Preface to the Second Edition

When the first edition of this textbook went to press in 2000, responsible conduct of research (RCR) was in its infancy. Since then, there has been a great deal of change at many different levels—governmental, institutional, and individual. The Office of Research Integrity (ORI), part of the U.S. government, has funded empirical research, conferences, and curriculum development on RCR. Another part of the federal government, the National Science Foundation (NSF), has adopted new RCR education and training requirements. At the institutional level, many universities have developed RCR policies and implemented RCR education and training policies, and scientific journals have also developed rules and policies. At the individual level, researchers have published numerous books and articles on RCR and developed RCR courses, class materials, and training modules. However, it is not yet clear whether all of this activity has had a significant impact on scientific attitudes and behavior, and there are still many serious challenges in the field of RCR.

The media headlines featuring research misconduct in American universities continue to focus public attention on the dramatic ethical problems that can arise in research. In some instances, investigators have been accused and occasionally found guilty of falsifying, fabricating, or plagiarizing data. Since the first edition, there have been major fraud cases involving stem cells, nanotechnology, and clinical trials. There is widespread concern that public confidence in the scientific research establishment has been undermined. In the current atmosphere of accountability, the once-exempt research enterprise continues to be under increased scrutiny by the media, Congress, and the public. Issues related to conflict of interest and how it adversely affects research have been at the forefront of concerns among the congressional leaders, the public, and the media. Most clinical trials are now conducted outside the United States, often in developing countries. Many other issues also have gained in importance and attention, such as genetics and stem cells, research with vulnerable groups, and international research. In response to these pressures, there have been many calls for reforms in dealing with conflict of interest. This concern reached its heights when the U.S. Congress demanded and received the strongest conflict of interest rules governing the employees of the National Institutes of Health (NIH).

For some years, all trainees (students, fellows, and others) on training grants from the NIH have been required to have some exposure to issues related to research ethics. In the fall of 2000, the ORI announced its long-awaited mandate for training and education in RCR. The agency recommended that all personnel involved in research funded by U.S. Public Health Service grants or contracts, including principal investigators, postdoctoral...
4. Do you think researchers should adhere to the same ethical standards that apply to other professions, such as medicine or law? Why or why not?

5. Do you think researchers have ethical duties and responsibilities “over and above” the ethical obligations of ordinary people?

6. Can you think of any principles to add to our list of principles for ethical research conduct? What would they be, and how would they be justified? Do you think our list contains some principles that should be omitted or reworded?

7. Is reasoning the best method for making an ethical decision? Why or why not?

8. Do you think that ethical theories and principles have some bearing on practical choices and decisions? Why or why not?

9. How should one resolve conflicts among ethical principles? Do you agree with our approach to conflict resolution?

10. What ethical principles are most important in society? In science?

Scientific research is the systematic attempt to describe, explain, and understand the world. While all three main branches of science—physical science, biomedical science, and social and behavioral science—study different aspects of the natural world, they share some common methods and procedures. These methods and procedures are designed to achieve the goals of science by helping researchers to acquire accurate knowledge and information. Researchers' compliance with scientific methods and procedures can help to minimize falsehoods and biases and maximize truth and objectivity (Shamoo and Annau 1987, Cheny 1993, Kitcher 1993, Resnik 2007b). One pillar of the scientific method is that researchers should subject their theories and hypotheses to rigorous tests (Popper 1959). A test is an attempt to gather empirical evidence (i.e., data) that tends to either confirm or disconfirm a theory or a hypothesis. Ideas that cannot be tested, such as metaphysical theories or ideological claims, are not scientific hypotheses, theories, or facts. Some (but not all) tests involve experiments. In an experiment, a researcher attempts to reduce the number of variables and to control the conditions of a test in order to understand statistical or causal relationships between variables or parameters. For an experiment to be rigorous, a researcher must describe it in enough detail that other researchers can obtain the same results by replicating the experimental conditions (Kirk 1995).

Repeatability is important in experimentation because it confirms that others can carry out the methods and procedures used and attain the same data. Repeatability, or lack thereof, provides substance for public debate and inquiry. Private intuitions, hunches, faith, introspection, or insight can play an important role in generating new ideas to test, but they do not constitute rigorous proof. Therefore, all test results in science, whether from controlled experiments, field observations, surveys, epidemiological studies, computer models, or meta-analyses, should be open to public scrutiny and debate. Peer review, with some limitations, is one of science's most important methods.
because it promotes the public scrutiny of hypotheses, theories, and test results. Peer review also plays an important preliminary gate-keeping role, ensuring that interpretations of data are self-consistent and consistent with existing literature. In this manner, peer review can contribute to the quality and integrity of published research. Once a hypothesis or theory becomes well established, it may be said to be a "fact," and it is no longer subjected to rigorous tests. For example, the idea that the sun is the center of the solar system is now accepted as a fact, but it was a hypothesis during the time of Copernicus (1542 [1995]). Well-established generalizations, such as Newton's laws of motion and the ideal gas laws, are known as laws of nature (Popper 1959, Hempel 1965, Giere 1991, Resnik 1998c).

Scientific investigators work in different ways to attain new knowledge and have many different motives for conducting research. Most researchers have a deep desire to understand the world, to make new discoveries, and to pursue truth, to the best of their ability. Others want to make an important contribution to the world by improving the human condition or protecting the natural environment. Researchers may also have goals that are less altruistic or noble. Some seek fame, glory, and prestige, and almost all researchers also have strong economic motivations. For most researchers, science is a career and a way to make a living. For example, the U.S. research enterprise consists of more than six million individuals with master's or doctoral degrees, including nearly one million professionals directly engaged in research (Greenberg 2001). Thus, the scientific enterprise is no different from any other business sector of our society, and its performance reflects the values, motives, interests, and shortcomings of our culture (Longino 1990). The failure to understand the selfishness, greed, and bias that is as inherent in science as it is in the other social sectors could lead to unrealistic expectations of the research enterprise and impractical rules and policies.

**STEPS IN SCIENTIFIC RESEARCH (OR SCIENTIFIC METHOD)**

**Plan the Research and Design the Protocol**

To develop new knowledge, one must follow numerous steps in planning the research project and designing the protocols. (A protocol is a set of rules, methods, and procedures used to obtain the objectives of a research project.) Each event in the chain of planning and design of the protocol is necessary to ensure that quality, integrity, and objectivity of the data and final results. Every scientist—whether consciously or subconsciously—follows something like the chain of events described below. In the twentieth century, these events became more formalized and rigid, especially in large projects. Although we present these steps in linear order, some of them may occur concurrently, and researchers sometimes return to earlier steps when revising the project and protocol. The following steps outline the processes that usually compose a research project. (For further discussion of the scientific method, see Kitcher 1993, Haack 2003, Resnik 2007b; for a more specific and detailed protocol description for research with human subjects, e.g., clinical trials, see Hulley et al. 2001, Inadomi 2006.)

**State the Objectives of the Research Project**

The objectives of a research project are the questions that researchers are attempting to answer or the problems they are attempting to solve (Grinnell 1992). For example, if a research project is addressing the toxicity of a particular drug in laboratory mice, then one of its objectives may be to "test toxicity of certain drug in laboratory mice." The questions answered may be "what is the toxicity of the drug?" The knowledge obtained from answering questions such as this could satisfy the needs of society for improving the health and education of its citizens.

**Develop Specific Aims for the Project**

Specific aims list the particular goals of the project that need to be achieved in order to attain its overall objective(s). The aims may help meet the objectives of the project either wholly or in part. For example, to test toxicity of a certain drug in animals, one must design specific aims to test for lethal doses, toxic doses, and side effects, and one must describe the species and gender of animals, duration of testing, and types of measurements (e.g., blood pathology, temperature, and biopsies).

**Propose the Hypotheses**

Hypotheses are statements that are designed to answer research questions (Grinnell 1992). One way to test a hypothesis is to put it in the form of a conditional statement, for example, "If A occurs, then B will occur." The antecedent (A) in the conditional specifies the test conditions; the consequent (B) states predicted results (Giere 1991). Suppose we want to know whether a drug inhibits the growth of cancerous tumors. The hypothesis could be "drug A inhibits cancer growth in species S." To test this statement, we can develop a conditional statement that makes predictions about specific results that should occur if the hypothesis is true. For example, the conditional could be "if drug A inhibits cancer growth in species S, then we should be able to find the dose where growth of tumors in the animals used will slow or stop within a month of receiving the dose." If researchers conduct tests with the dose believed to stop tumor growth and it does not stop or slow tumor growth, then these negative results would disconfirm or disprove the hypothesis. But if a large number of animals show reduction in the size of the tumor or a stoppage in growth, then these positive results confirm (or prove) the hypothesis. In this example, the test conditions specify the procedure used for administering the drug to the species, and the outcome (or result) is what happens to the animals. Very often, test conditions include unstated or implied assumptions used in conducting research. For example, the type of syringe used to administer the drug, the diet, and overall health of the population may be unstated test conditions. Sometimes researchers may modify a hypothesis based on negative results, unexpected findings, or
Conduct a Thorough Literature Search

The literature search step can be the first step in the overall project. This is an important step for the investigator because it can save a great deal of time and money by eliminating a flawed objective or a hypothesis. It can also help researchers learn whether their projects may make an original or worthwhile contribution or whether they merely repeat previous work or would result in knowledge that has little value. A literature search can also help researchers learn about previously used methods, procedures, and experimental designs and can place the project's experimental design and protocol within the known realities of the subject matter. A thorough literature search can allow researchers to give proper credit to others who have already worked in the area. Failing to acknowledge other relevant work is arrogant and self-serving and is a type of plagiarism or serious bias if one knowingly or unknowingly claims to be the originator of someone else's idea (Shamoo 1992, Resnik 1998a).

It is important to note that an inadequate literature search in clinical research can lead to tragic results. Ellen Roche died while participating in an experiment designed to produce a mild asthma attack in healthy (non-asthmatic) volunteers at Johns Hopkins University. Roche inhaled hexamethonium, a blood pressure medication used in the 1950s and 1960s. Roche developed a cough and breathing difficulties and was put on ventilator. She died from extensive lung damage produced by hexamethonium. An Office of Human Research Protections investigation of Roche's death determined that this tragedy probably could have been avoided if the principal investigator, Alkis Togias, had consulted articles published in the 1950s (and cited in subsequent publications) warning of lung damage due to inhaling the hexamethonium. Togias did a standard PubMed search on hexamethonium and was unaware of the serious side effects. It is important for researchers to note changes they make and to state the reasons for them. Furthermore, researchers should not make changes in the middle of a test or experiment, because this will bias or corrupt the data (Broad and Wade 1982 [1993]). Because it is not always possible to see the biases in one's own work, it is important to solicit critical feedback from colleagues when designing experiments.

Identify and Describe Methods to Be Used

In this step, researchers identify and describe in detail methods to be used in the project based on their own methods and previous research, existing literature, laboratory manuals, and other sources. Researchers should follow appropriate standards in applying methods and should keep records of what methods they use and how they use them. During initial tests, researchers should use and identify standard (or well-established) methods, but they can modify these methods to suit new experimental applications or testing procedures. It is important for researchers to note changes they make and to state the reasons for them. Furthermore, researchers should not make changes in the middle of a test or experiment, because this will bias or corrupt the data. Accidental changes, such as dropping a test tube, should be noted in the laboratory notebook. If researchers perform tests or experiments to produce data for statistical analysis, the procedures should be carried out in the same exact manner each time. Researchers should not pick and choose among experiments or tests to achieve a desired result. However, they may do so if they recognize a variable inherent in the protocol that was not first recognized in earlier stages of the project. For example, in testing a new drug in humans, researchers may realize that an unanticipated side effect should be recorded and could therefore change the protocol and design a new experiment that measures this side effect. However, researchers should record these decisions and discuss them in detail at the same time and place where the experiments are recorded, derived, or manipulated.
Collect and Record Data

Proper documentation of all aspects of research (e.g., methods, protocols, and data) is crucial to ensuring accountability in research and to keeping a proper paper trail for management and for other future interested parties to authenticate the data. Thorough documentation is also useful for future analysis, verification, and replication by others or investigations of misconduct, error, or other problems (Shamoo 1989, 1991a,b). Detailed and accurate record keeping is essential for proving ownership of intellectual property, such as copyrights and patents. Although this may sound strict to some, we believe that research records can be viewed as quasi-legal documents analogous to medical records, business inventories, or investment accounts.

Raw (or original) data are the records of direct or indirect observations of a test or experiment. Some observations involve the unaided senses, while others involve instruments or devices (Grinnell 1992). For example, when conducting an experiment on rodent maze-learning behavior, the raw data may be the records of the observations made with one's eyes (e.g., the rat completed the maze at a specific time). When testing a metal for electrical conductivity, the raw data would be a record of the output of an ammeter that could be connected to a computer for recording. Raw data, therefore, are those data drawn directly from the experiment or test: data recorded on a laboratory notebook from direct observations, recorder charts, field notes, machine tapes, computer printouts or disks, slides, photographs, and the like.

It is important to note that modern researchers are moving away from laboratory notebooks toward computerized record keeping. Electronic records can enhance security and efficiency, but they also have potential problems for manipulation without a paper trail.

Researchers record the raw data in a data notebook or its equivalent, such as a computer disk, computer printout, or instrument output. The data notebook (or other document) is crucial to future review and to test the integrity and quality of the research output. A laboratory data notebook should be bound and the pages numbered consecutively. Loose-leaf notebooks are hazardous and may tempt a beginning researcher or technician to tear off pages with mistakes. All entries in the laboratory notebook should be made legibly with permanent, nonerasable ink. Ideally, entries should also be signed (or initialed) and dated. Researchers should draw a line through a mistaken entry, without making it completely illegible, and should not use correction fluid. Mistakes that can be traced can be valuable in assessing the progress of the project or observing new, unintended findings. All additive information directly relevant to the raw data, such as derived data, tables, calculations, or graphs, should be either done directly in the laboratory notebook or taped thoroughly on an adjacent page in the notebook. If this is not feasible, files can be used; providing clear identification of the data and the page where the data were derived from is essential (National Academy of Sciences 1994, Macrina 2005). Although many researchers take data with them when they change jobs, we strongly recommend that research institutions keep copies of all raw data while allowing individuals to have copies. Some universities follow the example of private industry and treat research data as the property of the institution. Keeping the data within the institution is important so that future interested parties can check the original data against derived data, graphs, or published results.

There are no excuses for not keeping accurate and informative records of methods and data. In the modern age, a large number of principal investigators are far removed in their research operation from these two steps. Therefore, investigators need to exert quality control and insist on proper documentation to assure that the integrity of the data is preserved. Moreover, the existence of an accurate paper trail may provide invaluable data for future discoveries. Some investigators may design detailed standard operating procedures (SOPs) to monitor the research protocol. Other investigators or supervisors may even add a blind quality assurance sample to ensure quality control and integrity of the process.

Some recent studies indicate that academic researchers are not doing a good job of record keeping. In a survey of 1,479 researchers funded by the National Institutes of Health (2007a), Martinson et al. (2005) found that the most prevalent (27.5%) self-reported inappropriate behavior was “inadequate record keeping.” Moreover, one in ten had withheld details in publications, used inadequate experimental design, or dropped data. At 90 major research institutions, 38% of research integrity officers reported encountering problems with research records during misconduct inquiries and investigations, which often delayed investigations or made them impossible to complete (Wilson et al. 2007). In a survey conducted at the National Institute of Environmental Health Sciences (NIEHS), 31% of 243 researchers said that they had encountered poor record keeping at the NIEHS (Resnik 2006).

Raw data are usually manipulated (or processed) through many stages, depending on the type of research, before they are presented as graphs, charts, or tables or in a publishable form. As data are processed, the risk of introducing (intentional or unintentional) biases, adjustments, or errors increases (Grinnell 1992, Shamoo 1989, 1991a,b). Thus, it is important to include quality assurance steps to maintain the quality, objectivity, and integrity of derived data—data obtained, calculated, or derived from the raw data. Derived data appear in many forms, most commonly quantitative and qualitative data such as outputs from computer programs or instruments that process data, such as optical scanners, gas chromatographs, or DNA sequencing machines.

In addition to taking good care of raw and derived data, researchers should also act as good stewards of materials that are needed to carry out experiments or conduct research, such as chemical reagents, cells, bacteria, viruses, vectors, transgenic animals, tissue samples, blood samples, and many others. SOPs, computer software, and the like are not data but are an adjunct to the research protocol. However, they are needed to correctly carry out the proposed experiments and thus replicate the results.
Analyse the Data

The analysis of data in modern science involves the application of various statistical techniques, such as correlation, regression, analysis of variance (ANOVA), and chi-square tests. These techniques provide a way of drawing inductive inferences from data and distinguishing any real phenomena or effects from random fluctuations present in the data. A responsible researcher will make every attempt to draw an unbiased inference from a data set. Different disciplines use different statistical techniques, and statistical practices vary a great deal across different disciplines. Most fields have norms or accepted practices for data analysis, and it is prudent for researchers to follow the accepted norms (Resnik 2000). These norms are usually based on two factors: (a) the nature of the variables used (i.e., quantitative, comparative, or qualitative), and (b) assumptions about the population from which the data are drawn (e.g., random distribution, independence, sample size). There is nothing inherently unethical in the use of unconventional norms. It is important, however, to be forthright in clearly stating the method of analysis, why it is being used, and how it differs from others. It is unethical to fail to disclose some important information relevant to the data analysis (Resnik 2000).

Given the complexities of data analysis, it is easy to introduce biases or other errors in the analysis and misrepresent the data (Bailar 1986). The failure to provide an honest and accurate analysis of the data can have as significant an impact on research results as recording data improperly. Moreover, research indicates that statistical errors are fairly common in science (DeMets 1999). Thus, this step is crucial to ensuring the objectivity, integrity, and quality of research. Some aspects of data analysis that raise ethical concerns are excluding outliers, imputing data (i.e., using a statistical method to fill in missing data), editing data, analyzing databases for trends and patterns (or data mining), developing graphical representations of the data, and establishing the statistical and practical significance of the data. While none of these areas of data analysis is inherently deceptive, biased, or unethical, researchers must be sure to follow good statistical practices and honestly describe their statistical methods and assumptions to avoid errors in data analysis (American Statistical Association 1999). Intentionally misrepresenting the data can be regarded as a type of misconduct (Resnik 2000).

Manipulate the Data

When data are published in a journal article, report, or Web page, they are rarely published in raw form and are usually highly processed. Choices of how to present derived data, which portion, why, how, and to whom are all important scientific aspects of data manipulation. For example, a researcher may select a particular set of tables, figures, or spectral analysis, and not others. All of the data (presented in a publication or a report) are part of the supporting documentation of the published material. It is important to keep an adequate and accurate paper trail of data manipulation for future review and potential use (Shamoo 1989). This information is valuable not only to ensure the integrity of the process but also for the additional use of the data. For example, data from several sources may provide a new finding, or a new investigator may find a whole new way to interpret the data missed by the original investigator.

Computer programs, such as Photoshop, can be used to manipulate digital images (e.g., pictures of proteins from gel electrophoresis or cell structures). In some cases, researchers have manipulated images in order to deceptively change the image to obtain a desired result. Several journals, including Science and Nature, have special requirements for the submission of images to the journal for publication (Couzin 2006a). The Office of Research Integrity has special instructions on its Web site for forensic tools to detect fraud in images (Office of Research Integrity 2007b). Researchers should be aware of and use these tools, when necessary. While it is acceptable to use image manipulation technologies to make it easier for researchers to perceive patterns in an image, it is not acceptable to manipulate an image in order to mislead or deceive other researchers. The Journal of Cell Biology has adopted the following guidelines, which we endorse:

- No specific feature within an image may be enhanced, obscured, moved, removed, or introduced. The grouping of images from different parts of the same gel, or from different gels, fields, or exposures must be made explicit by the arrangement of the figure (i.e., using dividing lines) and in the text of the figure legend. If dividing lines are not included, they will be added by our production department, and this may result in production delays. Adjustments of brightness, contrast, or color balance are acceptable if they are applied to the whole image and as long as they do not obscure, eliminate, or misrepresent any information present in the original, including backgrounds. Without any background information, it is not possible to see exactly how much of the original gel is actually shown. Non-linear adjustments (e.g., changes to gamma settings) must be disclosed in the figure legend. All digital images in manuscripts accepted for publication will be scrutinized by our production department for any indication of improper manipulation. Questions raised by the production department will be referred to the Editors, who will request the original data from the authors for comparison to the prepared figures. If the original data cannot be produced, the acceptance of the manuscript may be revoked. Cases of deliberate misrepresentation of data will result in revocation of acceptance, and will be reported to the corresponding author's home institution or funding agency. (Journal of Cell Biology 2007)

Researchers should also develop the habit of stamping laboratory notebooks and other records to indicate who owns copyrights (or patents) and who is the principle investigator. Entries should be dated with perhaps the signature of the original investigator. Most researchers keep their data practically until they retire, or until they no longer have sufficient space to store them. Recently, the U.S. Public Health Service adopted the same storage time requirement for research data as for the financial records: three years from the time of last report filed to the
federal agency. Keeping data for this short period of time is not justifiable, because publication of these data may take several years beyond the time of the last expenditure report. It is our view that data should be stored for at least seven years after the last expenditure report or submitted publication (Shamoo and Teaf 1990). In the event the federal agency is auditing and inquiring about the data, the time is automatically extended to the needed length of time. If the federal agency is investigating certain data, the agency has the right to obtain these data if they are available regardless when they were obtained in the first place. Few universities have provisions for storing data in centralized facilities. Furthermore, granting agencies have not provided the means to store data for future generations. We recommend that research institutions develop computerized data archives and that they require those researchers not working with human subjects to deposit data in these archives on an annual basis. (Researchers have an obligation to destroy some data pertaining to human subject’s research if they contain an identifying trail, as discussed in chapter 12) Like any business keeping a centralized inventory of its stock, a research institution should keep a centralized inventory of its research.

Although it is important to store data, research materials, and other records, storage introduces problems of space allocation. Some of these problems can be handled by using technologies to transfer all types of data to digital formats. Data and other records can be stored on CD-ROMs, hard drives, servers, or other media, thus vastly reducing the space problem. However, converting data to digital formats introduces other problems, such as choosing a format that will not soon become obsolete or developing procedures for periodically transferring data to new formats. Most institutions may have trouble finding room for data storage, maintaining technologies, or transferring data to new media. Thus, while data storage is important, specific ethical dilemmas concerning the storage of data must be approached with an eye to other important values and concerns in research (Resnik 1998c). The federal government can and should provide funding to develop resources for data storage, such as databanks or archives. Additionally, research material cannot be easily converted into digital form. For example, cell or tissue samples are physical objects that take up space. Researchers who create banks for storing biological samples will face significant issues concerning space allocation.

Interpret the Data

If all researchers interpreted the data in the same way, science would be a dry and dull profession. But this is not the case. Many important and heated debates in science, such as research on firearm violence, studies of intelligence tests, and studies of global warming, involve disputes about the interpretation of data. Sometimes an important discovery or advance in science occurs as the result of a new interpretation of existing data. Of course, challenging a standard interpretation of the data is risky: Those who challenge the existing paradigm either go down in flames or win the Nobel Prize. Most challenges to the existing paradigm turn out to be wrong. But those few times that the new interpretation is correct can change and advance our knowledge in a revolutionary fashion. For example, Peter Mitchell won the Nobel Prize for his chemiosmotic theory. He advanced the notion that a proton gradient across the mitochondrial membrane is the driving force to synthesize adenosine triphosphate (ATP) from adenosine diphosphate (ADP) and inorganic phosphate. The chemiosmotic theory was originally considered heresy because it contradicted the long-held theory of a phosphorylated intermediate for the synthesis of ATP.

The path of a trailblazer is full of hazards. Most researchers resist new ideas and stick to generally accepted standards, despite their image as being open-minded and liberal. Although revolutions do occur in science, most research conforms to the model of “normal” science—science that falls within accepted standards, traditions, and procedures (Kuhn 1970). It is often the case that researchers who have new interpretations are scoffed at before their ideas are accepted. For example, the idea of continental drift was viewed as ludicrous, as was the idea that a bacterium could cause ulcers. However, if researchers can find new ways of interpreting data, they should be encouraged. And their new interpretations will be more readily accepted (or at least considered) if they properly acknowledge the existing paradigm (Resnik 1994).

Even within the existing paradigm, the interpretation of the same data can take very different pathways, none of which are likely to be unethical. As we discuss in chapter 8, there is an important distinction between misconduct and disagreement. Just because one researcher disagrees with another’s interpretation does not mean that one of them is being dishonest. It is especially important for researchers with new interpretations to be even more careful in documenting and leaving a thorough paper trail of their data, so that other researchers will be able to understand their interpretations and not dismiss them as resulting from fraud or error. Ensuring the integrity of research data does not mean straitjacketing the investigator’s creativity and latitude in introducing new ideas and interpretation. However, prudence suggests that all interpretations of data should be consistent with the existing knowledge. If the interpretation of new data is inconsistent with existing knowledge, an honest discussion of the differences is in order.

One common ethical problem with data interpretation is what we will call “overreaching.” Researchers overreach when they claim that their data are more significant or important than they really are. This problem often occurs with industry-funded pharmaceutical research (Resnik 2007b). For example, suppose that a study shows that a new analgesic medication is 2% more effective at reducing arthritis pain compared to acetaminophen and 4% more effective than aspirin. However, the new medication also increases systolic and diastolic blood pressure by 10% in about 30% of the people who take it. Since its patent has not expired, the new medication will be much more expensive than acetaminophen or aspirin. The researchers would be overreaching if they claimed that the new medication is superior to acetaminophen and aspirin, because the medication brings a marginal improvement.
in pain relief and has some dangerous side effects. Overreaching can be an ethical problem in clinical research if it causes physicians to prescribe new medications to their patients without considering their higher costs or side effects (Angell 2004).

Put the Results into a Publishable Format

Putting results into a publishable format, such as a paper or conference presentation, is an important part of the research project, because this is how results are disseminated to the wider community of researchers. Research papers should provide readers with an honest, accurate, and thorough description of all the steps of the research project. Researchers should accurately report data and the contributions of other contributors. They should also disclose sources of funding or outside support as well as any potential conflicts of interest (other chapters cover these issues in more depth).

Most journals require authors to divide their papers into specific sections, such as abstract, introduction, materials and methods, results, discussion, and conclusion. The abstract is a short summary of the paper that reports its key findings. Because computer database programs for literature searches usually search for words found in abstracts, it is important for authors to write an accurate and useful abstract. In the introduction section, researchers usually review previous research in the area of the project, describe its aims and objectives, and discuss its importance. In the materials and methods section, authors describe the design of the tests or experiments as well as materials, methods, statistical techniques, and procedures used. In the results section, authors report processed and sometimes raw data as well as the results of the analysis of the data. In the discussion section, the authors may address a number of different issues relating to the research, such as placing the new data within the existing data in the literature; how and why they differ; potential biases, flaws, or shortcomings; difficulties in conducting the research; significance of the research and its relation to other studies; and areas for further research and exploration. The conclusion section summarizes all aspects of the research.

All papers and presentations should be clearly written. If the authors have some help from an editor or writer in preparing their publication, they should acknowledge this contribution.

Publish the Results

We discuss aspects of publication of results in more detail in chapter 7 on publication and peer review. For now, we simply note that researchers have an obligation to disseminate work for the obvious reason that science cannot advance unless researchers report and share results. Dissemination can include publication in peer-reviewed journals, monographs or other books, and Web pages, as well as presentations at professional meetings. The important ethical consideration is that research should be disseminated to colleagues and the public for scrutiny and review. Indeed, researchers who receive grants from the government or private funding agencies are usually required to specify a plan for disseminating their research in the grant proposal and to report to the agency about publications that result from the grant (Grinnell 1992). However, researchers who work for business and industry or the military often sign agreements to not publish results or to withhold publication until they obtain approval from management (Gibbs 1996, Blumenthal 1997). For instance, researchers working for the tobacco industry did not publish their work on nicotine's addictive properties for many years (Resnik 1998a). We explore these issues in chapter 10, as well. As noted in chapter 10, pharmaceutical companies have also suppressed data pertaining to their products. Officials at Merck, for example, knew that Vioxx was associated with cardiovascular problems, but they kept this information from the public for several years (Resnik 2007b).

Replicate the Results

Once the results are published, it is important for other researchers to be able to replicate the results. Although scientists do not frequently repeat each other's tests or experiments, because of an emphasis on original research, it is important that research be repeatable in principle. Repeatability is the primary assurance of the integrity of research data. Moreover, repeated confirmation of results by others lends greater credence that the data are usable, especially those data that can have an impact on the well-being of millions of people. The ability of other investigators to replicate the experiments by following the method in the published report is crucial to the advancement of science. It is important that the published work give sufficient details for others to replicate it. If there is not sufficient journal space to state the experimental details, several other means should be attempted to publish and provide the experimental details, such as mini-print appendixes, archives, and an invitation to the reader to ask for the full report from the investigator.

Share Data and Results

As noted above, openness is a key principle in research ethics. Scientists should share data and results (a) to promote the advancement of knowledge by making information publicly known; (b) to allow criticism and feedback as well as replication; (c) to build and maintain a culture of trust, cooperation, and collaboration among researchers; and (d) to build support from the public by demonstrating openness and trustworthiness. The ideal of openness is considered by many people, including many researchers, to be a fundamental part of research and scholarship. The real world of research does not usually conform to this ideal, however. Although researchers share data within the same team of collaborators working on a common project, they rarely share data with noncollaborators and often do not welcome requests to share data from other researchers in the field, much less people from outside the research community. The resistance to data sharing is especially high among researchers who have concerns about intellectual property, such as potential patents or trade secrets, but resistance is also high among researchers who
want to protect their own interests in claiming priority (to be first) for discoveries or publishing original research.

Several recent studies have documented problems with data sharing in the biomedical science. In a survey by Campbell et al. (2002) of academic geneticists concerning their experiences with data withholding, 47% stated that at least one of their requests to share data or research materials related to published research had been denied in the last three years; 28% reported that they had been unable to confirm published research due to refusals to share data or materials; and 12% said that they had denied a request to share data or materials. Of those who refused to share data or materials, 80% said they refused because sharing required too much effort; 64% said they refused to share to protect someone else’s ability to publish, and 53% to protect their own ability to publish (Campbell et al. 2002). A survey by Blumenthal et al. (2006) found that 32% of biomedical researchers had engaged in some type of data withholding in the last three years and that data withholding is common in the biomedical sciences.

Although refusals to share data and materials appear to be common, especially in biomedical sciences, some organizations have adopted policies that require researchers to share data and materials following publication. Many government granting agencies, such as the National Institutes of Health (NIH) and the National Science Foundation, encourage or require researchers to share data and materials. The NIH expects intramural and extramural researchers to share data:

Data sharing promotes many goals of the NIH research endeavor. It is particularly important for unique data that cannot be readily replicated. Data sharing allows scientists to expedite the translation of research results into knowledge, products, and procedures to improve human health. There are many reasons to share data from NIH-supported studies. Sharing data reinforces open scientific inquiry, encourages diversity of analysis and opinion, promotes new research, makes possible the testing of new or alternative hypotheses and methods of analysis, supports studies on data collection methods and measurement, facilitates the education of new researchers, enables the exploration of topics not envisioned by the initial investigators, and permits the creation of new datasets when data from multiple sources are combined. In NIH’s view, all data should be considered for data sharing. Data should be made as widely and freely available as possible while safeguarding the privacy of participants, and protecting confidential and proprietary data. (National Institutes of Health 2003)

The NIH also has policies that encourage or require funded researchers to share reagents and model organisms (e.g., transgenic animals). The NIH also requires researchers to state their plans to share data, reagents, or organisms in their grant applications or to explain any proposed restrictions on sharing (National Institutes of Health 1998b, 2003). Also, the NIH has a genomewide association studies (GWAS) policy that establishes an open repository for all GWAS data obtained with NIH funding (National Institutes of Health 2007c,d). There are additional guidelines for many other purposes such as intellectual property and stem cells.

Many scientific journals have also created policies that require researchers to share supporting data or materials as a condition of publication. Many journals have Web sites where researchers can deposit data and other supporting materials that do not appear in the published article. For example, Science requires researchers to share data: “Science supports the efforts of databases that aggregate published data for the use of the scientific community. Therefore, before publication, large data sets (including microarray data, protein or DNA sequences, and atomic coordinates or electron microscopy maps for macromolecular structures) must be deposited in an approved database and an accession number provided for inclusion in the published paper.... After publication, all data necessary to understand, assess, and extend the conclusions of the manuscript must be available to any reader of Science (Science 2007).” Science also requires researchers to share materials following publication:

After publication, all reasonable requests for materials must be fulfilled. A charge for time and materials involved in the transfer may be made. Science must be informed of any restrictions on sharing of materials (Materials Transfer Agreements or patents, e.g.) applying to materials used in the reported research.

Any such restrictions should be indicated in the cover letter at the time of submission, and each individual author will be asked to reaffirm this on the Conditions of Acceptance forms that he or she executes at the time the final version of the manuscript is submitted. The nature of the restrictions should be noted in the paper. Unreasonable restrictions may preclude publication. (Science 2007)

While the progress of science thrives on sharing information and data and as soon as possible, there are some legitimate reasons to refuse to share data or materials, at least temporarily:

1. To protect intellectual property claims. Sometimes investigators are conducting research that may be patentable. Sharing data or other information related to the research prior to submitting a patent application can jeopardize the patent. Thus, researchers may refuse to share data to protect their potential patents. It is important for society to protect patent rights to stimulate invention and private investment in research and development, or R&D (Resnik 1998a, 2007b). We discuss intellectual property issues in more depth in chapter 9.

2. To protect a researcher’s interests in publishing articles from the data or materials. If a researcher collects data or develops materials for a project, she should not have to share the data or materials until she is ready to publish, since sharing prior to publication may affect her ability to publish. But once a researcher has published, she has an obligation to share. A difficult question arises when a researcher has acquired a large database and hopes to publish a series of papers from the database. Should the researcher be required to share the whole database as soon as she publishes the first paper from it? If she must share the whole database with other investigators, this could jeopardize her
They often are not. Sometimes be legitimate attempts to advance scientific knowledge, institutional pressures to produce results in order to obtain new funding, pressure to harass or intimidate researchers. While these requests can be arbitrary and possibly biased, the agency should respond to this request within 20 days by sending the documents, promising to send the documents within a reasonable time, or explaining why they cannot be sent. The agency may charge a reasonable fee for sending the records sought. There are some exceptions to FOIA: Agencies can refuse to share records pertaining to national security or foreign relations, agency rules or practices, confidential business information, information related to personal privacy, some types of law enforcement records, and information pertaining to the supervision of financial institutions. Federal authorities have determined that some of these exceptions apply to federally funded scientific research. For example, researchers do not have to disclose confidential information pertaining to human subjects. They also do not have to disclose information protected by trade secrecy law, including information pertaining to potential patents (U.S. Department of Justice 2007).

Some scientists have objected to FOIA on the grounds that it could subject them to harassment from people who want to interfere with their work (Macilwain 1999). Although it is important for researchers to be free from harassment from industry representatives, political activists, or other parties, we do not think that researchers who receive public funds can be completely shielded from this threat. It is difficult to know in advance whether any particular request for information would be harassment of researchers. Without having this knowledge in advance, any policy short of answering all requests for data would be arbitrary and possibly biased.

CORRUPTING INFLUENCES IN THE CURRENT RESEARCH ENVIRONMENT

Although following the steps of the scientific method discussed above can help to promote the objectivity, quality, and integrity of research, a number of different psychological, social, economic, political, and institutional influences can undermine the research process. Objectivity, quality, and integrity are ideal standards that may be difficult to achieve in practice. The following influences and trends can interfere with and undermine research results and their application.

Pressure to Produce Results

Researchers who receive government funds face enormous financial and institutional pressures to produce results in order to obtain new funding, to continue receiving funding, or to publish papers. The phrase “publish or
perish" accurately describes the life of the academic researcher. Researchers employed by private industry face similar pressures to produce results that provide useful information, although they may not face any pressure to publish. Because researchers in private industry who do not produce results can lose their jobs or their sources of funding, the phrase "produce or perish" is more apt. When the research plan is not going well or is taking longer than expected, researchers can be tempted to compromise the integrity of the research process in order to obtain results, which may result in bias, error, sloppiness, or even fraud (Broad and Wade 1982 [1993], Woof 1986, Shamoo 1989, National Academy of Sciences 1992, Resnik 1998a). These pressures often fall most severely on junior researchers and graduate students, who may be under pressure to produce results for senior colleagues in order to advance their own careers or retain their jobs (Browning 1995).

Careerism
Research is no longer an avocation or hobby; it is a career. Career advancement usually results from many different types of achievements, such as publications, grants, intellectual property, special appointments, awards, and recognition. While the desire for a career in research can inspire dedication and hard work, it can also lead researchers to violate standards of ethics and integrity to achieve various goals along the path of career advancement (National Academy of Sciences 1992, 1994).

Conflicts of Interest
Conflicts of interest, financial or otherwise, can undermine trustworthiness and objectivity, which are required in virtually all steps of the scientific method, especially study design, data interpretation, and publication (Shamoo 1989, 1992, Krimsky 1996, 2003, Bok 2003, Angell 2004, Resnik 2007b). These issues are discussed in more depth in chapter 10.

Intellectual Property Interests
Researchers in the private or public sector frequently seek intellectual property rights, such as patents or copyrights (Krimsky 1996, 2003). To secure these rights, researchers may be tempted to violate standards of ethics and integrity. Some but not all attempts to secure intellectual property create conflicts of interest.

Complexity
Research projects often involve many different collaborators, institutions, disciplines, research sites, and sources of funding. It may be very difficult for any one person to understand or control an entire research project. This complexity can lead to problems in monitoring data, revising hypotheses or study aims, initiating tests or experiments, and so on. Complexity can also lead to communication problems among different members of the research team, and between the team and institutions, sponsoring organizations, and government agencies (Grinnell 1992).

Remoteness
The principal investigator or the manager of the project sometimes is far removed physically from the project itself and its various collaborators. More important, often the investigator relies on less knowledgeable individuals to carry out daily monitoring and discussions. This remoteness results in the investigator being mentally removed from the day-to-day operations of obtaining research data. Remoteness also results in poor supervision of those directly involved in data acquisition, analysis, and manipulation. According to several studies, poor supervision of subordinates is one of the chief causes of misconduct, error, and bias in research (National Academy of Sciences 1992). Because principal investigators may be so far removed from the day-to-day research operations, trust is a key component of ethical conduct: Principal investigators and managers must be able to trust subordinates, and vice versa.

Self-deception
Although self-criticism and skepticism play an important role in research planning and execution and are part of the ethos of science, scientists, like other people, succumb to self-deception (Broad and Wade 1982 [1993]). There are many different types of self-deception, including observer bias (where one sees what one wants to see), that can affect data collection, research design, and data analysis (Resnik 1998a). The steps of the scientific method are designed to counteract self-deception, but nothing can change the fact that research is conducted by human beings who often believe what they want to believe.

Political and Sociocultural Biases and Pressures
Many research projects address issues that are clouded with political and social controversy. Researchers on different sides of a controversial topic, such as gun control, global warming, tissue engineering, consumer safety, environmental management, homosexuality, or human intelligence, may have different stakes in the results of research. These pressures can undermine objective judgment and decision making in all phases of research (Longino 1990, Crossen 1994, Shrader-Frechette 1994, Resnik 1998a).

THE IMPORTANCE OF GOOD RESEARCH PRACTICES
To deal with corrupting influences and assure the quality, objectivity, and integrity of research data, it is important to promote ethical attitudes and good research practices (GRPs) among the participants in the enterprise (e.g., the principal investigator, technician, supervisor, and management) toward research integrity (Shamoo 2006). An ethical attitude embodies a positive orientation toward ethics, an awareness of ethical issues, and a commitment to ethics in research. A person with an ethical attitude wants to do the right things for the right reasons. GRPs (described below) are rules that researchers can follow to help ensure the quality, objectivity, and integrity of data (Shamoo 1989, 1991a, Shamoo and Davis 1989, Glick and Shamoo...
1993, 1994). People in positions of leadership in research can play a key role in developing a culture in which ethical attitudes and GRPs prevail. If principal investigators, managers, corporations, and government agencies demonstrate and tolerate unethical attitudes and poor research practices, then unethical attitudes and poor research practices will prevail. The research culture (attitudes and behaviors) sets the tone for the importance of quality, objectivity, and integrity of data and results.

**GRP Aims**

The following are aims of GRPs (Shamoo 1991a).

**Cardinal Rules**

1. Published data are verifiable: A paper trail exists documenting the origin of the data.
2. Published data are reproducible: Other investigators are able to reproduce the data by following the published procedures.

**Commonsense Rule**

The conclusions drawn from the published research data should be consistent with the data.

**Procedures to Achieve GRP Objectives and Aims**

The aims of GRPs can be achieved by numerous methods. The investigator should be more concerned with making a sincere effort to accomplish these aims than with following any proposed specific procedure. All proposed procedures should serve the GRP aims and not hinder them. Therefore, any proposed procedure that may result in a contrary outcome should be either modified or discarded.

**Quality Control and Quality Assurance**

Industries have used quality control and quality assurance processes for years (Shamoo 1991a,b). These concepts are based on common sense and good business practices. Quality control is concerned with developing rules and procedures designed to ensure that products and services during production are of high quality and conform to original specifications. Quality assurance is concerned with reviewing (or testing) the quality of products and services after they have been produced or used (Shamoo 1991a,b).

Unfortunately, these concepts are foreign to researchers, especially to those in academic institutions, but this should not be the case. Many in academic researchers loath the concepts of quality control and quality assurance because they associate them with increased bureaucracy and red tape. But we believe that these concepts can be adapted to the research environment without increasing red tape and bureaucracy and without interfering with the creative process (Shamoo 1989). A recent report by Harvey et al. (2007) found that implementing SOPs for data extraction in a surgical research protocol improved the completeness of data extraction from a range of 14–100% to 95–100%.

The following rules can help establish quality control in research:

1. All equipment used should have been calibrated within the time frame recommended by the manufacturer.
2. All equipment should have its SOP available.
3. All materials consumed during research experiments should be properly labeled with all of the essential information, such as date of manufacture, expiration date, concentration, pH, storage conditions (e.g., refrigeration, freezer, room temperature).
4. Documentation of procedures used to carry out the research protocol should be in its proper place. Documents may include lab notebooks, computer software, or automated instruments.
5. All research data should be promptly recorded, dated, and signed in a permanent manner.
6. Except for some types of human subjects research, all research data and records should be retained for a specified period of time (we recommend at least seven years).

The following rules, which pertain to actions performed after research is conducted, can help promote quality assurance:

1. Require researchers to keep original data at the institution.
2. Develop centralized data archives that can be used to audit or review data.
3. Examine research for potential conflicts of interest and disclose those conflicts to the appropriate parties (see chapter 10 on conflicts of interest).
4. Audit or peer review data every three years. The audit or peer review should be conducted by the research chief or director, an outside researcher within the research institution, or a researcher from outside the research institution.
5. File the results of data audit or peer review with the research institution and the agency sponsoring the research.
6. Verify in peer review/data audit all of the data, from the published data all the way to the original raw data.

The Potential Value of GRP and Peer Review/Data Audit

Implementing the rules listed above can help promote GRPs (Shamoo 1989, Glick and Shamoo 1994) and can also help protect the human and financial investment in research (Shamoo and Davis 1990). Peer review/data audit has some special advantages:

**Reduction of Errors**

Human errors are a part of any human function, and the human factor has a large influence on the quality of data produced. Peer review/data audit can uncover errors both before and after those errors have contributed to large problems. Modern methods of online data processing certainly have reduced errors but have also contributed to the increased...
volume of data that requires human judgment, either before or after online data processing. Thus, the possibility of error in data analysis remains a significant factor (Resnik 2000).

Reduction of Irregularities Data audit can uncover both unintentional and intentional errors. Instituting peer review/data auditing itself may discourage such irregularities, especially those that are intentional. The amount of data to be fully audited can vary, depending on the preliminary analysis. A strong system of quality assurance can promote cost-effectiveness by ensuring accurate and efficient processing of data as well as reduce the cost of the peer review/data audit.

Reduction of Fraud and Potential for Fraud The existence of a systematic way to examine independently the data, or at least part of the data—or the thought that the data may be examined—may help reduce fraud and the potential for fraud. But peer review/data audit is by no means a foolproof method to eliminate fraud. If a researcher or an organization is intent on deception, there is as much potential for success as for fraudulent financial transactions. Peer reviewers/data auditors should therefore strive to reduce the ability of a person or an organization to succeed in fraud. But at the same time, peer reviewers/data auditors should be aware of their limitations—the system is not perfect.

Protection for the Public, Government, Industry, and Investigators All segments of society benefit from the peer review/data audit because it increases the likelihood of actually achieving worthwhile products. The greatest benefit of peer review/data audit falls to the public, which is the ultimate consumer of all goods and services of industry and government. After all, it is people who must suffer the consequences of poorly tested pharmaceuticals or poorly designed cars. Industry can protect itself from overzealous or dishonest employees as well as unintentional errors. The company’s reputation as well as its actual services or products would be enhanced by peer review/data audit. Also, individual investigators can be protected from false accusations, rumors, and gossip.

Improvement of Products and Services Data audit(peer review not only can eliminate error but also can improve the overall quality of a product or service. Toxicological research, for example, is conducted by some in the chemical industry for certain products covered by a regulatory law. Furthermore, management uses these research data for the purpose of protecting the consumers and employees from these potentially toxic substances.

There are broad and general benefits to the consumers of the products and services. Industries such as pharmaceutical, chemical, petrochemical, and pesticide manufacturers, among others, may use and benefit from these procedures. For toxic substances that have specific federal regulations, the National Toxicology Program uses project management systems and quality assurance systems to monitor and evaluate the toxicological studies performed by the industry.

Establishment and Improvement of Future Research and Development Standards The study and application of peer review/data audit are in their infancy. Peer review/data audit standards that individuals and organizations involved in research data production should adhere to and abide by have yet to be well established. One of the primary objectives of applying peer review/data audit in organizations would be to establish such standards, first by borrowing from the experience of finance and molding it to the world of research. Another objective would be to consistently review and revise these standards as needed.

Improvement of Risk Assessment Risk assessment is an important tool that helps policy makers to determine regulations regarding such issues as nuclear safety, carcinogens, and pesticides. One of the critical factors involved in risk assessment is the use of the historical database collected from past research. Thus, the accuracy and reliability of these data become crucial for risk assessment. Peer review/data audit, by ensuring the accuracy and reliability of these data, can become an important partner in public health and safety.

Reduction of Liability Reduction of legal liability is not an immediate or an obvious purpose of peer review/data audit, but it can be a side effect of that process. In the long run, peer review/data audit may contribute to a greater reliability of and confidence in the data in various segments, such as markets, courts, government, and insurance companies. For example, the increased confidence in the data could provide an incentive for insurance companies to reduce liability. Peer review/data audit could also strengthen the hand of industry in defending itself against unfair charges.

This concludes our discussion of data acquisition and management. Topics discussed in subsequent chapters, such as intellectual property and research misconduct, will have direct or indirect connections to the topic discussed in this chapter. In closing, we also mention that managing a large volume of data often requires tools that are often not available to every researcher. There is a need to develop these tools and make them available to all researchers (Anderson et al. 2007). The NIH has recognized this need and has encouraged centralized facilities such as bioinformatics, statistics, and imaging, among many others (National Institutes of Health 2005).

QUESTIONS FOR DISCUSSION

1. What are your thoughts about scientific research? In your opinion, what is the most crucial part of research?
2. How would you list the steps in carrying out research? Are there some steps you could skip? Why?
3. How would you introduce quality assurance and integrity into your steps for carrying out research?
4. Can you give an example of how data can be "modified" to suit inappropriate goals in steps of research?
5. Give an example of an experimental design that would bias the data.
6. When would you be justified in refusing to share data?
7. How many of these GRPs do people follow (or fail to follow) in your research environment? Why?
8. Can scientific research incorporate quality control and quality assurance methods? Would this stifle creativity, or increase workload?
9. How do you ensure that peer review/data audit is workable, and how would you modify it to accomplish its purpose in your research environment? Can you suggest a whole new system to ensure the quality and integrity of research data?
10. How is a lab notebook like (or not like) a medical record?

CASES FOR DISCUSSION

Case 1

A medical student has a summer job with a faculty mentor at a research university. The student is bright, hard working, and industrious and hopes to publish a paper at the end of the summer. He is the son of a colleague of the mentor at a distant university. The student is working on a cancer cell line that requires three weeks to grow in order to test for the development of a specific antibody. His project plan is to identify the antibody by the end of the summer. The student has written a short paper describing his work.

The mentor went over the raw data and found that some of the data were written on pieces of yellow pads without clearly identifying from which experiment the data came. She also noticed that some of the experiments shown in the paper’s table were repeated several times without an explanation as to why. The mentor was not happy about the data or the paper, but she likes the student and does not want to discourage him from a potential career in research.

- What is the primary responsibility of the mentor?
- Should the mentor write a short paper and send it for publication?
- Should the student write a short paper and send it for publication?
- If you were the mentor, what would you do?
- Should the mentor or her representative have paid more attention to the student’s work during the course of the summer? Should the student have been taught some quality control and/or GRP during the summer?

Case 2

A graduate student at a research university finished her dissertation and graduated with honors. Her mentor gave the continuation of the project to a new graduate student. As usual, the mentor gave the entire laboratory notebook (or computer disk) to the new graduate student, who had to repeat the isolation of the newly discovered chemical entity with high-pressure liquid chromatography (HPLC) in order to follow up the chemical and physical characterization of the new compound.

The new graduate student found that if he follows the exact method described in the laboratory notebooks and published by the previous student, he obtains the new chemical entity not at the same HPLC location as published, but slightly shifted to the left, and there was a different peak at the location stated. However, the new student discovered that if the ionic strength is doubled, he could find the same chemical at the same location in accordance with the previous student’s dissertation. The new student discussed with the mentor how he should proceed. The mentor replied, “Why make a fuss about it? Just proceed with your slightly different method and we can move on.”

- What are the responsibilities of the new student? Should the new student refuse to accommodate the mentor’s request?
- Should the new student have read more thoroughly the relevant laboratory notebooks prior to starting the experiment? Should there have been a paper trail of the error in the laboratory notebook? Do you think the error was intentional, and does it matter?
- If the laboratory notebook does not reveal the error, is it then misconduct? Does it indicate that a better recording of the data would have been helpful?
- Should the mentor have had training and education in responsible conduct of research (RCR)? If the mentor has had the necessary training in RCR, what actions would you suggest?
- Can you propose a reasonable resolution to the problem?

Case 3

A new postdoctoral fellow in a genetic research laboratory must sequence a 4-kDa fragment. After the sequence, he is to prepare a 200-base unit to use as a potential regulator of a DNA-related enzyme. The 4-kDa fragment is suspected to contain the 200-base unit. The sequence of the 200-base unit is already known in the literature, but not as part of the 4-kDa fragment, and not as a potential regulator. The fact that the 200-base unit is known is what gave the mentor the idea that it may have a functional role.

The new postdoctoral fellow tried for three months to sequence the 4-kDa fragment, without success, and so simply proceeded to synthesize the 200-base unit without locating it within the fragment. After two years of research, the 4-kDa fragment appeared to play a key regulatory role in an important discovery, but at this time the mentor learned that the postdoc never sequenced the original 4-kDa fragment. The mentor could never find a “good” record of the attempts to sequence the 4-kDa fragment.

- What impression do you gather about how this mentor runs the laboratory?
- Should there be records of sequence attempts of the 4-kDa fragment?
Case 4

A graduate student prepared for her thesis a table showing that a toxic substance inhibits an enzyme's activity by about 20%. She has done only six experiments. The mentor looked at the data and found that one of the data points showed a stimulation of 20% and that this point is the one that skewed the results to a low level of inhibition with a large standard of deviation. The mentor further determined with the student that the outlier is outside the mean by 2.1 times the standard derivation and that it is reasonable not to include it with the rest of the data. This would make the inhibition about 30% and thus make the potential paper more in line with other research results and hence more “respectable.” The mentor instructed the student to do so.

- Should the student simply proceed with the mentor’s instructions?
- Should the mentor have been more specific regarding what to do with the outlier? In what way?
- Can you propose a resolution? Should the outlier be mentioned in the paper?
- How should this laboratory handle similar issues in the future?
- Should each laboratory have an agreed-upon SOP for such a statistical issue?

Case 5

A social scientist is conducting an anonymous survey of college students on their opinions on various academic integrity issues. The survey is administered in four different sections of an introduction to sociology. The survey includes 20 questions in which respondents can use a Likert scale to answer various questions: 1 = strongly agree, 2 = agree, 3 = neither agree nor disagree, 4 = disagree, and 5 = strongly disagree. The survey also includes 10 open-ended questions that ask for respondents to state their opinions or attitudes. The social scientist distributes 480 surveys and 320 students respond. A graduate student is helping the social scientist compile the survey data. When examining the surveys, the student encounters some problems. First, it appears that eight surveys are practical jokes. The persons filling these surveys wrote obscene comments and for many questions added extra numbers to the Likert scale. Although some of the 20 Likert-scale questions in these surveys appear to be usable, others are not. Second, in 35 surveys, the respondents appeared to have misunderstood the instructions on how to use the Likert scale. They answered “5” on questions where it would seem that “1” would be the most logical answer, given their answers to other Likert-scale questions and their written comments. Third, on 29 surveys, the respondents wrote their names on the survey, when they were instructed not to do so.

- How should the mentor proceed?
- If you were the new postdoc, what steps you would take to ensure proper records of your work?

Case 6

A pharmaceutical company conducts five different phase I studies on a new drug to establish its safety in healthy individuals. Three of these studies had a p-value < 0.05, indicating significant results; two had a p-value > 0.05, indicating nonsignificant results. As it so happens, undesirable side effects were observed in one of the studies with the nonsignificant results. None of the studies with significant results had a significant proportion of side effects. The researchers report these results to the U.S. Food and Drug Administration and in a publication, but do not mention the nonsignificant results.

- Is there an ethical responsibility to report all of the data? Would it make a difference if the subjects were not human (i.e., animals)?
- What are the responsibilities of the researchers to this company, to themselves, and to society?
- Should there be a federal mandate to report all side effects?
- How could the GRP help in this case? Would a quality assurance program be helpful?

Case 7

A graduate student is planning to write a thesis on the affects of exercise in managing diabetes in dogs. He is planning to do a trial with dogs with diabetes, control matched with respect to age, breed, sex, and other factors. One group will receive no extra exercise; another group will receive 30 minutes of exercise a day; and another group will receive two 30-minute periods of exercise per day. He will measure blood sugar levels in all of these dogs, as well as the quantities of drugs used to control diabetes.

The graduate student is also conducting a literature review on the subject as a background to his research. In conducting this review, he searches various computer databases, such as the Science Citation Index and MEDLINE, for the past five years. He gathers many abstracts and papers. For much of the research, he reads only abstracts and not the full papers. Also, he does not include some of the important work on diabetes in dogs that took place more than five years ago.

- Should the graduate student read articles, not just abstracts?
- If he cites an article in a publication or in his thesis, should he read the full article?
- If he cites a book, should he read the full book or only the part that he uses?
- Should the graduate student include articles published more than five years ago?
Case 4
A graduate student prepared for her thesis a table showing that a toxic substance inhibits an enzyme's activity by about 20%. She has done only six experiments. The mentor looked at the data and found that one of the data points showed a stimulation of 20% and that this point is the one that skewed the results to a low level of inhibition with a large standard of deviation. The mentor further determined with the student that the outlier is outside the mean by 2.1 times the standard derivation and that it is reasonable not to include it with the rest of the data. This would make the inhibition about 30% and thus make the potential paper more in line with other research results and hence more “respectable.” The mentor instructed the student to do so.

• Should the student simply proceed with the mentor’s instructions?
• Should the mentor have been more specific regarding what to do with the outlier? In what way?
• Can you propose a resolution? Should the outlier be mentioned in the paper?
• How should this laboratory handle similar issues in the future? Should each laboratory have an agreed-upon SOP for such a statistical issue?

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• Is there an ethical responsibility to report all of the data? Would it make a difference if the subjects were not human (i.e., animals)?
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• How could the GRP help in this case? Would a quality assurance program be helpful?

Case 7
A graduate student is planning to write a thesis on the affects of exercise in managing diabetes in dogs. He is planning to do a trial with dogs with diabetes, control matched with respect to age, breed, sex, and other factors. One group will receive no extra exercise; another group will receive 30 minutes of exercise a day; and another group will receive two 30-minute periods of exercise per day. He will measure blood sugar levels in all of these dogs, as well as the quantities of drugs used to control diabetes.

The graduate student is also conducting a literature review on the subject as a background to his research. In conducting this review, he searches various computer databases, such as the Science Citation Index and MEDLINE, for the past five years. He gathers many abstracts and papers. For much of the research, he reads only abstracts and not the full papers. Also, he does not include some of the important work on diabetes in dogs that took place more than five years ago.

• Should the graduate student read articles, not just abstracts?
• If he cites an article in a publication or in his thesis, should he read the full article?
• If he cites a book, should he read the full book or only the part that he uses?
• Should the graduate student include articles published more than five years ago?