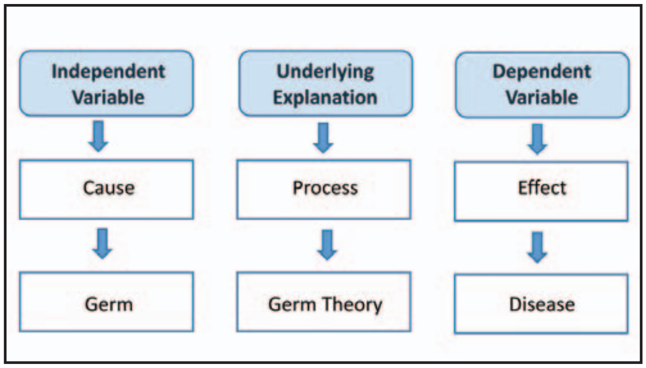

Figure 2-1. Relationship between the independent and dependent variable.

2.1 Science, Research, and Theory

The concept of the scientific method was first introduced by the ancient Greeks, who proposed that knowledge is enacted by formulating a hypothesis that leads to observation and logical reasoning (Northrop, 1981). The scientific method is founded upon an empirical view of the world. The scientific method can be summarized in four steps:

1. A hypothesis that is testable is proposed, preferably based on a proposed theory.
2. Objective observations are collected.
3. Results are analyzed in an unbiased manner.
4. Conclusions proposed are based on the results of the study and previous knowledge.

The dictionary definition of *research* is "systematic knowledge of the physical or material world gained through observation and experimentation" (Webster's College Dictionary, 1992, p. 1201). *Science* is defined as the "systematic, objective study of empirical phenomena and the resultant bodies of knowledge" (Gould & Kolb, 1964, p. 620). Research and science are almost identical in definition; both imply systematic objective inquiry resulting in knowledge. Scientific *theory*, on the other hand, is a comprehensive explanation of empirical data. Theory predicts what will be observed under certain conditions. A theory, formulated by induction from empirical data, represents a *proposed method* of understanding the world. It predicts causal relationships in nature. Theories are developed by considering underlying processes, linking an observed cause with an effect.

For example, when medical scientists investigated the relationship between a specific bacteria and the cause of a disease, a theory was proposed to explain this relationship. The theory served as the *underlying explanation*—that is, the link between the *independent variable* (presumed cause) and *dependent variable* (presumed effect). This relationship is schematically diagramed in Figure 2-1.

2.1.1 Theory Building

Theory building is a key part of research. Many assumed cause-effect relationships instead may be in actuality *associational* or *statistical relationships* where a direct connection between cause and effect does not exist. Instances of associational relationships are those phenomena in nature that may occur together, such as precipitation in India and an increased birth rate, or solar activity and wars. By proposing a theory, however, a researcher seeks to explain the direct relationship between observed causes and effects. Theory building is a way of distinguishing those relationships that are interdependent. Theories are developed by scientists who have systematically collected data. Proposed scientific theories generate research by inviting studies to support or refute them.

2.1.2 Characteristics of a Theory

A theory is defined "as a set of interrelated constructs (concepts), definitions and propositions that present a systematic view of phenomena by specifying relations among variables, with the purpose of explaining and predicting phenomena" (Kerlinger, 1986, p. 9). Scientific theories are characterized by certain assumptions:

- *Technical vocabulary, language, or terms are generated by a theory.* For example, Piaget, in developing a theory of cognitive development, introduced the terms *assimilation*, *accommodation*, and *differentiation*. Theorists now use these terms in child development to explain how a child thinks. Freud, in introducing the theory of psychoanalysis, gave new meaning to familiar terms such as *ego*, *id*, *super ego*, *unconscious*, *libido*, and *catharsis*. Sometimes these terms lose their ordinary connotations and take on the precise meanings of the theorist.
- *Natural phenomena or behavior can be explained by a theory.* For example, Darwin's theory of evolution was shaped by his observations of animals and the examination of fossils. He formulated a theory from years of painstaking field observation. The pieces of evidence he amassed on animal and plant evolution were mosaics that he composed to form a theory. His research expeditions were guided by questions about the wide variations in animal structure and behavior that he observed in his expeditions to South America and the Pacific Islands.
- *A theory is a tentative set of beliefs that can be supported or undermined by scientific research.* Pasteur, in 1863, proposed the germ theory after proving that the processes of putrefaction and fermentation were caused by microorganisms. In 1880, Koch built on the work of Pasteur by completing scientific laboratory investigation of tuberculosis and cholera, thus demonstrating the validity of the germ theory. Koch's (1880) postulates were an example of deterministic causality.

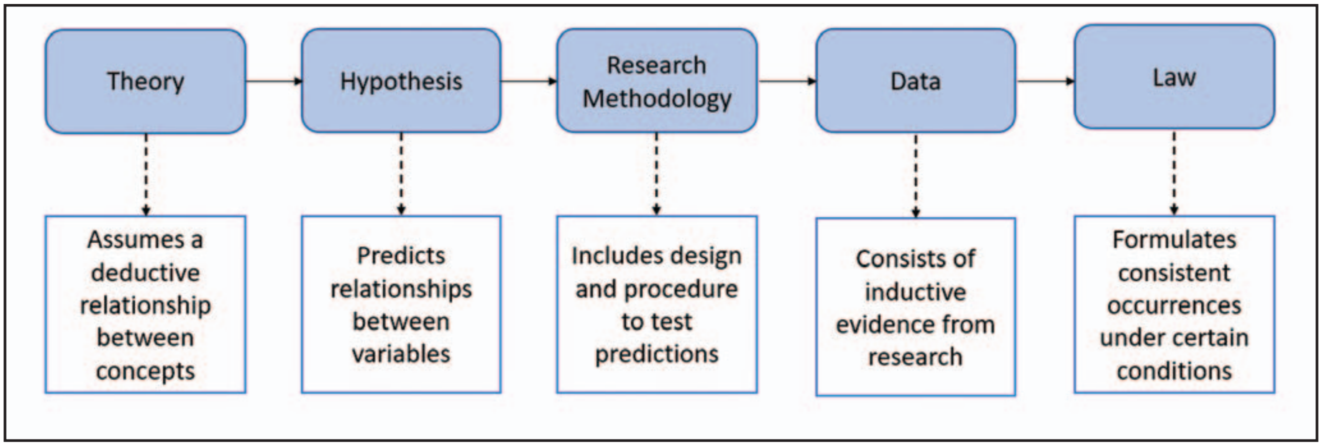

Figure 2-2. Relationship between theory and law. A theory can become a law only through accurate and systematic research resulting in repeated confirmatory findings.

To claim that an organism causes a disease, he required that (a) the organism must be isolated in every case of the disease (i.e., be necessary); (b) the organism must be grown in pure culture; (c) the organism must always cause the disease when inoculated into an experimental animal (i.e., be sufficient); and (d) the organism must then be recovered from the experimental animal and identified.

- *A theory predicts events that can be simulated in the laboratory or observed under controlled conditions.* The theory of genetic determinacy predicts that a child born with a chromosomal deficit, such as Down syndrome, may likely develop intellectual disabilities. An infant is diagnosed with Down syndrome when an extra chromosome 21 is detected through genetic screening.
- *A theory gives a researcher tools to interpret results and to form conclusions.* Konrad Lorenz (1937/1957), an ethnologist who received the Nobel Prize in Medicine, studied instinctive behavior patterns and proposed a theory of aggression. This theory seeks to explain the presence of conflicts and wars throughout human history.
- *A theory organizes knowledge and leads to the development of further theories.* Gesell's (1928) theory of development predicted that normal human growth is based on sequential, hierarchical stages that unfold at critical ages. Other theorists, such as Erikson (1950; eight stages of psychosocial development), Kohlberg (1981; theory of moral reasoning), and Brofenbrenner (1979; theory of ecological systems), were greatly influenced by Gesell's work in the 1920s.
- *A theory can be completely or partially accurate or completely inaccurate.* When Freud proposed the psychoanalytic theory at the turn of the 20th century, many of his colleagues rejected his work as unsubstantiated, based on clinical speculation. Psychoanalysis was later incorporated into psychiatric treatment programs, especially in the United States, from early in the 20th century until about 1960 when criticism started to appear in professional journals. Many parts of Freud's theory, such as the terms he defined, are widely used in many studies of psychotherapy. Does psychoanalysis retain any accuracy as a theory of behavior? This question is still unresolved.

For clinical research, theories are a critical component in a study. To paraphrase Lewin (1939), nothing is so practical as a good theory. A scientific theory implies that phenomena or events in the world can be explained in a logical or rational way. Theories are the engines for scientific research that relies on an inductive-deductive system of knowledge formation. Data, which are collections of facts or information, result from research and, in turn, can give rise to scientific theories. The systematic collection of data entails procedures for the review of previous results, the selection of research subjects, and the use of measuring instruments.

The relationship between theories and laws is diagramed in Figure 2-2. In all scientific research, the objectivity and scientific competence of the investigator are the most crucial variables. How a clinician or practitioner gains knowledge is often through the process of constructivism. Proponents of this paradigm of learning (constructivism) believe that a person gains knowledge through relating a personal experience to what he or she already knows. Constructivism is learner-driven rather than teacher-initiated (Piaget, 1977; Steffe & Gale, 1995; Vygotsky, 1986). A person can construct his or her knowledge base in several ways. Figure 2-3 describes major factors that promote constructivism.

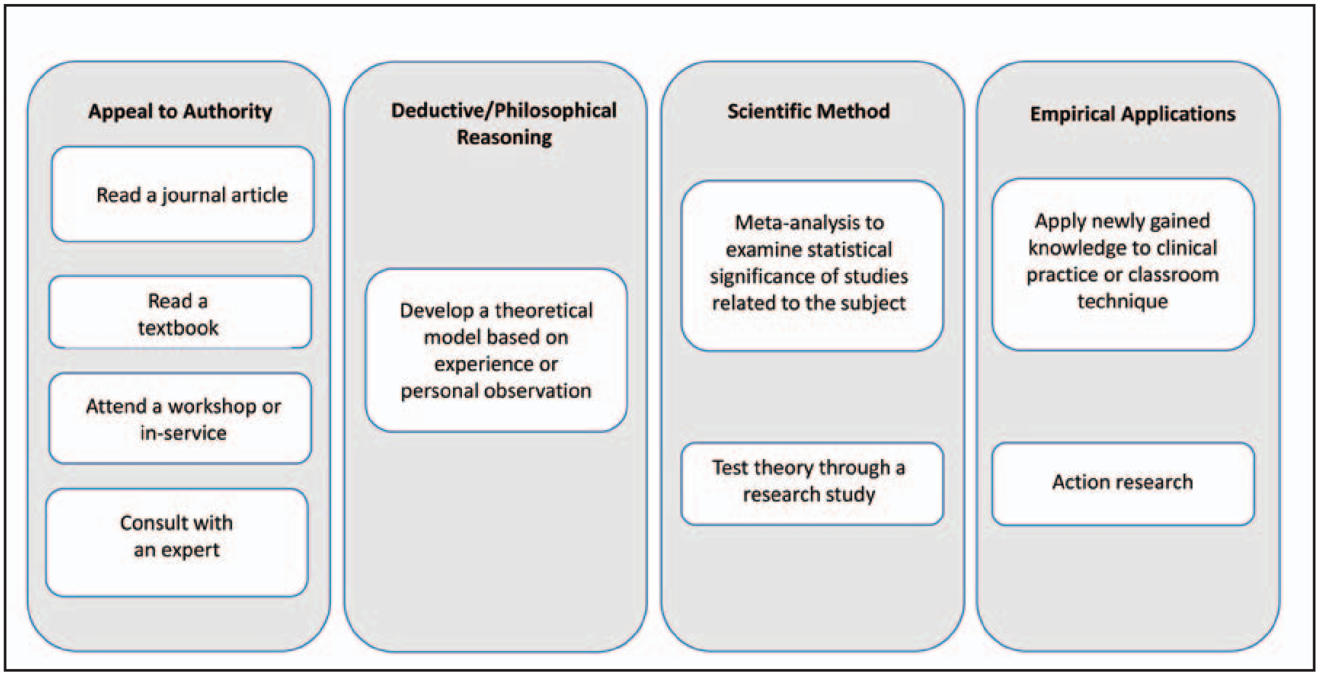

Figure 2-3. Factors that promote constructivism or the construction of one's knowledge base.

2.2 Fallacies Related to Research

Before the development of scientific research at the turn of the 20th century, our knowledge of medicine rested on a combination of trial and error methodology and deductive reasoning based on a priori assumptions. Fallacies growing out of the acceptance of invalid methods of treatment were common during times of superstition, such as in the Dark Ages in Europe and in primitive societies. These fallacies are incorrect arguments that are psychologically persuasive and, in many societies, continue to influence health practices. For example, contemporary practitioners who treat patients with methods that have no theoretical foundation act as if there were data supporting their methods. Some clinicians advocate a particular treatment method or drug based on the fallacious premise that a disease is highly prevalent, and therefore, any treatment is better than no treatment. A specific example of this may be the use of antibiotics to treat the cold virus. Also, explanations by authorities in the field are used to support therapeutic applications. In the past, experimentation with radical procedures, such as the use of psychosurgery with psychiatric patients, was rationalized as relevant to treatment merely because the patients were severely psychotic and considered hopeless. To cite another fallacy, people refuse to accept data linking smoking to lung cancer and heart disease because they assume it cannot happen to them, but only to other people. Knowledge of the more common fallacies is helpful to analyze objectively the validity of published studies. Gambrill (2012) proposed common fallacies that can occur in scientific research. These fallacies and others applied to health research and clinical practice are listed here.

2.2.1 Irrelevant Conclusion

This fallacy is evident when an investigator intends to establish a particular conclusion by shifting his or her argument to another conclusion. For example, a clinician seeks support for a treatment method for patients with arthritis by arguing that arthritis is a crippling disease affecting millions of individuals. The fallacy in this argument is that the clinician proposes the acceptance of a treatment method based on the irrelevant fact that a specific disease is widespread. In this case, the specific treatment method that is introduced requires objective data to support its use irrespective of the pressing need to help patients with arthritis. Another example of this fallacy in research is the use of unreliable or invalid tests because no other tests for measuring a specific variable exist. For example, a test written in English is given to a speaker whose first language is Navajo because there are no tests written in Navajo. Results obtained are questionable and probably invalid. If a test is invalid or unreliable, it should not be used to measure function.

2.2.2 Appeal to Authority

It is fallacious for a researcher to accept the opinions of respected scientists on the sole basis of their reputation but without any supporting data. For example, in recognizing an authority's knowledge of nutrition, an investigator may use his or her opinions to support a position that megavitamins are an effective treatment for patients with schizophrenia. The authority on nutrition may not have any research data to support or negate this position. A respected authority's personal opinion is not valid scientific evidence. Researchers who appeal to authorities as supporting evidence fail to separate a scientist's previous reputation from his or her current opinion. In an age of specialization, scientists are no longer encyclopedists who are knowledgeable in all areas. The intensive study required for excellence in one area makes it almost impossible to have expertise in other areas, even in related ones. When a researcher uses greatly respected scientists' opinions as supporting evidence, especially outside their area of competence, he or she is committing the fallacy of appeal to authority.

2.2.3 False Cause

This fallacy is common in societies where superstition and ignorance of cause and effect exist. Curing diseases through special amulets, magical words, or patent medicines are examples of the use of false cause. It also exists in some nonexperimental research where correlational relationships are observed. For example, it may be noted that a full moon is associated with an increase in admissions to psychiatric hospitals. The relationship between the full moon and insanity (Raison, Klein, & Steckler, 1999) is then fallaciously transposed to the conclusion that a full moon causes insanity. A cause-and-effect relationship is not established by correlational data.

In the absence of valid causes of a disease, simple and reductive explanations often are accepted. For example, a researcher investigating a complex variable, such as a learning disability, may accept *prima facie evidence* that the learning disability is caused by hyperactivity. The researcher bases this conclusion on correlational evidence that children with a learning disability are also hyperactive. The fallaciousness of the argument is illustrated in Figure 2-4.

In this hypothetical example, not all individuals with ADHD have a learning disability, although a large number of individuals with a learning disability do have ADHD. Nonetheless, there is no evidence to support the conclusion that ADHD causes a learning disability or that a learning disability causes ADHD. The very nature of a complex variable presupposes multiple causes and interactional effects among variables.

Another example of false cause in clinical practice is observing the effectiveness of a treatment method without adequately explaining the direct effect of treatment on improvement. Even though a treatment method is associated sequentially with improvement, it does not logically follow that it alone changed the condition of the patient. There may be other factors in a patient's experience or in the research conditions that could have contributed to a patient's or subject's improvement. These potential factors, which could affect the result of an experiment, must be controlled before a researcher can conclude that a specific treatment affects improvement. For example, the *placebo effect* (or "dummy treatment") is widely recognized in drug research as a change in a condition brought about seemingly by a drug but in reality by the power of suggestion that is attached to a drug. The *Hawthorne effect* is another example of a camouflaged relationship between cause and effect. In the Hawthorne effect, the change in behavior is produced by the attention of the researcher or clinician to the subjects or patients rather than solely by the specific treatment method applied. False cause is a fallacy based on traditional thinking or superstition and without supporting research evidence.

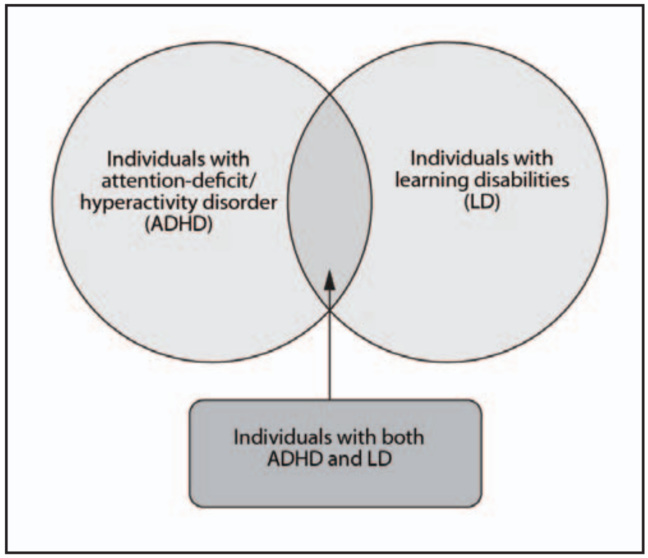

Figure 2-4. The diagram depicts the fallacy of the argument that all individuals with ADHD are learning disabled. In fact, there are two populations: individuals with ADHD and those with learning disabilities. A few of the individuals have both conditions.

2.2.4 Ambiguity

The lack of rigor in operationally defining terms and variables used in research produces the fallacy of ambiguity. When researchers compare outcome studies of wellness, perception, functional capacity, or weight loss, false conclusions may result if their comparisons fail to acknowledge the differences in defining and measuring these variables. Wellness can be defined in multiple ways and is measured by various tests and outcome measures. How the researcher defines and measures wellness will affect the conclusions and comparisons made. When a researcher states that there is a direct relationship between healthy living and wellness, one must denote how these variables were operationally defined. Otherwise one may be operating on a simplistic and false basis that fails to take into consideration the various ways of operationally defining wellness.

For the purpose of explanation, let us examine a hypothetical example of ambiguity as shown in Table 2-1. In this example, if the researcher did not state how these two variables—healthy living and wellness—are operationally defined, then there is no basis for comparing the results.

Table 2-1

Operationally Defining Ambiguous Terms

Presumed Cause: Healthy Living	**Presumed Effect (Outcome Measure):** Wellness
• Balanced diet • Adequate exercise • Reduction of stress • Positive interpersonal relationship	• Trips to a physician • Self-report • Findings from a physical examination • Standardized test of wellness

In actuality, there are many different studies measuring the relationship between these two abstract variables. For example, in one study the researcher could examine the effects of nutrition on the four outcome measures; in another study, exercise could be substituted for nutrition. Each of these presumed causes and effects will need to be elaborated on further so that another researcher can replicate the study.

Complex abstract variables that are investigated by researchers must be operationally defined; that is, the measuring instrument or procedure must be clearly identified before studies can be compared and conclusions proposed. Ambiguity is an example of comparing apples with oranges. For example, an investigator decides to use diet therapy as an independent variable (presumed cause) and weight reduction as the dependent variable (presumed effect); however, the specific method employed in diet therapy and the method used in measuring weight reduction are the variables that are, in fact, being investigated, not diet therapy or weight reduction per se. Clearly, operationally defining variables is important in eliminating the fallacy of ambiguity.

2.2.5 Generalization

Much quantitative scientific research involves collecting group data from a representative sample of a target population. Group data represent the average of all individual scores. Also, the data imply a range of scores from high to low on specific measured variables. The fallacy of generalization occurs when a researcher applies group data to a specific individual subject. For example, a researcher collects evidence of a statistically significant relationship between the absence of epilepsy and the occurrence of schizophrenia. The researcher concludes this from a study of seizures in which there were fewer individuals with epilepsy among patients with schizophrenia compared to the general population. However, the statistics are based on probability factors, not on a one-to-one relationship. The investigator can conclude only that there are fewer individuals with epilepsy in a population of individuals also exhibiting schizophrenia than in the general population, but not that every individual with epilepsy will not become schizophrenic nor that every individual with schizophrenia will not be epileptic. Nor can one conclude that if epilepsy is produced through electric shock, schizophrenia can be prevented or treated. This is a fallacy where group data describing a population is generalized to every individual in the population. The error variance in probability makes it impossible to make predictions about the specific individual from group data. One can only describe the general characteristics of groups, not the individual subjects that comprise the group. From probability statistics we can describe groups of patients, students, hospitals, or schools, but we are unable to predict the individual case with any confidence. For example, Alberg and Samet (2003), in reviewing the literature, reported that 90% of people who get lung cancer are smokers; however, we cannot predict which of those individuals who smoke will actually develop lung cancer.

Another example of generalization fallacy is in the selection of students based on entry examinations, such as the SAT or Graduate Record Examination. For example, a researcher interested in predicting academic success in an occupational therapy program may find a positive correlation of $r = .73$ between aptitude test scores and grade point averages. This is not a perfect correlation; however, it indicates only that many students with high aptitude test scores will attain relatively high grade point averages. If a program director has to predict a specific individual's success or failure, the data cannot support complete accuracy. In fact, the chance of error in predicting a specific individual's grade point average is high, although there may be accuracy in predicting a group's success in a program.

An example of the fallacy of generalization applied to clinical treatment is the *Procrustean bed*. In this case, clinicians who advocate a specific treatment method apply this method as a panacea to all patients regardless of individual differences. The clinician falsely applies the treatment method as a cure-all. For example, in the 15th and 16th centuries, tobacco was thought to have several therapeutic purposes and was considered to be a panacea for health. In the mid-20th century, the harmful effects of tobacco were established (Fraga, 2010). Good treatment implies fitting the best available treatment method to the individual based on his or her needs rather than fitting the patient to a panacea.

Despite the strong arguments used by researchers to convince clinicians to accept the findings of a study or the efficacy of a treatment method, the fallacies of irrelevant conclusion, appeal to authority, false cause, ambiguity, and generalization must be recognized by consumers of research as totally unacceptable means of advancing knowledge. The following discussion includes positive guidelines for analyzing the research process and the qualities of the researcher.

2.3 Critical Analysis of the Research Process

How is a research study judged to be either adequate or valid? How does one analyze the components of research and detect the biases of the investigator, the limitations of the design, and the deficiencies of the sampling procedure? The consumer of research must critically evaluate the methodology of a study before feeling confident in the results and conclusions. Many times, the results of a study are reported in mass media without an evaluation of the methodology. The results of research can play a prominent role in supporting or undermining a particular theory or social action. Governmental policies affecting funding patterns and priorities of social programs are influenced by the results of research studies. For example, continued funding of the children's television program *Sesame Street* is dependent on data that support the position that the program has educational value. Early childhood programs, such as Head Start, manpower retraining, state mental health systems, and graduate training programs in the occupational therapy profession are examples where evaluation research was used to justify federal grant support. The unfortunate policy of "benign neglect" toward minority groups during the latter half of the 1960s and 1970s was a result of government-sponsored research that supported the discontinuance of many antipoverty programs. When research is used as evidence to initiate or discontinue social programs, there is an obvious need to evaluate methodology before accepting or rejecting the conclusions. Research is not acceptable merely on the basis of social appeal, no matter how desirable the conclusions. Political considerations are one of the abuses of research that confront investigators of controversial social issues, such as community health programs or family planning.

Despite the diversity in content and the differences in application to treatment, all research has a common methodological format. When a researcher poses a question, the process of research is initiated. The question generates a search of the literature, predictions of results, and for quantitative research, a controlled objective procedure for collecting data. Background questions are generated by an investigator to help lead into specific research questions. This is a way of helping students to discover research topics of interest to them and to narrow a research study to feasible dimensions.

Raising background questions is a brainstorming tactic to lead one into a review of the literature. The student or clinical investigator is encouraged to list as many basic questions as possible to initiate a study. For example, if the goal of a clinical study is to determine the most effective treatment methods for children with traumatic brain injury (TBI), the background questions related to TBI would include the following:

- How is TBI operationally defined?
- What are the diagnostic tests to identify TBI?
- What are the prevalence and incidence rates of TBI?
- What are the most common treatment methods for children with TBI?
- What are the research data supporting treatment interventions for TBI?
- What are outcome measures used to measure treatment effectiveness?
- What is the typical course of the disability?
- What is the prognosis of TBI?
- How can vocational rehabilitation be used to treat individuals with TBI?
- How are functional capacity evaluations applied?

The investigator uses a literature review to answer some of these background questions. This process enables the investigator to become familiar with the research literature and to begin narrowing the study. In general, research is a process of systematically accumulating knowledge. What has been done previously is incorporated into current research. Background questions generate the research process and set in motion the beginning stages of completing a research study. Figure 2-5 describes this process.

The following outline of a quantitative research study is based on the scientific method. It is a systematic and objective way to investigate a topic.

I. A *title* includes variables investigated, populations studied, and the setting to which the results can be generalized, such as a hospital or outpatient clinic.

II. An *abstract* is usually between 150 and 300 words, contains 1 or 2 sentences from each section of the research study, and summarizes the findings, limitations of the methods, and recommendations for further research.

III. The *problem* includes the research questions examined and the stated need and significance of the study.

IV. A *literature review* contains the findings of related studies that are obtained through a systematic search.

V. *Stated hypotheses* include the operationally defined variables and research predictions.

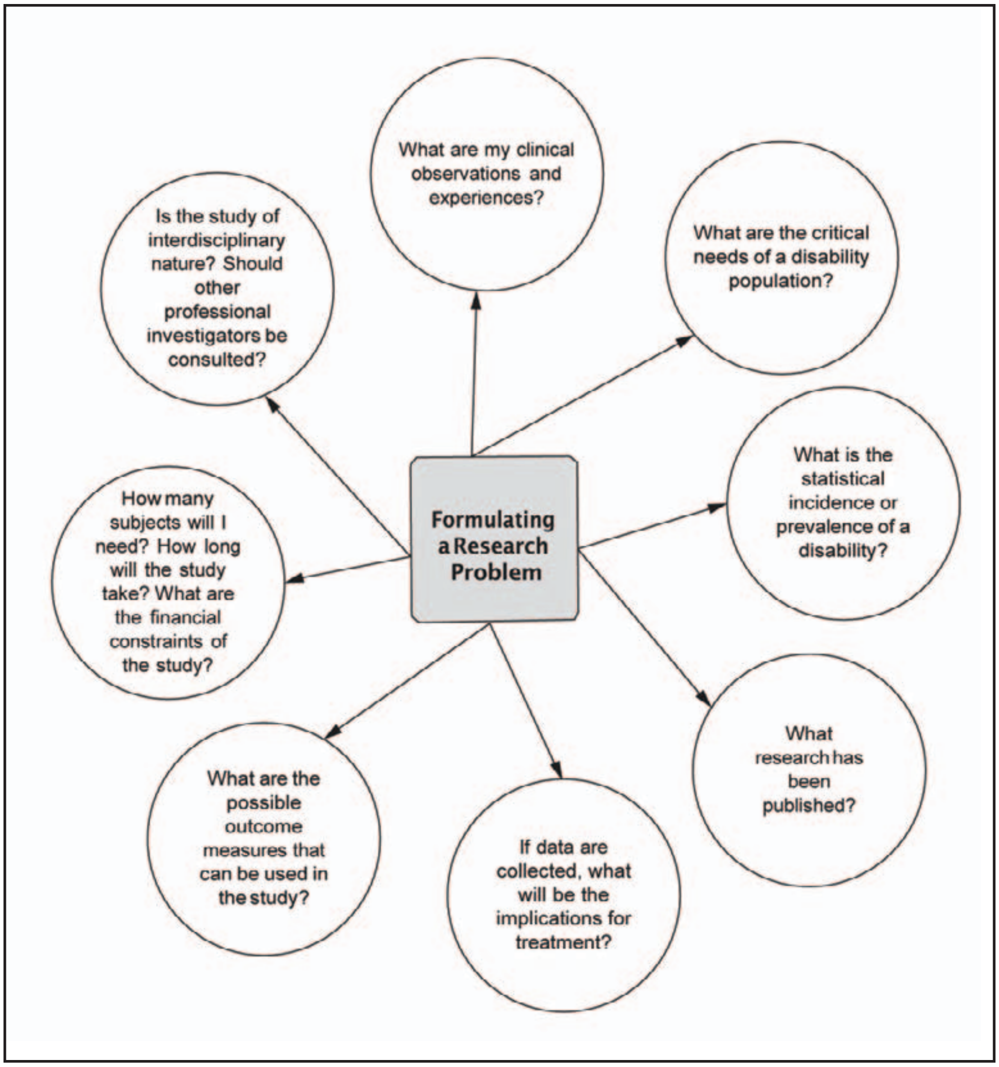

Figure 2-5. Raising basic questions, such as those in this figure, lead to a review of the literature as the beginning of a research study.

VI. A *methods section* includes obtaining approval from a human ethics review board, procedures for selecting subjects, screening criteria, measuring instruments, data collection procedures, and a plan for statistical analysis.

VII. *Results* include objective findings that are organized into tables, charts, and graphs and are statistically analyzed.

VIII. *Discussion, conclusions, limitations, and recommendations* include the significance of the findings related to previous research and the implications for further investigations.

Each of the subsections can be analyzed by posing specific questions relating to the objectivity of the investigator and the validity of the methods:

I. Title
  a. Does the title of the study clearly define what was actually done by the investigator or does it refer only to a segment of the study?
  b. Can the results of the study be generalized to the population identified by the title?
  c. Are the variables stated in the title identifiable and unambiguous?

II. Abstract
  a. Are the number of words between 150 and 300?
  b. Does the abstract include the highlights from each section of the study?
  c. Does the abstract summarize the results of the study?
  d. Are implications or recommendations for further research summarized?

III. Problem or research question
  a. Are the purposes or objectives of the study stated clearly?
  b. Are the research questions clearly identified?
  c. Is the study justified in relation to social need, importance, or potential contribution to occupational therapy?

d. Are statistics used to support the incidence and prevalence of a disability or to justify the investigation?
e. What is the relationship of the study to occupational therapy?
f. Does the study have a potential significant contribution to evaluation methods, treatment techniques, student training, or program administration?
g. Are the projected results of the study practical so they can be implemented into practice?
h. Is the researcher being objective in selecting a specific problem for investigation or is there evidence that personal biases will affect the results?

IV. Literature review
a. What information retrieval systems and primary sources of data did the investigator use in systematically reviewing the literature?
b. Are there theoretical assumptions that are unstated but are tacitly accepted?
c. What major areas were reviewed?
d. Was the literature search exhaustive in regard to the research problem?
e. Did the investigator use primary or secondary sources of information?
f. Was the investigator objective in listing results from studies that refute the stated hypotheses, as well as those studies that support the hypotheses?
g. How were previous studies reported? Did the investigator describe the number and characteristics of subjects and tests used when reporting the results of studies?
h. Are references up to date?
i. Did the researcher review a wide range of computer databases and journals related to the research topic?

V. Stated hypotheses
a. Are independent and dependent variables identifiable?
b. Are variables operationally defined?
c. Did the investigator present guiding questions?
d. Were hypotheses generated from a review of the literature, and did the investigator cite previous findings?
e. Were the hypotheses stated in null form or directionally?

VI. Research methods
a. How were the subjects selected for the study: randomly, convenience sample, or volunteers (e.g., they responded on their own to a mass communication)?
b. Were screening criteria used in selecting a representative sample (this may not be appropriate for all research designs)?
c. Were subjects a representative sample for a specified target population?
d. How were the measuring instruments selected?
e. Did the investigator state the reliability and validity of measuring instruments?
f. Do the measuring instruments have a test manual including standardized procedures for data collection and scoring?
g. How did the researcher inform subjects of risks and benefits in the study?
h. How easily could the research study be replicated?
i. Did the investigator carefully outline the procedure for data collection?

VII. Results
a. What statistical techniques were used in analyzing the data?
b. How were the results reported?
c. At what level of statistical significance were results reported?

VIII. Discussion, conclusions, limitations, and recommendations
a. Were the findings compared to or contrasted with previous literature?
b. Were conclusions justified from reported results?
c. Is researcher bias evident in interpreting results or "rationalizing away" results?
d. Were there unforeseen events that influenced results?
e. Are results omitted that contradict the hypothesis?
f. Were limitations of the study presented?
g. Is further research indicated?

2.4 Qualities of a Researcher

What are the qualities of a researcher? Scholars analyzing the process of research consider that the attitudes and integrity of the researcher are sometimes more important than the rigor of the methodology and the veneer of scientism. The following has been enlarged from Gee's (1950) discussion of the qualities of a researcher.

2.4.1 Dissonance

The researcher feels uncomfortable with an aspect of the world and the problem serves as the motivation for carrying out the research. Research is perceived as problem oriented. For example, Semmelweis's concern over the large number of maternal deaths after pregnancy in the 19th century spurred him to initiate research into the causes of puerperal fever. Salk's experimenting with a vaccine to prevent polio was concerned with the alarming incidence of polio world wide. These are two examples of medical researchers who were motivated by dissonance. Investigators starting with a problem, such as delinquency, malnutrition, AIDS, cancer, or homelessness, are energized and moved to action by the