) may occur so infrequently that we cannot study a class of these events. There is no happy solution to this problem. Often the best that we can do is to have multiple observers on the scene at the time of occurrence. Although the event itself may not be repeatable, a number of observations can be made independently and the results compared. Fortunately, the rare, important event does not appear with sufficient frequency to pose a serious problem for science.

Distinguishing Observation From Inference

Of the many activities that scientists undertake, two of the most important are making accurate observations of the phenomena under study and drawing inferences from these observations. The activity of drawing inferences includes such things as providing interpretations of the data, explaining the data, theorizing or guessing about the underlying processes responsible for the observations, and creating new concepts to explain the observations. Although both observation and inference are important, the first, accurate observation, is critical. Our scientific enterprise begins here. The usefulness or goodness of our interpretation depends on the accuracy of our observations. As we will see in the following chapters, many factors can affect our observations. However, even though we may begin with accurate observations, it does not follow automatically that our interpretations will be correct. They may still be wrong. In other words, the observations that we record may occur for reasons other than the ones we give.

It is important that we distinguish between observing an event and making inferences based on those observations. As the following anecdotes illustrate, the observations may be objective and repeatable, but the inferences can be wrong.

This story, a humorous example of faulty inference or logic, has appeared in many guises. Imagine, if you will, a well-trained cockroach capable of responding to verbal commands. Whenever the trainer said “Jump!” the cockroach immediately did so. A researcher became interested in the behavior of the cockroach and decided to study the jumping behavior. After a few observation sessions, he pulled a leg off the cockroach and gave the command “Jump!” Again the roach jumped. The process of systematically removing legs continued until all legs were removed. Again the researcher gave the command “Jump!” but the roach did not move. The results were written up in an experimental report with the conclusion, “When a cockroach loses all of its legs, it becomes completely deaf.”

Consider another humorous example of faulty logic. Imagine a young woman born and raised in a small, isolated community without any form of outside communication. One day, she hears of the wonders of other places and decides to visit them. She travels to one of our large cosmopolitan cities. The sights and sounds of the city fascinate her, but the most fascinating of all are her experiences interacting with people in the ethnic parts of the city. She notes that some people speak very smooth and fluent English, but others have strong accents. She also accurately observes that it is usually the much older members of the community who have these accents. After thinking about this observation for a while, our visitor concludes, “As people grow older, they develop accents.”

Systematic Nature of Science

We have noted three major characteristics of the scientific method (empirical referent, repeatability, self-correcting). Another important characteristic distinguishes knowledge gained using the scientific method from that gained through our daily experiences. Science is *systematic*. For example, in psychology, whether scientists or laypeople, we all have some familiarity with the subject matter. We spend major portions of each day of our lives interacting with others, observing others, evaluating people, and considering our own behavior. Everyone has learned something about human behavior without studying it scientifically. Also, philosophers, poets, and literary people often have insights into behavior that exceed those of psychologists. Based on our daily experiences, we arrive at many conclusions. Unfortunately, not all of our conclusions derived from daily experiences are accurate. Many, in fact, are false. To avoid arriving at conclusions that appear intuitively correct but are in fact false, we need a systematic approach to the study of behavior. A systematic approach allows us to collect data under clearly specified and controlled conditions that can be repeated, measured, and evaluated. Considerable emphasis is placed on evaluating and ruling out alternative explanations (hypotheses) for the phenomena being studied. In addition, a special effort is made to identify relations among phenomena. Much of this book is devoted to teaching you how to perform these activities.

Inductive and Deductive Research Strategies

The systematic nature of science involves the use of both inductive and deductive research strategies. **Inductive reasoning** involves the formulation of a general principle or theory based on a set of specific observations. Conversely, **deductive reasoning** involves the formulation of specific observational predictions based on a general principle or theory. Figure 3.2 depicts the direction of reasoning. Notice that with inductive reasoning, multiple observations lead to one theory. With deductive reasoning, one theory leads to multiple predictions.

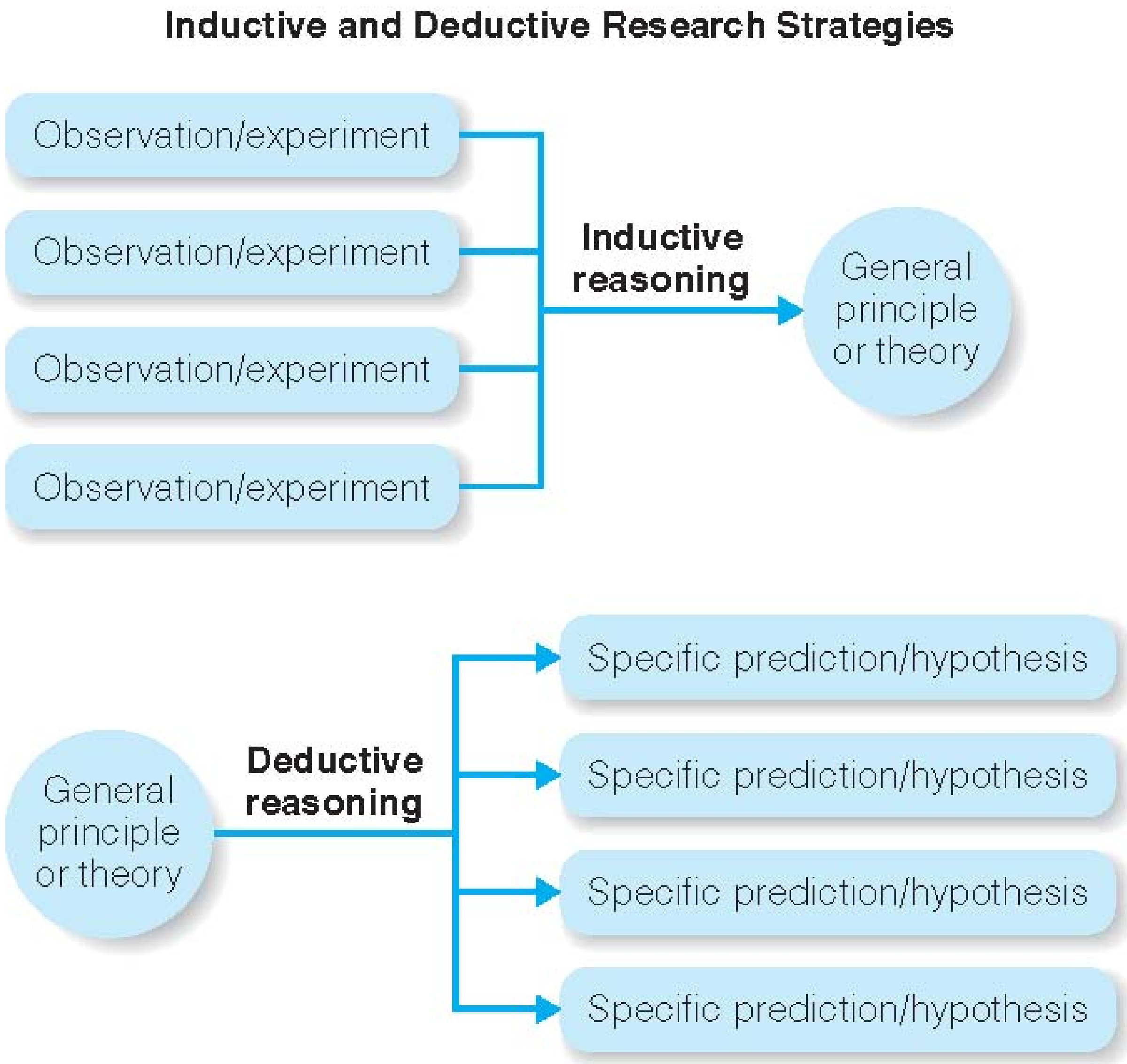

Figure 3.2 The direction of reasoning for inductive and deductive research strategies.

As an example, let's consider the dopamine hypothesis for schizophrenia. Schizophrenia is a serious mental disorder that may include symptoms such as unreal thoughts, hallucinations, emotional disturbance, and social withdrawal. As you might imagine, one of the first "theories" of the disorder involved possession by evil spirits. During the mid-20th century, a few French psychiatrists administered a new drug for anesthesia (later called chlorpromazine) to a group of mental patients. The schizophrenic patients improved. Other drugs such as amphetamines and cocaine were observed to increase the severity of the symptoms. Animal research showed that chlorpromazine reduced the activity of a certain chemical in the brain (dopamine) and that amphetamines and cocaine increased the activity of dopamine in the brain. Through inductive reasoning, these specific observations, along with others, led to the dopamine hypothesis of schizophrenia. Through deductive reasoning, the theory then predicted that certain other drugs that reduce dopamine activity should be helpful in treating schizophrenia. Many of these drugs have been tested and are now in use.

Role of Theory in Science

So far in this chapter, we have used the term *theory* several times. As we noted, development of theory is one important method we use for making understandable the subject matter that we are studying. Although everyone agrees that theories are important, the question "What is a theory?" is difficult to answer. There is often disagreement about the meaning of the term, and much has been written on the topic. However, some agreement does exist. A **theory** is a system of ideas or a set of principles, often dealing with mechanisms or underlying reasons for behavior that help us organize and assimilate the empirical relationships (observations) that we discover. This is an important function because without theory to aid us in organizing our observations, we would soon be overwhelmed by the accumulation of huge numbers of isolated facts.

Theories are evaluated through research. There is an interplay between theory and research in that theories guide research and the research findings are then used to revise or modify the theory. The worth of a theory is determined by how well it accounts for the observed relationships, its precision in making predictions, its parsimony (accounting for the largest number of observations with the fewest number of principles), and its internal consistency. Theories, when tested, are not judged to be true or false, proven or unproven. Instead, we describe them as being supported or unsupported, confirmed or unconfirmed.

When testing theories, scientists must guard against confirmation bias. To illustrate confirmation bias, consider the following exercise. We are going to provide you with a series of three numbers. It is your task to discover the rule by which we generated the three numbers. You are to do this in as few trials as possible. We will now give you some numbers generated by our rule—that is, an example of our rule—the series 2, 4, 6. Please generate a further series using what you think our rule is. We will say "yes" if your series agrees with our rule and "no" if it does not. Tell us when you think you know the rule. Begin.

If you behave as most people do, you will say something similar to "8, 10, 12." Our answer is "yes." You may then say "7, 9, 11," and again our answer is "yes." Perhaps you will attempt one more series, such as “14, 16, 18,” before you state the rule. Most likely, you have concluded that the rule is “numbers increasing by twos.”If so, you are incorrect! You could go on indefinitely generating numbers increasing by twos and never discover that your hypothesis of “two” was incorrect! If you followed a procedure similar to the one described, you were illustrating confirmation bias. You were repeatedly attempting to confirm your hypothesis of “increasing by twos” rather than disconfirming (falsifying, or proving it wrong) it by considering alternative rules. In each case, you gave examples increasing by twos. Thus, **confirmation bias** is a general tendency to emphasize positive confirming outcomes rather than negative or disconfirming ones.

What if your second reply had been “5, 8, 11” and we responded “yes”? At this point, you would have disconfirmed the rule “increasing by twos.” You still wouldn’t know the rule, but you would have eliminated one hypothesis. Perhaps your next thought is that the rule is “equal intervals between numbers.” If you now try 5, 10, 15, you would again receive a “yes,” indicating that the series is compatible with our rule, but you would again be illustrating confirmation bias. To test the “equal interval” hypothesis would require that you try to disconfirm (falsify) it by testing “not equal intervals” such as 5, 8, 15. If we say “no,” then your hypothesis of equal intervals may be correct. If we say “yes,” then you know immediately that it is incorrect, and you go on to another hypothesis, such as “any series of three increasing numbers.” The point is that the fastest way to test this hypothesis (identify a false theory) is to try to disconfirm it. To disconfirm the hypothesis, a series of three decreasing numbers might be chosen, such as 8, 5, 2. We would give you a “no,” because 8, 5, 2 is not compatible with our rule. This information suggests that your last hypothesis of “three increasing numbers” may be correct. In fact, this was the rule that we wanted you to try to discover.

This example illustrates an important point. We can now return to some points made earlier. Any number of theories or hypotheses can be supported, even if incorrect, by a continuing run of positive instances (successful predictions). You could have continued using inductive reasoning and generalizing the “twos” hypothesis endlessly, thinking it was correct. This strategy is often used by scientists, but as our illustration shows, it has shortcomings of which we should be aware. We can never establish that a theory is correct with this strategy. As the number of positive instances increase (instances of support or confirmation), so does our confidence in the theory. But sometimes this confidence is misplaced.

Summary of the Scientific Method

Let’s summarize the characteristics of the scientific method. As we have seen, science cannot be defined simply. An adequate definition requires a statement of the assumptions, goals, and methods. Table 3.1

provides a summary that many, but not all, scientists would agree with. The box "Thinking Critically About Everyday Information" provides an exciting "scientific" claim from the Internet.

Table 3.1 Characteristics of Science

Assumptions of Science	The universe (for psychologists, behavior) is lawful or orderly The lawfulness is discoverable
Goals of Science	Prediction of events in nature Control of events in nature Understanding of events in nature
Characteristics of Methods	Empirical referents (objective, observable, public events) Deals with repeatable events Self-correcting Systematic study Tentative and falsifiable (no appeal to authority)

Thinking Critically About Everyday Information: Human Sex Pheromones

A recent search on the Internet using the search word "pheromone" found this site. The Web site included the following statements: "Science Has Finally Done It! A men's cologne that contains genuine human sex pheromones. Scientifically designed, tested and proven to Attract Women Like Magic! Now YOU can be more popular with women than you ever thought possible!" "Improve your sex appeal 1000% for less than the cost of a good meal! How much is it worth to attract beautiful, sexy women? If you don't try something new – this year won't be any better than last year." "The powerful effects of sex pheromones have been well substantiated. You may have seen stories about human pheromones on 20/20, Dateline NBC, Hard Copy, or many other television programs. Newspapers from coast to coast, medical journals, and many different magazines have featured stories about the amazing discovery of pheromones."

Wow! That sounds pretty impressive, and it seems to be based on science. Are you convinced? We hope not. We hope that you look at such information with a skeptical eye. Consider the following questions:

- What clues should make you skeptical?
- What "sources of knowing" are used to make the claim?
- How many citations for scientific studies are included?
- How many scientific studies are described?
- How do you believe that they calculated the statistic that your sex appeal will improve 1000%? Empirical data?

Pheromones are chemicals that are released by one animal and detected by another animal. Research shows that pheromones can be a very potent method of communication in many animal species. Human research also supports the existence of pheromones and the vomeronasal organ that detects them. However, no quality studies support the claims made in the preceding advertisement. Much of the research suffers from inadequate research designs that do not account for placebo effects and self-fulfilling prophecies. These issues and the research techniques to control for them are discussed in Chapters 8 and 9. So, let us return to the concepts of the chapter to become more critical consumers of information.

SOURCE: http://androsterone-pheromone-concentrate.com/

Comparisons of Science and Nonscience

One approach to understanding science is to compare it with knowledge that is not based on science. People differ in their views regarding the origins of life on earth. As introduced earlier in this chapter, one set of views has been termed *creationism* or *creation science*; approximately one-third of college students endorse this view. Although some details differ (depending on whether or not one interprets the Bible literally), the basic tenets of this "theory" include the notions that a supernatural force (a God) created the earth and this God is responsible for designing the diversity of life forms on it. Let's examine this "theory" in terms of some of the principles outlined above.

As noted above, one of the hallmarks of scientific theory is that it makes predictions that can be empirically tested. The notion that God created the earth and the life forms on it is not a testable theory. What predictions follow from the theory? How could one make observations in an attempt to falsify the theory? Rather, creationism is not a science but a matter of faith that relies primarily on authority as the source of knowledge.

This debate has been prominent in deciding what is appropriate to teach in public schools. In several instances, the courts have had to intervene and determine whether creationism is a valid scientific theory. For example, in *McLean v. Arkansas Board of Education* (1982), the court determined that "creation science" is not in fact a science and struck down an Arkansas statute that mandated a balanced treatment of "creation-science" and "evolution-science" in the public schools.

A national Harris Poll in 2000 showed that approximately 40% of adults believed in astrology (about the same percentage believed in ghosts). The distinction between astronomy and astrology provides another comparison of science and nonscience. Astronomy is the scientific study of the natural forces that explain planetary phenomena. Astrology is the study of how planetary objects and their alignments affect the behavior of people and the occurrence of events on earth. Theories in astronomy make precise predictions that are testable; theories in astrology typically explain events after the fact or make predictions that are so vague they are not testable. What is very misleading is the current trend by some to label astrology a science. Astrology is not made scientific by its recent use of some principles of astronomy (to better understand alignments) and statistical analyses. There is no scientific evidence to support the basic principles of astrology.

Common Sense and Science

When it comes to human behavior, some have argued that common sense produces the same conclusions that psychological research does. Implied in this comment is that scientific research is a waste of time and effort because common sense would provide the same answers. What is meant by common sense? It is usually taken to mean the accumulation of knowledge through our experiences that allows us to develop generalizations (statements, conclusions, hypotheses) about the world in which we live. These generalizations simplify complex situations by drawing conclusions that are absolute—that is, without qualifications.

It is not unusual for the conclusions of common sense to agree with the findings of science, but the two may also conflict. As already noted, principles derived with the methods of science are based upon careful, systematic observation of empirical events, often in controlled settings. The observations are then evaluated carefully and communicated precisely to others, who can then undertake further evaluation. Usually, the principle (generalization, conclusion) derived from this research predicts behavior consistently. If it does not, further research is undertaken and additional principles are derived. Often the derived principles are stated in a qualified form, such as “Given these conditions, then this behavior is expected to occur.” This is not the case with common sense, particularly as found in proverbs of generalized “truths.” Proverbs based on common sense often conflict with each other. For example, the proverb “Look before you leap” is contradicted by the proverb “He who hesitates is lost.” Yet, given the proper set of circumstances (unspecified by the proverb), both proverbs may be correct. Further examples abound. “Two heads are better than one” is not consistent with “Too many cooks spoil the broth.” Is it true that “Absence makes the heart grow fonder,” or is it the case that “Out of sight, out of mind”? How often have you heard that you are “Never too old to learn” and also that “You can’t teach an old dog new tricks”? Should parents rely on the proverb “Spare the rod and spoil the child” or instead “You catch more flies with honey than with vinegar”?

When stated in absolute terms, as in these examples, the proverbs appear inconsistent and contradictory. It may well be that “Out of sight, out of mind” is an accurate conclusion under certain conditions and that “Absence makes the heart grow fonder” is an accurate conclusion under other conditions, but these conditions remain unspecified. Scientific knowledge improves upon commonsense proverbs by specifying the conditions necessary for the principles to be applied.

We should note that while recognizing the serious weaknesses of a strictly commonsense approach to knowledge, we also recognize the contributions made to our understanding of behavior by nonscientists such as poets, playwrights, novelists, and philosophers. Such individuals can provide us with great insights into human behavior that serve as a creative source for our research.

Molecular to Molar Levels of Analysis and Explanation

The molecular–molar continuum illustrates that the evolution of various disciplines did not occur arbitrarily. Generally, as knowledge accumulated, different questions were asked requiring different units of measurement. Figure 3.3 illustrates the focus of various disciplines and clearly depicts a degree of overlap among them. For example, physicists are generally interested in the level of analysis emphasizing atomic and subatomic particles. This currently is the most molecular level of analysis. Atoms combine and form the basis for molecules, and molecules are the domain of the chemist. The questions usually asked by chemists, therefore, deal with molecules as the unit of analysis. Molecules combine to make up systems such as the circulatory system, glandular system, muscular system, and so on. Physiologists are generally concerned about questions that relate to these systems. These systems combine to give us the next level of analysis, which is the behaving organism. This is the domain of the psychologist. Psychologists are interested in the behavior of individual organisms. Individual organisms combine into groups, and the study of group behavior defines sociology. Groups combine into larger units to make up cultures. The study of cultures defines ethnology. Obviously, these are not competing disciplines; they are usually complementary, each with its own level of analysis.

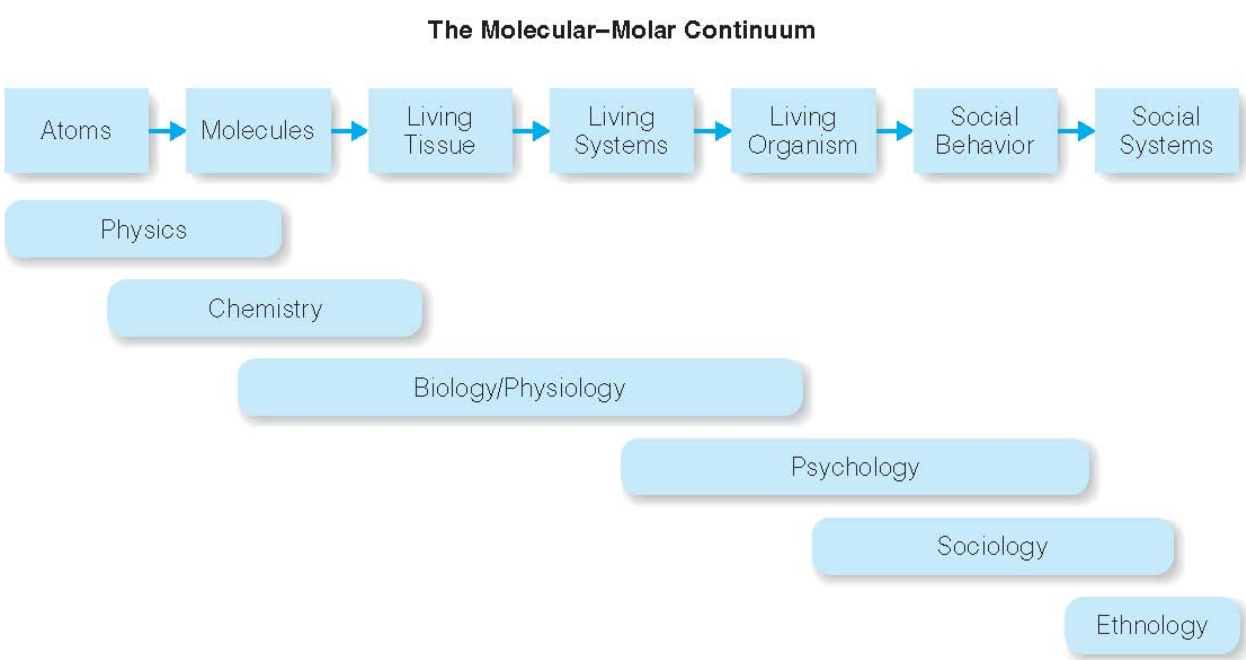

Figure 3.3 The molecular–molar continuum. The level of analysis is extremely small in nuclear physics (molecular) and extremely large in ethnology (molar). The overlapping boundaries indicate that the

various sciences are not rigid and fixed. At times, a psychologist may operate at the level of analysis of a physiologist and, at other times, at the level of a sociologist.

Controversies have arisen from time to time regarding the kind of theory that scientists should develop. At what level should we attempt to theorize about and explain behavior? What would our unit of analysis (level of analysis) be? In psychology, should the unit of analysis be the atom? The molecule? Perhaps it should be a physiological system? What about intact behavior? Could it not also be group behavior or an entire culture?

Some psychologists have argued that the level of analysis and theory construction in our discipline should be at the physiological (molecular) level. Such individuals have been referred to as **reductionists** because they seek to explain complex behaviors in terms of relatively simple structures and functions. Others have argued that the unit of measurement and theory construction should be at the behavioral (molar) level. Obviously, *molecular* and *molar* are relative terms. Psychology, with its emphasis on the physiology of the organism or on the observable behavior of the organism, is molecular relative to sociology, where the emphasis is on group behavior. Yet relative to chemistry, the unit of analysis in psychology is molar.

Most scientists believe that theorizing at different levels is necessary and can be complementary. Perhaps at some future time we may be able to be reductionist (molecular) and interpret the phenomena of all sciences in the language of physics. Clearly, we cannot come close to doing so at this time.

Importance of Basic Research

Basic research is not easy to define, and unfortunately, it is often unappreciated by those who control considerable sums of money for research. To some, basic research may seem frivolous. Surely, we are indulging scientists by supporting their pet hobbies, such as studies of the sexual behavior of moths, communication among bees, and sexual attractants among insects. But in each instance, as is often the case with basic research, the results of these studies have ultimately had important implications for agricultural practices, the world's food supply system, and the economy. To illustrate, insects cause crop damage in the multimillion dollar range annually, but chemical control of these insects has created its own serious problems. New and safer techniques of biological control have been made possible because of basic research on the behavior and physiology of insects. Nonetheless, such research is often ridiculed or criticized.

One further comment before describing basic research more fully: Political leaders controlling research funds may not appreciate the value of basic research for many reasons. At times they consider it unimportant, but at other times they reject it because of their own bias, prejudice, or moral values rather than on the basis of scientific merit. Whatever their basis for not appreciating its value, the fault, at times, rests with the scientists. Scientists too often consider the value of basic research to be self-evident and have not always made a strong argument in its defense. Thus, scientists and educated laypeople need to devote more care to presenting a defense of basic research.

A Defense of Basic Research

It is often difficult to see the relationship between basic research done years ago and the application of sophisticated technology to current problems. Basic research provides the foundation (database) for the resolution of present and future problems, for the development of technology, and for a better understanding of all aspects of the world in which we live.

Basic research is research directed to the understanding of nature, of all aspects of the universe, of natural processes. It is not research directed toward solving specific social problems. It is not mission oriented; that is, it is not involved in the mission of curing or correcting a specific illness or problem or in developing a specific technology. Basic research has no immediate regard for practical application; paradoxically, however, it is probably the most effective way of solving many of our current and future problems. It has been a critical component in virtually every approach to our major problems. In 1969, the National Science Foundation released the results of a study (TRACES) showing the importance of basic research. They examined technological innovations of wide importance and diverse application, tracing research back to 1850. It was concluded that about 70% of the key and critical events were derived from basic research.

Some examples may provide us with a better appreciation of the virtues of basic research. X-ray photography was not developed by physicians as an aid in the diagnosis of disease. Rather, medical use of X-rays followed the pioneering research of Wilhelm Roentgen who was “only” interested in basic problems dealing with the physics of rays. A few decades ago, poliomyelitis (infantile paralysis) was a dreaded disease that left many of its survivors permanently paralyzed. We are all familiar with the applied research of Drs. Salk and Sabin that culminated in vaccines that immunized against the disease. But how many of us have heard about the basic research of John Enders, who was “merely” interested in studying viruses? To accomplish his goal, he needed to devise a means of growing viruses in cultures. When he finally succeeded, he opened the gates for a veritable flood of practical applications of his techniques. The Salk and Sabin vaccines are but two of many monumental advances that had their underpinnings in the laboratory of John Enders. George Cotzias was not pursuing a treatment for Parkinson’s disease, but because of his interest in trace metals and body metabolism, the drug L-Dopa was developed for treating the disease. Similarly, the drug that has nearly eradicated tuberculosis, streptomycin, was discovered by a soil biologist. Most of the treatments now available for AIDS are based on basic research in such areas as molecular virology, immunology, biochemistry, and genetics.

As another example, consider the animal research of behavioral psychologists such as B. F. Skinner. For hours on end, Skinner recorded pigeons pecking at a spot in a cage. Many might ask (and we are sure they did) what pecking pigeons have to do with understanding human behavior. Skinner in fact knew that the basic principles of learning that were being revealed in his research could have far-reaching implications for understanding human learning and that the principles could be used in therapeutic situations to help people with psychological problems and disorders. The present-day widespread use of behavior modification techniques attests to the value of the basic behavioral research that was conducted many years ago and that is still being conducted today.

It is very difficult to appreciate the importance of basic research at the time it is being conducted. How important was the effect of current flow on magnetic needles at the time of Faraday? Today, induction coils in the field of transportation are incredibly important. People interested in transportation didn’t discover induction coils (this would have been mission-oriented research). The discovery of induction coils gave rise to a transportation industry. IBM, Control Data, and other computer giants did not set out to discover basic circuits for computers. Physicists in the 1930s interested in nuclear physics discovered them. At the time of Boyle (gas laws), how important were the properties of vacuum tubes? Who could have anticipated transistors, printed circuits, or computer chips? With the discovery of the atom, who could have anticipated the electronics industry?

Basic research continues today to produce exciting and promising findings. Recombinant DNA research has made it possible to produce relatively pure forms of insulin, a marked improvement over the insulin currently derived from animals. The discovery and now production of the substance interferon holds promise for the treatment of certain ailments. A discovery that has excited both scientists and technicians is the identification and production of monoclonal antibodies. This discovery should allow specific antibodies (monoclonal) to be developed that attack specifically targeted bacteria, viruses, or other materials foreign to the body. Important discoveries have also occurred for behavioral scientists. One of these is the use of biofeedback procedures to teach individuals to control their own blood pressure, heart rate, brain waves, and other response systems. In addition, we are now beginning to understand the effects of peptides (compounds formed by groups of amino acids) on social behavior, development, perception of pain, and other human functions.

We could continue with many more examples of this type. Clearly, basic research is important, and its full impact may not be felt for many years. However, we do not mean to suggest that the value of basic research is determined solely by its practical significance. Basic research can be justified on the basis that the production of knowledge is, in itself, of great value. It is our firm belief that knowledge has inherent value—that it is strongly preferred to ignorance. In this sense, practical significance is a bonus.

Two Important Reasons for Supporting Basic Research

After reviewing the history of discovering important events and also observing the problems experienced by each succeeding generation, we conclude that there are two fundamental reasons for fully supporting basic research: (1) we cannot determine today what discoveries will prove important for tomorrow, and (2) we cannot determine today what problems we (the world) will experience tomorrow. In fact, we have not become much better over the years at predicting what important problems we will experience in the future. We do not know today what will be important tomorrow. We must be prepared for any eventuality. Our sights must not be narrow in terms of specific missions or focus solely on today's problems. Change is so incredibly fast that we must be in a position to move in many directions—we must have a solid database in all areas. New problems continue to appear that require more basic knowledge: AIDS, carcinogens, ozone depletion, nutrition and cell health, pollution, energy supplies, and toxic shock syndrome are but a few examples. Others could be the effects of depletion of the rain forest, issues related to biological weapons, ocean warming and melting of glaciers, or new epidemics. The more developed the database of basic research, the better we can deal with these problems.

It is understandable to some extent that some members of society insist that scientists concentrate on more relevant social problems. This emphasis reflects a genuine belief that by addressing the problems directly, we can solve them more quickly. Unfortunately, an excessively focused effort to make science more productive by directing its efforts toward specific unsolved problems may actually make it less productive. The war on cancer may be an example. Nature is not yet ready to reveal its secrets. Scientists within the American Institute for Cancer Research have essentially acknowledged, after years of trying to find cures, that much more basic research on cell physiology is needed before success can be achieved. To insist that scientists solve problems before the basic research data are in may be wasteful of highly trained researchers and other resources in money and personnel.

Science and Technology

Science is generally thought of as seeking information or discovering basic phenomena in a systematic way and then organizing this information into general explanatory principles. Technology is usually thought of as the application of these scientific discoveries and principles to existing practical problems. As noted earlier, at times scientists discover the basic principles many years before they are applied in the form of technology. Computers are one example; immunization techniques in medicine are another. Before technology develops, the principles must be available; but at times, a technology must be developed before the principles can be applied. Examples of the latter can be related to the space program and to atomic weaponry.

Too frequently, scientists are blamed for the problems created by the technology that follows from scientific discoveries. Although we assert that knowledge in itself is good, the application of that knowledge can be either good or bad. The stereotype of the "mad scientist" might be better applied to the "mad technologist." Again, we use computers as an example. Scientists cannot be blamed for the abuses (invasion of privacy, identity theft) occurring in today's society. Similarly, the automobile is a technical achievement; the problems created by it (pollution) cannot be blamed on scientists. Discoveries related to genetics are leading to technologies of genetic engineering (and even cloning) over which scientists may have little control.

What we are attempting to do here is to urge everyone to think critically about the distinction between science and technology as we ponder the problems besetting society. However, we must also recognize the interplay between science and technology, and that the distinction between them may be blurred. It is unfortunate that scientists are often blamed for problems but not recognized for contributions that benefit society. Technologists, but not scientists, usually get the credit for these contributions. For example, the technology of medicine is based on the sciences of physiology and chemistry; the technology of engineering is based on the science of physics; the technology of education is based on the science of learning. Most people wrongly attribute achievements in medicine, engineering, and education solely to the technologists and not to the scientists. Both groups should receive credit for such achievements.

A final example will illustrate how science and technology can complement one another. Vampire bats are a serious problem in some Latin American countries. At night these bats silently attack sleeping animals by painlessly scooping out a piece of skin and then taking some of their blood. Some cattle receive bites from as many as 15 bats in a single night. Because of an anticoagulant in the bat's saliva, the blood flows freely most of the night. Some of the bitten cattle are infected with rabies carried by the vampire bats. In other cases, the wounds become infected, resulting in lower weight gains and lower milk production. The solution to this problem illustrates the complementary nature of science and technology in solving problems.

Various previous attempts had been made to destroy the vampire bats. These included shooting, netting, and electrocuting bats in flight. A major problem with these procedures was that they killed beneficial insect-eating bats without reducing the loss due to vampires. Biologists from the Denver Wildlife Research Center began working on the problem in 1968. Because only some of these bats attacked cattle, they wanted to devise a method that would control only vampires that attacked farm animals. The biologists brought bats into their Denver laboratories and discovered that the vampires suffered fatal bleeding if an anticoagulant was added to their blood. Question: How do you get additional anticoagulant into free-flying bats? The biologists tried several techniques, unsuccessfully. They then tried injecting the anticoagulant into the first stomach of cattle in doses harmless to the cattle, but not harmless to the vampires attacking cattle. Bats feeding on the blood of treated cattle received sufficient amounts of the anticoagulant to kill them. Cattle could be treated twice a year at 30 or 40 cents per animal. The method resulted in a 91% reduction in vampire bat bites and an increase in milk and beef production (Mitchell, Thompson, & Burns, 1972).

Science and Public Policy

Sometimes the public is unhappy with the progress that societies make toward the resolution of problems. Science is often implicitly accused. You have heard many times, “If scientists can put a man on the moon, why can’t they . . . ?” The implication is that scientists should be able to cure diseases, clear up pollution, end drug and discrimination problems, and eliminate the food supply problem. Some of these problems are technological, some scientific, but all are also philosophical, political, and economic. Problems of society must be dealt with at several levels. In addition to the scientific laws and basic principles, we also need the technology. Equally important, philosophical, political, and economic decisions must be made as to which problems will be addressed, and political support must be given to implement the decisions. We must decide philosophically the priorities of the goals we wish to pursue. Our economic system must be sufficiently robust to provide the necessary wealth. Politically, legislatures must pass legislation and provide funding to implement these goals. Many problems of the world are not scientific or technological, but philosophical, political, and economic.

Case Analysis

Many individuals claim special abilities, including extrasensory perception (ESP), the ability to predict the future, and the ability to see and hear people who are no longer living. In recent years, a few of the individuals who claim to see and hear the dead have become very well known and financially successful (for example, Sylvia Brown, John Edwards). In his television show *Crossing Over with John Edwards,* Mr. Edwards interacts with people in his audience and relays messages to them from departed friends and family. It is obvious that many people, both in the audience and viewing the TV show at home, believe John Edwards and believe in these special abilities. Let’s consider a few important questions.

Critical Thinking Questions

1. First, do you believe the information provided by John Edwards and others like him? Why or why not?
2. For those who do believe this information, what is its source—authority, personal experience, rationalism, or empiricism?
3. Do you believe that this information about our world is scientific? Which of the characteristics of science does this area possess? Which does it not possess?
4. If it is not scientific, is there a way to make it scientific?
5. Even if an area is not scientific, does that necessarily make it wrong or incorrect? Should people believe in knowledge that is not scientific?

General Summary

Our understanding of the world is based on several factors, including information from authority, personal experience, logical reasoning, and scientific inquiry. Scientific information is based on a set of assumptions, goals, and methods that are designed to provide the most accurate information about our world. By testing ideas through empirical observation and revising theories based on observations, science self-corrects as it reveals the secrets of nature. Although many of these secrets may not have immediate application to practical problems, such basic research increases our foundation of knowledge so that we will be poised to address the issues of the future. To increase this foundation of knowledge, we must be able to ask questions that can be tested empirically. Thus, the next chapter will discuss the formulation of research hypotheses.

Detailed Summary

1. Four principal means by which we gain knowledge are information from authorities, personal experiences, the logical reasoning of rationalism, and the systematic observations of empiricism.
2. Three primary goals of science are understanding, prediction, and control.
3. Science makes two basic assumptions: first, that events in the universe occur in a lawful and orderly manner (determinism), and second, that this lawfulness is discoverable.
4. Chaos theory is an attempt to understand complex, nonlinear, dynamic systems by using mathematical modeling.
5. The scientific method requires empirical referents—observable and measurable phenomena.
6. With science, accurate observations are followed by inferences that reflect the interpretation of and explanation for the observations.
7. The scientific method is characterized by empirical referents, repeatability, self-correction, systematic investigation, and falsifiability.
8. Inductive reasoning involves the formulation of a general principle or theory based on a set of specific observations. Conversely, deductive reasoning involves the formulation of specific observational predictions based on a general principle or theory.
9. Scientific information may or may not match commonsense information. Typically, science provides explanations that are more specific than the generalities of common sense.
10. Disciplines of science exist on a continuum from more molecular levels of analysis to more molar levels of analysis. The same phenomenon can be explained at different levels of analysis.
11. Basic scientific research is very important because we cannot determine today what discoveries will prove important for tomorrow, and we cannot determine today what problems we (the world) will experience tomorrow.
12. It is important to distinguish science from technology. Science is the accumulation of systematic observations and the explanations for those observations; technology is the application of scientific information.
13. Science does not happen in a vacuum. It is influenced by philosophical, political, economic, and technological values and priorities of society.

Key Terms

basic research

chaos theory

confirmation bias

deductive reasoning

determinism

empirical referent

empiricism

inductive reasoning

rationalism

reductionist

systematic observation

theory

Review Questions / Exercises

1. Consider several things that you believe to be true in the world. Identify one that is based on authority, one that is based on personal experience, one that is based on rationalism, and one that is based on empiricism.
2. Conduct an Internet search related to depression. Find and summarize information for each of the three goals of a science—in this case, the scientific study of depression.
3. In your own words, summarize why determinism is a necessary assumption of behavioral science. Do you agree with this assumption? Why or why not? We challenge you to identify a single behavior that is not the result of prior events in the world. Can you do it?
4. Paranormal psychology is a field that investigates phenomena such as extrasensory perception (ESP), astrology, graphology (relating handwriting to personality), ghosts/spirits, and dream analysis. Students who take introductory psychology classes are often disappointed that these topics are not included. The reason is that they are not scientific. You may know that Sigmund Freud emphasized dream analysis. Based on the characteristics of science discussed in this chapter, why is the interpretation of dreams unscientific?

5. Describe how we might study the issue of depression from a very molecular to a very molar level of analysis. Provide several examples of research at various points along this continuum.
6. At a scientific conference that one of your authors recently attended, there were several presentations on the sexual behavior of the Japanese quail. Do you believe that this is worthwhile science? Assume that it is your job to defend this basic research. Write an argument of support. How might such basic research have applicability either now or in the future?