DONALD ARY
LUCY CHESER JACOBS
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Introduction TO RESEARCH IN Education

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***Introduction to Research in Education*, Ninth Edition**

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To Donald Ary, our friend and colleague.

Contents

Preface

This edition of *Introduction to Research in Education* continues our commitment to providing a comprehensive, reader-friendly introduction to the concepts, principles, and methodologies used in educational research. As in previous editions, our goal is to provide students with the knowledge and skills needed to be intelligent consumers of research, as well as to plan and conduct quality research studies on their own. Recent federal legislation calls for more rigorous evidence-based research to provide knowledge for developing and evaluating effective educational programs and practices. Future educators who will be a part of this educational "revolution" need to understand and be prepared to carry out a research study. This book is written primarily for beginning graduate students in education, but it is also appropriate for students in other social sciences.

The sequence of topics in this text loosely corresponds to the steps in the research process. The first five chapters focus on an introduction to the scientific approach in education, the nature and selection of the research problem, the review of relevant literature, and the development of hypotheses. The next section deals with the measurement tools used in gathering research data and the statistical procedures used in the analysis of data. In the third section we introduce the major research methodologies used in both quantitative and qualitative educational research. The final section deals with interpreting and communicating the results of research.

NEW AND UPDATED IN THIS EDITION

For the ninth edition, we have retained features previously designed to enhance students' understanding and added additional features.

- "Think About It" boxes conclude major discussions in chapters, and prompt students to apply and think critically about material covered in a previous section. These exercises can be used as concept checks for students.
- Through original illustrations conceptualized by Donald Ary and created specifically for this book, the "Picture This" feature reinforces key chapter concepts in a clever and entertaining manner.
- A new feature in this edition is the "Research in the Public Eye" box in each chapter, which presents examples of research that appeared in popular publications. Students are asked questions that require them to critique various methodologies employed, interpret findings, and evaluate the conclusions reached.
- End-of-chapter exercises expose students to intriguing research problems and help develop critical thinking.

In addition to these new features, all chapters and references have been thoroughly updated for this edition. Most notably, Chapter 4 has been revised to include the latest Internet search tools and electronic database resources for accessing related literature.

SUPPLEMENTS

Instructor's Manual with Test Bank and Online ExamView®

The online Instructor's Manual, available through the instructor web site, contains information to assist the instructor in designing the course. For assessment support, the Test Bank offers over 100 questions to assess your students' knowledge.

Also available for download from the instructor web site, ExamView® testing software includes all the test items from the Test Bank in electronic format, enabling you to create customized tests in print or online.

Powerpoint Slides

Available for download at the instructor's web site, these ready-to-use Microsoft® PowerPoint® lecture slides cover content for each chapter of the book.

Companion Web Site

The book-specific web site offers students a variety of study tools and useful resources including glossary/flashcards, online workshops, tutorial quizzes, and links related to each chapter. Students can access these book resources through CengageBrain.com. For instructors, the instructor's manual with test bank, PowerPoint slides, and ExamView files are available for download.

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We welcome David A. Walker as a new co-author for the ninth edition. We want to thank Gregg S. Geary, Interim University Librarian and Director of the Student Success Center at the University of Hawaii at Manoa, for his work on updating the chapter on library and Internet resources. We are grateful to Pearson Education Ltd. on behalf of the literary executor of the late sir Ronald A. Fisher, F.R.S., and the late Dr. Frank Yates, F.R.S., for permission to reprint Tables III, IV, and VII fro m *Statistical Tables for Biological, Agricultural and Medical Research* (6th ed., 1974).

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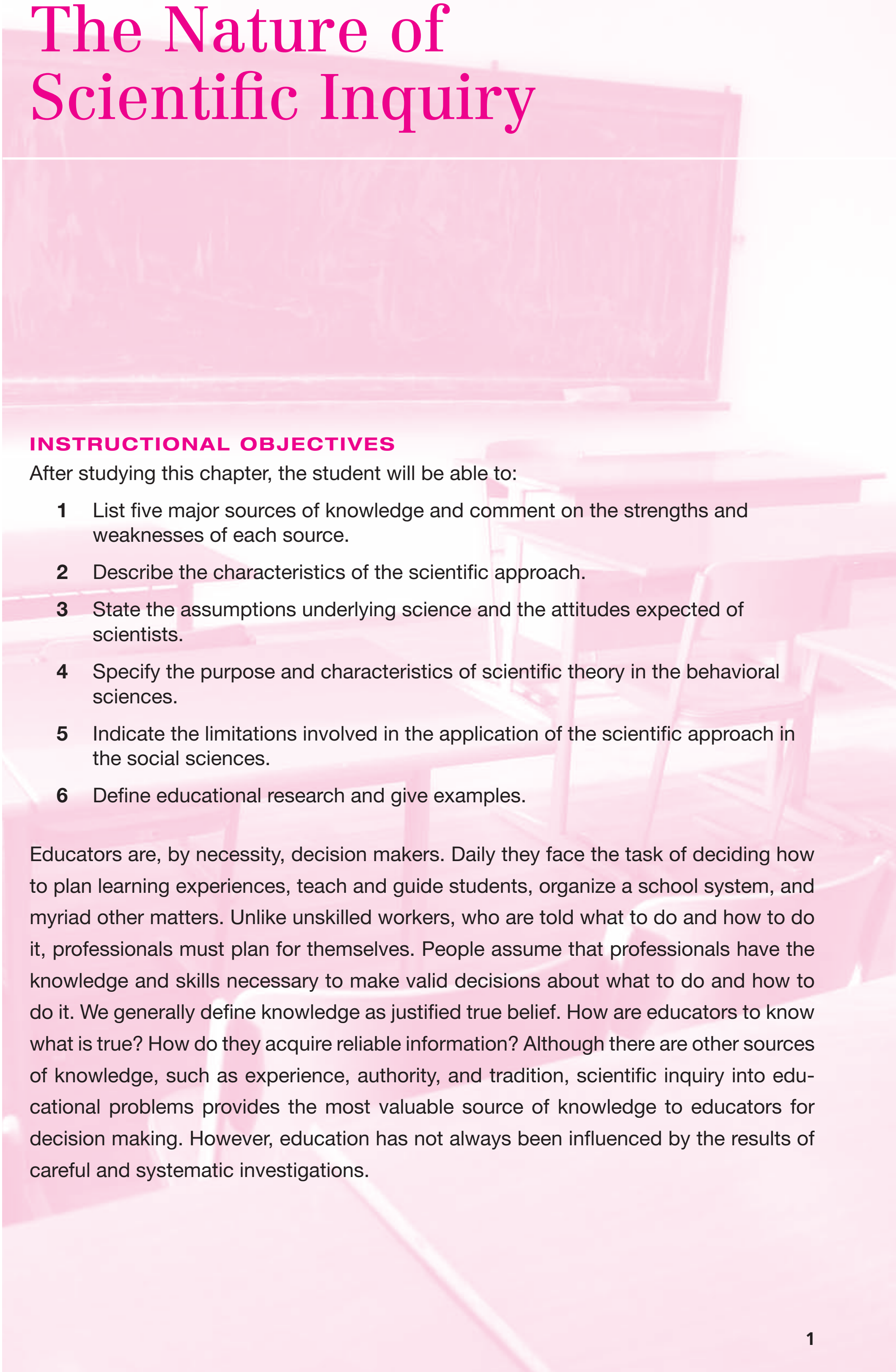

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Knowledge
is power.

CHAPTER 1

The Nature of Scientific Inquiry

INSTRUCTIONAL OBJECTIVES

After studying this chapter, the student will be able to:

1. List five major sources of knowledge and comment on the strengths and weaknesses of each source.
2. Describe the characteristics of the scientific approach.
3. State the assumptions underlying science and the attitudes expected of scientists.
4. Specify the purpose and characteristics of scientific theory in the behavioral sciences.
5. Indicate the limitations involved in the application of the scientific approach in the social sciences.
6. Define educational research and give examples.

Educators are, by necessity, decision makers. Daily they face the task of deciding how to plan learning experiences, teach and guide students, organize a school system, and myriad other matters. Unlike unskilled workers, who are told what to do and how to do it, professionals must plan for themselves. People assume that professionals have the knowledge and skills necessary to make valid decisions about what to do and how to do it. We generally define knowledge as justified true belief. How are educators to know what is true? How do they acquire reliable information? Although there are other sources of knowledge, such as experience, authority, and tradition, scientific inquiry into educational problems provides the most valuable source of knowledge to educators for decision making. However, education has not always been influenced by the results of careful and systematic investigations.

SOURCES OF KNOWLEDGE

Before we further pursue the role of scientific inquiry in education, let us review some of the ways in which human beings throughout history have sought knowledge. The major sources of knowledge can be categorized under five headings: (1) experience, (2) authority, (3) deductive reasoning, (4) inductive reasoning, and (5) the scientific approach.

EXPERIENCE

Experience is a familiar and well-used source of knowledge. After trying several routes from home to work, you learn which route takes the least time or is the most traffic free or the most scenic. Through personal experience, you can find answers to many questions that you face. Much wisdom passed from generation to generation is the result of experience. If people were not able to profit from experience, progress would be severely retarded. In fact, this ability to learn from experience is a prime characteristic of intelligent behavior.

Yet for all its usefulness, experience has limitations as a source of knowledge. How you are affected by an event depends on who you are. Two people will have very different experiences in the same situation. The same forest that is a delightful sanctuary to one person may be a menacing wilderness to another. Two supervisors observing the same classroom at the same time could truthfully compile very different reports if one focused on and reported the things that went right and the other focused on and reported the things that went wrong.

Another shortcoming of experience is that you so frequently need to know things that you as an individual cannot learn by experience. A child turned loose to discover arithmetic alone might figure out how to add but would be unlikely to find an efficient way to compute square roots. A teacher could learn through experience the population of a classroom on a particular day but could not personally count the population of the United States.

AUTHORITY

For things difficult or impossible to know by personal experience, people frequently turn to an *authority;* that is, they seek knowledge from someone who has had experience with the problem or has some other source of expertise. People accept as truth the word of recognized authorities. We go to a physician with health questions or to a stockbroker with questions about investments. To learn the size of the U.S. population, we can turn to reports by the U.S. Bureau of the Census. A student can look up the accepted pronunciation of a word in a dictionary. A superintendent can consult a lawyer about a legal problem at school. A beginning teacher asks an experienced one for suggestions and may try a certain technique for teaching reading because the teacher with experience suggests that it is effective.

Throughout history you can find examples of reliance on authority for knowledge, particularly during the Middle Ages when people preferred ancient scholars such as Plato and Aristotle, and the early Fathers of the Church, as sources of information—even over direct observation or experience. Although authority is a very useful source of knowledge, you must always ask, How does

Joe Rocco

authority know? In earlier days, people assumed an authority was correct simply because of the position he or she held, such as king, chief, or high priest. Today, people are reluctant to rely on an individual as an authority merely because of position or rank. They are inclined to accept the assertions of an authority only when that authority is indeed a recognized expert in the area.

Closely related to authority are *custom* and *tradition*, on which people depend for answers to many questions related to professional as well as everyday problems. In other words, people often ask "How has this been done in the past?" and then use the answer as a guide for action. Custom and tradition have been prominent influences in the school setting, where educators often rely on past practices as a dependable guide. However, an examination of the history of education reveals that many traditions that prevailed for years were later found to be erroneous and had to be rejected. For generations, it was considered good practice to humiliate students who made mistakes with dunce caps and the like. It is wise to appraise custom and tradition carefully before you accept them as reliable sources.

Authority is a quick and easy source of knowledge; however, it has shortcomings that you must consider. First, authorities can be wrong. People often claim to be experts in a field when they do not really have the knowledge to back up the claim. Second, you may find that authorities disagree among themselves on issues, indicating that their authoritative statements are often more personal opinion than fact.

DEDUCTIVE REASONING

Ancient Greek philosophers made perhaps the first significant contribution to the development of a systematic approach for gaining knowledge. Aristotle and his followers introduced the use of **deductive reasoning,** which can be described as a thinking process in which you proceed from general to specific knowledge through logical argument. An argument consists of a number of statements standing in relation to one another. The final statement is the conclusion, and the other statements, called *premises*, offer supporting evidence. One major type of deductive reasoning is the syllogism. A syllogism consists of a major premise and a minor premise followed by a conclusion. For example, "All men are mortal" (major premise); "The king is a man" (minor premise); "Therefore, the king is mortal" (conclusion). In deductive reasoning, if the premises are true, the conclusion is necessarily true. Deductive reasoning lets you organize premises into patterns that provide convincing evidence for a conclusion's validity. Mystery fans will recall that Sherlock Holmes frequently would say, "I deduce …" as he combined previously unconnected facts in such a way as to imply a previously unsuspected conclusion.

Deductive reasoning can answer the question, "How likely is it that a student could pass a 20-item multiple-choice test with five options per item by chance alone?" Given the premise that there is a 20 percent chance of getting a single item right and an 80 percent chance of getting it wrong, and given the premise that these same chances are true for every item, Figure 1.1 shows the probability of the following outcomes with three items.

The probability of getting three right is .008. There are three ways to get two right and one wrong, so the probability of two right is (.032)(3) = .096. The

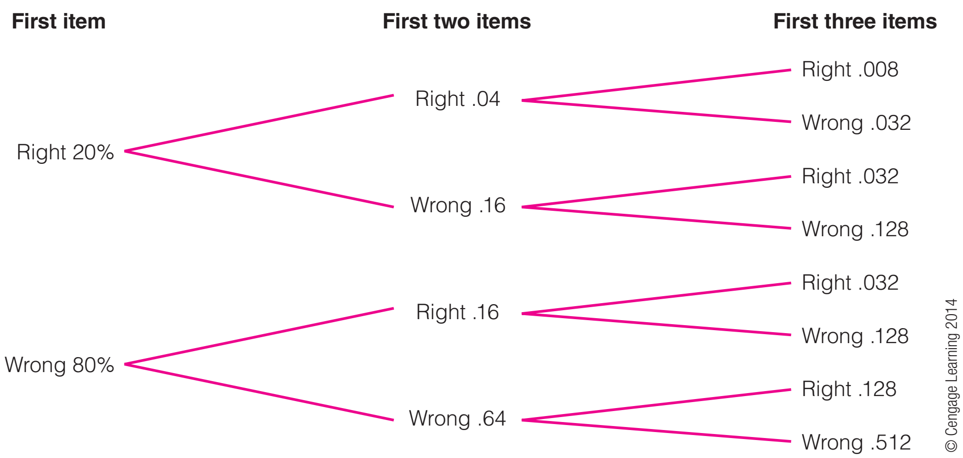

Figure 1.1 Probabilities of Getting Various Outcomes with Three Items

probability of getting one right and two wrong is (.128)(3) = .384. There is only one way to get three wrong; that probability is .512.

If we extended Figure 1.1 to determine the likelihood of getting a passing 60 percent (12 correct items in a 20-item test), we would find there is approximately one chance in 10,000 of passing. The probability of passing two 20-item tests is $(1/10{,}000)^2$ or one chance in 100 million. The notion that a student has a reasonable chance of passing a test through sheer guessing is a myth.

Deductive reasoning has its limitations. To arrive at true conclusions, you must begin with true premises. The conclusion of a syllogism can never exceed the content of the premises. Because deductive conclusions are necessarily elaborations on previously existing knowledge, you cannot conduct scientific inquiry through deductive reasoning alone because it is difficult to establish the universal truth of many statements dealing with scientific phenomena. Deductive reasoning can organize what people already know and can point out new relationships as you proceed from the general to the specific, but it is not sufficient as a source of new knowledge. Despite its limitations, deductive reasoning is useful in research because it provides a way to link theory and observation. It lets researchers deduce from existing theory what phenomena they should observe. Deductions from theory form hypotheses, which are a vital part of scientific inquiry.

INDUCTIVE REASONING

As noted previously, the conclusions of deductive reasoning are true only if the premises on which they are based are true. But how are you to know if the premises are true? In the Middle Ages, people often substituted dogma for true premises, so they reached invalid conclusions. It was Francis Bacon (1561–1626) who first called for a new approach to knowing. He held that thinkers should not enslave themselves by accepting premises handed down by authority as absolute truth. He believed that an investigator should establish general conclusions on the basis of facts gathered through direct observation. Bacon advised the seeker of truth to observe nature directly and to rid his or her mind of prejudice and preconceived ideas, which Bacon called "idols." For him, obtaining knowledge required that the thinker observe nature itself, gather particular facts, and formulate generalizations from these findings. You can see the importance of observation in the following anecdote (probably apocryphal) attributed to Bacon:

> In the year of our Lord 1432, there arose a grievous quarrel among the brethren over the number of teeth in the mouth of a horse. For 13 days the disputation raged without ceasing. All the ancient books and chronicles were fetched out, and wonderful and ponderous erudition, such as was never before heard of in this region, was made manifest. At the beginning of the 14th day, a youthful friar of goodly bearing asked his learned superiors for permission to add a word, and straightway, to the wonderment of the disputants, whose deep wisdom he sore vexed, he beseeched them to unbend in a manner coarse and unheard-of, and to look in the open mouth of a horse and find an answer to their questionings. At this, their dignity being grievously hurt, they waxed exceedingly wroth; and, joining in a mighty uproar, they flew upon him and smote him hip and thigh, and cast him out forthwith. For, said they, surely Satan hath tempted this bold neophyte to declare unholy and unheard-of ways of finding truth contrary to all

> the teachings of the fathers. After many days more of grievous strife the dove of peace sat on the assembly, and they as one man, declaring the problem to be an everlasting mystery because of a grievous dearth of historical and theological evidence thereof, so ordered the same writ down (Mees, 1934, p. 115).

The youth in this story was calling for a new way of seeking truth: namely, seeking the facts rather than depending on authority or on sheer speculation. This became the fundamental principle of all science.

In Bacon's system, the investigator made observations on particular events in a class (or category) and then, on the basis of the observed events, made inferences about the whole class. This approach, known as **inductive reasoning**, is the reverse of the deductive method. You can see the difference between deductive and inductive reasoning in the following examples:

Deductive: Every mammal has lungs.
All rabbits are mammals.
Therefore, every rabbit has lungs.

Inductive: Every rabbit that has ever been observed has lungs.
Therefore, every rabbit has lungs.

Note that in deductive reasoning you must know the premises before you can reach a conclusion, but in inductive reasoning you reach a conclusion by observing examples and generalizing from the examples to the whole class or category. To be absolutely certain of an inductive conclusion, the investigator must observe all examples. This is known as **perfect induction** under the Baconian system; it requires that the investigator examine every instance of a phenomenon. In the preceding example, to be absolutely sure that every rabbit has lungs, the investigator would have to make observations of all rabbits currently alive, as well as all past and future rabbits. Clearly, this is not feasible; you generally must rely on imperfect induction based on incomplete observation.

Imperfect induction is a system in which you observe a sample of a group and from that sample infer characteristics of the entire group. An example of a conclusion based on imperfect induction is the present thinking concerning the physical characteristics of very intelligent children. For many years, people generally believed that exceptionally bright children tended to be poor physical specimens. Even today, cartoonists portray the bright child as a scrawny creature with thick spectacles. Terman, a pioneer in the field of mental testing, was interested in the characteristics of exceptionally bright youngsters (Terman, 1926). In a landmark investigation, Terman intensively studied more than 1,000 California children who scored higher than 140 on the Stanford-Binet intelligence test. He found the average height, weight, and general physical health of these children to be slightly above average for children of their age. From this and subsequent studies of the phenomenon, researchers have concluded that bright children, far from being scrawny, are slightly more likely to be above average in physical development than children with average IQ scores. Note that this conclusion has not been positively proved. It is simply probable. To be positively sure about this conclusion, you would need physical measures for *all* children with IQ scores of 140 or higher on the Stanford-Binet. Even then, you could only be positive about the characteristics of such children today; you could not be 100 percent sure that the same would be true of such children in the future. Although imperfect induction does not lead to infallible conclusions, it can provide reliable information about what is likely to be true and on which you can make reasonable decisions.

An inductive way to investigate the question, "Should you stick with your original answers on a multiple-choice test, or should you change your answers when, upon reconsideration, you think you have a better answer?," would be to go over scored exams and identify items with erasures or cross-outs. Then count the changes that go from right to wrong, wrong to right, or wrong to wrong.

Dozens of researchers have published the results of such studies, beginning with Crawford (1928). These studies have all found that more changes are from wrong to right than from right to wrong. Waddell and Blankenship (1994), through a thorough search of the literature for the years 1988–1992, found 61 studies whose results could be combined through meta-analysis (see Chapter 6). The combined results were as follows: 57 percent of changes were from wrong to right, 21 percent were from right to wrong, and 22 percent were from wrong to wrong. Therefore, the best advice is to encourage students to make changes whenever, after rethinking, they find an answer that they prefer over their original answer. It is interesting to note that those studies that also surveyed students and professors found the majority advised sticking with your original answer. The myth that you should stick with your original answer has persisted for generations, despite overwhelming evidence to the contrary.

> It's not so much what folks don't know that causes problems.
> It's what they know that ain't so.
>
> Artemus Ward

THE SCIENTIFIC APPROACH

Exclusive use of induction often resulted in the accumulation of isolated facts and information that made little contribution to the advancement of knowledge. Furthermore, people found that many problems could not be solved by induction alone. In the 19th century, scholars began to integrate the most important aspects of the inductive and deductive methods into a new technique, namely the inductive-deductive method, or the **scientific approach.** This approach differs from inductive reasoning in that it uses hypotheses. A **hypothesis** is a statement describing relationships among constructs. Constructs are abstract ideas devised on the basis of observations in order to relate the observations to theory, but constructs themselves are not observable. Examples of constructs include motivation, achievement, etc. We will discuss constructs more fully in Chapter 2. Once a hypothesis is formed, it is tentatively assumed to be true. It identifies observations to be made to investigate a question.

For example, a researcher interested in enhancing mathematics performance might hypothesize that the use of a computer-based mathematics game would improve performance on mathematics assessments. All hypotheses indicate specific phenomena to be observed (the variables)—in this case, use of the game, and improvement in students' mathematics performance.

Charles Darwin, in developing his theory of evolution, is generally recognized as the first to apply this method in the pursuit of knowledge. Darwin reported that he spent a long time making biological observations, hoping to establish some generalizations concerning evolution. In the following passage, he describes how he arrived at a new approach:

> My first note-book (on evolution) was opened in July 1837. I worked on true Baconian principles, and without any theory collected facts on a wholesale scale, more especially with respect to domesticated productions, by printed enquiries, by conversation with skillful breeders and gardeners, and by extensive reading. When I see the list of books of all kinds which I read and abstracted, including whole series of Journals and Transactions, I am surprised at my industry. I soon perceived that selection was the keystone of man's success in making useful races of animals and plants. But how selection would be applied to organisms living in a state of nature remained for some time a mystery to me. In October 1838, that is, fifteen months after I had begun my systematic enquiry, I happened to read for amusement "Malthus on Population," and being well prepared to appreciate the struggle for existence which everywhere goes on from long-continued observation of the habits of animals and plants, it at once struck me that under these circumstances favourable variations would tend to be preserved, and un-favourable ones to be destroyed. The result of this would be the formation of new species. Here then I had at last got a theory by which to work (Darwin, 2007, p. 68).

Darwin's procedure, involving only observation, was unproductive until reading and further thought led him to formulate a tentative hypothesis to explain the facts that he had gathered through observation. He then proceeded to test this hypothesis by making deductions from it and gathering additional data to determine whether these data would support the hypothesis. From this method of inquiry, Darwin was able to develop his theory of evolution. This use of both inductive and deductive reasoning is characteristic of modern scientific inquiry.

The scientific approach is generally described as a method of acquiring knowledge in which investigators move inductively from their observations to hypotheses and then deductively from the hypotheses to the logical implications of the hypotheses. They deduce the consequences that would follow if a hypothesized relationship were valid. If the deduced implications are compatible with the organized body of accepted knowledge, researchers then further test them by gathering empirical data. On the basis of the evidence, they accept or reject the hypotheses.

The use of hypotheses is the principal difference between the scientific approach and inductive reasoning. In inductive reasoning, you make observations first and then organize the information gained. In the scientific approach, you reason what you would find if a hypothesis were true and then make systematic observations to confirm (or fail to confirm) the hypothesis.

AN EXAMPLE OF THE SCIENTIFIC APPROACH

In a classic example, award-winning author Robert Pirsig provides a vivid and succinct description of the scientific approach by comparing it to the process of maintaining a motorcycle in good working order:

> Two kinds of logic are used, inductive and deductive. Inductive inferences start with observations of the machine and arrive at general conclusions. For example, if the cycle goes over a bump and the engine misfires, and then goes over

another bump and the engine misfires, and then goes over another bump and the engine misfires, and then goes over a long smooth stretch of road and there is no misfiring, and then goes over a fourth bump and the engine misfires again, one can logically conclude that the misfiring is caused by the bumps. That is induction: reasoning from particular experiences to general truths.

Deductive inferences do the reverse. They start with general knowledge and predict a specific observation. For example, if, from reading the hierarchy of facts about the machine, the mechanic knows the horn of the cycle is powered exclusively by electricity from the battery, then he can logically infer that if the battery is dead the horn will not work. That is deduction.

Solution of problems too complicated for common sense to solve is achieved by long strings of mixed inductive and deductive inferences that weave back and forth between the observed machine and the mental hierarchy of the machine found in the manuals. The correct program for this interweaving is formalized as scientific method.

Actually I've never seen a cycle-maintenance problem complex enough really to require full-scale formal scientific method. Repair problems are not that hard. When I think of formal scientific method an image sometimes comes to mind of an enormous juggernaut, a huge bulldozer—slow, tedious, lumbering, laborious, but invincible. It takes twice as long, five times as long, maybe a dozen times as long as informal mechanic's techniques, but you know in the end you're going to *get* it. There's no fault isolation problem in motorcycle maintenance that can stand up to it. When you've hit a really tough one, tried everything, racked your brain and nothing works, and you know that this time Nature has really decided to be difficult, you say, "Okay, Nature, that's the end of the nice guy," and you crank up the formal scientific method.

For this you keep a lab notebook. Everything gets written down, formally, so that you know at all times where you are, where you've been, where you're going, and where you want to get. In scientific work and electronics technology this is necessary because otherwise the problems get so complex you get lost in them and confused and forget what you know and what you don't know and have to give up. In cycle maintenance things are not that involved, but when confusion starts it's a good idea to hold it down by making everything formal and exact. Sometimes just the act of writing down the problems straightens out your head as to what they really are.

The logical statements entered into the notebook are broken down into six categories: (1) statement of the problem, (2) hypotheses as to the cause of the problem, (3) experiments designed to test each hypothesis, (4) predicted results of the experiments, (5) observed results of the experiments, and (6) conclusions from the results of the experiments. This is not different from the formal arrangement of many college and high school lab notebooks but the purpose here is no longer just busywork. The purpose now is precise guidance of thoughts that will fail if they are not accurate.

The real purpose of scientific method is to make sure Nature hasn't misled you into thinking you know something you don't actually know. There's not a mechanic or scientist or technician alive who hasn't suffered from that one so much that he's not instinctively on guard. That's the main reason why so much scientific and mechanical information sounds so dull and so cautious. If you get