# THE ETHICS OF SCIENCE
## An Introduction

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# CHAPTER 5

# Objectivity in Research

In the previous chapter I defended and described some principles of ethical conduct in science. In the remaining chapters in this book, I will expand on this general discussion of ethical standards by exploring some of the ethical dilemmas, problems and questions that arise in the interpretation and application of these principles. This chapter focuses on the first three principles of scientific ethics; honesty, carefulness and openness. I group these standards together here because they all have important implications for the objectivity of inquiry. The need for objectivity in science applies to collecting, recording, analyzing, interpreting, sharing, and storing data, as well as other important procedures in science, such as publication practices and peer review.

## Honesty in Research

In the previous chapter I argued that scientists should not fabricate, falsify, or misrepresent data or results. Most students of silence do not have a hard time understanding what is meant by "fabrication" or "falsification" or why one should not fabricate or falsify data. However, it may be useful to say a few words about the different kinds of fabrication and falsification that can occur, since there are different ways that people can commit these cardinal sins of science.' For our purposes we can distinguish between dishonesty in collecting data and dishonesty in recording data. Dishonesty in the collecting of data occurs when scientists construct artifacts or forgeries that produce fabricated results. When this kind of dishonesty occurs, the entire experiment or test is a sham. Dishonesty in recording data occurs when scientists conduct legitimate tests or experiments but then dishonestly report the results by making them up (fabrication) or changing them (falsification). Thus, fabrication can occur in collecting or recording data, though falsification only occurs in recording data.

An infamous case of scientific misconduct illustrates how fabrication can occur in collecting data. During the early 1970s, William Summerlin conducted skin transplantation experiments on mice and eventually joined the prestigious Sloan Kettering Institute in New York. Organ and tissue transplantation in mammals is usually unsuccessful unless the donor and recipient are genetically identical, since mammalian immune systems are very adept at distinguishing between "self" and "non-self" cells and tissues. Every cell in a mammalian body contains histocompatibility antigens (HLA) on its surface. These proteins, known as antigens, have a complex, genetically coded structure. The immune system will attack cells that do not have an HLA structure that it recognizes as belonging to the self. If donor and recipient are not genetically identical, then transplanted organs or tissues will be attacked by the recipient's immune system unless the immune system is suppressed through various drugs (immunsuppressants). Immuno-suppressants produce harmful side-effects by weakening the recipient’s immune system. While these drugs may be effective in the short run, many organ transplantations that depend on immuno-suppression are ultimately unsuccessful. Summerlin hoped to offer a new method of organ and tissue transplantation that would overcome some of these difficulties. Summerlin's approach was based on the idea that if tissues are removed from a donor and cultured in a nutrient solution for a period of time, they may lose some of their HLA, making them less likely to be recognized as "non-self" by the recipient's immune system. Summerlin claimed that he used this approach successfully to graft skin from genetically unrelated mice. In his experiments, he grafted pieces of skin from black-haired mice on to white-haired mice.

However, it was discovered in March 1974 that Summerlin had used a black felt-tipped pen to color white mice and fabricate successful results. James Martin, a lab assistant, noticed that the black colored hair could be washed away with alcohol. Martin reported this discovery to a research fellow, who brought it to the attention of the vice-president of Sloan Kettering. Summerlin soon confessed and he was temporarily suspended until a peer review committee could investigate the incident. The committee concluded that Summerlin was guilty of misconduct and that there were some irregularities in his previous research. The committee recommended that Summerlin be given a leave of absence and that he correct the irregularities in his previous research. The committee also concluded that the lab director should be held partly responsible, since he supervised Summerlin's research and even co-authored some papers with

Summerlin. In his own defense, Summerlin claimed that he fabricated research results because he was under a great deal of personal and professional stress, which led to mental exhaustion (Hixson 1976).

We can easily see the dishonesty in this case, since artifacts constitute physical evidence for unethical conduct. Some of the most outrageous cases of misconduct involve sham experiments and hoaxes (Kohn 1986, Broad and Wade 1993). However, determining whether a scientist has dishonestly reported results is often more difficult. Consider, for example, the allegations presented against Imanishi-Kari. She was never accused of faking the experiment itself but she was accused of making up or changing results. In order to determine whether she dishonestly recorded results, investigators studied her laboratory notebooks to determine whether the results had been recorded in an appropriate fashion. Although the Secret Service concluded that the notebooks had been faked, further inquiries showed that their forensic evidence was inconclusive. Imanishi-Kari has been found "not guilty" and the world may never know the whole truth about this case. This case illustrates the importance of trust in collecting data. Since scientists, including science students, often record results in private, there may be no witnesses to an act of false reporting of data. Just as a professor may never know whether a student has faked his lab notebooks or lab report, scientists may never know whether their colleagues have reported results falsely. Hence, scientists must trust that data have been reported accurately (Whitbeck 1995b, Bird and Houseman 1995).

Misrepresentation of data occurs when scientists honestly collect and record data but dishonestly represent the data. Cases of misrepresentation are usually much less clear cut than cases of fabrication or falsification, and misrepresentation remains a controversial topic in scientific ethics. As I mentioned in the previous chapter, misrepresentation can occur through the misuse of statistics in science. There are many different ways that scientists can misuse statistics, but one of the most common forms of the abuse of statistics is when scientists exaggerate the significance of results (Bailar 1986). I will not discuss all the possible misuses of statistics here, since this discussion would require an entire course on statistical reasoning.' However, I will note that since statistical methods play an important role in the analysis and interpretation of data, it is often very difficult to know when someone crosses the line from using to misusing statistics. In order to use statistics properly, scientists need to acquire a great deal of knowledge, experience, and judgment in their chosen professions and have a solid grasp of statistical techniques.

This discussion of statistics also brings us back to the another point I stressed in the last chapter, namely that the distinction between "misrepresentation" and "good scientific judgment or acceptable practice" is vague. Millikan's oil drop experiments provide a good illustration of how the boundary between misrepresentation and good judgment in science can be murky. Although I mentioned this case briefly in the last chapter, I will include a fuller discussion here. Millikan won the Nobel Prize in 1923 for experiments conducted in 1910 to determine the electrical charge of the electron. The experiments were an improvement on work done by Regener. In Regener's experiment, water droplets were dropped between two charged plates. One could compare the rate of fall of the droplets in the presence of charged plates to their rates of fall without the plates to determine the charge's effect. This difference would reflect the amount of charge acquired by the water droplets, which could be used to calculate the value of the smallest possible charge, i.e. the charge of an electron. This experiment had one main difficulty, however: the water droplets evaporated too quickly. One of Millikan's graduate students, Harvey Fletcher, suggested that the experiment be performed with oil droplets, and Millikan switched from water drops to oil drops. Millikan graded his results from "best" to "fair" and wrote down some reasons for his assessments of the data in the margins of his laboratory notebooks. However, his 1913 paper on his oil drop experiments did not include these comments, nor did it include forty-nine out of 140 observations that were judged as only "fair" (Holton 1978, Franklin 1981). Millikan's paper reported no fractional charge on the oil droplets but exact multiples of charges, while other papers on the same experiments had reported fractional charges. The net effect of excluding forty-nine drops was that Millikan's paper was more elegant, clear, and convincing than other papers on the subject. If Millikan had included the recalcitrant data, he might not have won the Nobel Prize. (By the way, Millikan also did not acknowledge Fletcher's contributions to the paper, a point I will discuss later.)

There are some difficult questions we need to ask about Millikan's conduct. The first is "did Millikan commit some form of scientific dishonesty?" One might argue that he should have reported all of his results instead of excluding forty-nine of them. By excluding these observations, he crossed the line from acceptable practice to dishonesty (Holton 1978). Millikan's paper should have discussed all of his results and explained why he based his calculations on the ninety-one good results. Indeed, today's science students are taught that they should analyze recalcitrant data and give reasons for excluding "bad" results. On the other hand, Millikan practiced science during an era where standards of evidence and proof were not as rigorous as they are today. Millikan's conduct might be judged as "unethical" by today's standards but it would have been regarded as "acceptable" by the standards of his own time. Millikan was an established scientist who had a good understanding of his experimental apparatus, he had good scientific judgment, and he followed standard research practices (Franklin 1981).

In order to understand situations like the Millikan case, it is useful to remind ourselves that dishonesty occurs only when there is an intent to deceive an audience. Thus, in order to know whether Millikan misrepresented the data we must understand his motives and intentions. We also need to acknowledge that there is a difference between dishonesty and disagreement (PSRCR 1992). Scientists often disagree about research methods and practices, and it makes little sense to accuse someone of acting dishonestly when scientists lack agreement on research methods and practices. Dishonesty occurs when a scientist intentionally defies widely accepted research practices in order to deceive an audience; disagreement occurs when scientists lack an overall consensus on research practices.

Before concluding this section, I will mention some other kinds of dishonesty that occur in science. First, sometimes scientists include some misinformation in papers they submit to scientific journals (Grinnell 1992). For example, a manuscript might not accurately report the details of an experiment's design. A person who lacks the experiment's secrets will not be able to repeat it. Researchers who engage in this practice often do so in order to protect their claims to priority and intellectual property, since they fear that referees could steal their ideas. They also often print a correction after their papers are accepted and they have received proper credit for their work. (Researchers may not always print corrections, however.)

Second, scientists sometimes stretch the truth or even lie when applying for government grants, and they also engage in a fair amount of exaggeration and hyperbole when lobbying for big science projects, such as the Super Conducting Super Collider (Slakey 1993). In applying for grants, scientists often overestimate the significance of their research or its feasibility, they may omit some important details that might portray their research in a dim light, and they may describe work that they have already done but have not yet published. Some scientists may even fabricate, falsify, or misrepresent preliminary results or lie when reporting their results to the funding organizations. Finally, scientists often use their funding to conduct research not explicitly funded by the granting agency.

Are these other kinds of dishonesty unethical? It is easy to understand why someone might include some misinformation in a paper or lie on a grant application, since these behaviors can be viewed as responses to a competitive research environment. Although these problems in the research environment can explain these actions, they cannot justify them. Dishonesty in all of its forms is harmful to objective inquiry. Scientists who include misinformation in their papers hamper the peer review process and they may also promulgate errors. The proper response to the fear of having one's ideas stolen by a referee is to take steps to promote ethical refereeing and peer review. (I will discuss these topics in the next chapter.)

Scientists who lie on grant applications interfere with the objective evaluation of grants, since granting agencies need accurate and truthful information in order to assess research proposals. Moreover, this type of dishonesty in silence can also lead to an unfair and wasteful distribution of resources. Distributions of funds by granting agencies are unfair if they reward people who lie or Beverly stretch the truth and they "punish" people who do not engage in these practices. Distributions are wasteful if they fund poor proposals that appear to be promising because a scientist has lied or stretched the truth. A certain amount of "selling" of science is acceptable, but not at the expense of seriously undermining the process of evaluating grant proposals.

Perhaps science as a whole would benefit if some changes were made in the process of evaluating grant proposals, since policies may encourage dishonesty. For instance, grants often stipulate that money is not to be used to conduct research unrelated to the proposal, but scientists often use grant money to perform research not directly related to the proposal, since they need some way of funding the research. Although granting agencies restrict the use of funds in order to insure accountability, perhaps they should allow more leeway so that scientists won't have to lie about their activities in order to conduct research not directly related to the proposal. Perhaps granting agencies should be less stringent in their evaluation of research as well. If the agencies were a bit less stringent in their evaluation of proposals, i.e. if they were more willing to fund research that is not progressing well or is based on very little experimental data, then scientists would not feel as compelled to lie to them in order to meet their standards.

Finally, I will also mention that there are various other ways that scientists may act dishonestly when they publish their research, such as plagiarism, misrepresentation of publication status, and so on (LaFollette 1992). Many scientists view plagiarism as a serious breach of scientific ethics on a par with fabrication or falsification. I will discuss plagiarism and other publications issues in more depth in the next chapter.

## Misconduct in Science

Serious deviations from the principle of honesty in science have been labeled "misconduct in science" by several scientific agencies and institutions, including the NAS, the National Academy of Engineers (NAE), the Institute of Medicine (IM), and the NIH. The organizations have developed a definition of "misconduct in science" for the purposes of reporting, investigating, and adjudicating alleged violations of research ethics. In an influential report, the NAS, NAE, and IM defined misconduct as fabrication, falsification, or plagiarism in research. This definition focuses on some of the most egregious kinds of unethical behavior in science, but it does not include other infractions, such as the misrepresentation of data or misconduct unrelated to the research process (PSRCR 1992). The report recognizes that there are many types of ethically questionable practices that can occur in science, such as abusing statistical techniques, exploiting subordinates, or failing to keep adequate records, but these practices are not treated as misconduct. The report also discusses a third category, "other misconduct," which includes unacceptable behavior not unique to science, such as harassment of individuals, misuse of funds, violations of government regulations, and vandalism (PSRCR 1992).

I do not find these definitions particularly useful in thinking about or discussing ethical issues in scientific research, since they oversimplify complex problems, such as dishonesty and plagiarism. This approach assumes that there is a "clear demarcation" between misconduct in science and questionable research practices, but as we have already seen (and we will continue to see in this book), the line between unethical and ethical conduct in science is often murky. Although some ethical questions have clear, unambiguous answers, most of the interesting and important questions in ethics do not have simple or easy answers. If ethical questions in science could be understood in black and white terms, then there would be no need for writing a book on ethics in science or teaching ethics to science students. Scientists could memorize various ethical principles and follow them without any further reflection. According to the view I defend in this book, there are some general guidelines for ethical conduct in science, which scientists should follow, other things being equal. These guidelines are easy to learn, but they are difficult to apply. In order to apply these principles, scientists must reason about ethical problems and questions and exercise their scientific, practical, and moral judgment.

I also object to the report because it obfuscates other important ethical problems and issues in scientific ethics, such as harassment and vandalism, by insisting that these problems and issues are not unique to science and therefore do not come under the purview of misconduct in science. I agree that many ethical questions and problems that arise in ordinary life also arise in science. Scientists are human beings who live in human societies, and the ethical problems inherent in all human interactions will also affect those interactions involving scientific research. I argued in previous chapters that scientists, qua members of society, have moral duties as well as ethical ones: standards of conduct in science therefore include and embody professional as well as moral principles and values. If we follow this report's advice, then a principle of mutual respect would pertain only to "other misconduct." This classification implies that a scientist who vandalizes his peers' work has violated moral (and probably legal) standards but not scientific ones. I do not agree with this way of thinking about ethics in science, since it simplifies the complex web of professional, moral, and legal obligations in science to the point of banality.

## Error and Self-deception

As I have noted earlier, dishonesty is not the same thing as error or disagreement. Both dishonesty and error presuppose some kind of methodological agreement in that errors or deceptions can only occur when we have some agreement on what counts as valid, honest research. Although dishonesty and error can have similar results — they undermine the search for objective knowledge — they arise from different motives. Since error and dishonesty often produce similar results, we often cannot tell whether someone has acted dishonestly by merely examining their actions; we must also try to uncover their motives or intentions. Although it is notoriously difficult to determine a person's motives or intentions, we can use several sources of evidence to classify an action as dishonest and not simply erroneous. First, we can try to assess the accused scientist's character by talking to her students and colleagues. Second, we can examine the scientist's previous work to see if there is a pattern of deception that supports fraudulent intent. In Summerlin's case, it turned out that many of his published papers were based on fabricated data (Kohn 1986). Third, we should pay close attention to a person's response to allegations of fraud. The person who willingly admits their errors and does their best to correct them is different from the person who maintains the validity of their results, denies all allegations, and refuses to admit errors in the face of strong incriminating evidence.

In the previous chapter I discussed some reasons why it is important for scientists to avoid errors as well as some of the different kinds of errors. I would like to re-emphasize a point made earlier that standards relating to errors must be discipline-specific, since different disciplines aspire to different degrees of reliability, objectivity, and precision. Since methodological standards in social science may not apply to chemistry or vice versa, principles for assessing errors in social science may not apply to chemistry or vice versa. Since errors are more prevalent than dishonesty and can have a detrimental impact on the advancement of knowledge, scientists need to devote a great deal of time toward teaching their students how to avoid errors. Students of science need to learn how to recognize the different kinds of error, possible sources of error, the importance of avoiding error, and the proper way to respond to error (Committee on the Conduct of Science 1994). The proper response to error is to print a correction, erratum, retraction, or apology, if a paper has been published. Most scientific journals routinely publish corrections for previously published papers. Since most scientists make mistakes during their careers, scientists are willing to tolerate and excuse occasional honest mistakes, provided that these mistakes are corrected. However, the research community should not take a sanguine attitude toward scientists who continually make mistakes or who fail to admit or correct their mistakes, since these researchers should be regarded as careless or negligent. If an error occurs in research that has not been published, the proper response is to insure that any colleagues who are using the unpublished research learn about the error and correct the error in any manuscript submitted for publication.

Although many errors in silence are straightforward and simple, many of the worst errors in science are subtle and complex. These are the errors that result from faulty assumptions, fallacies in reasoning, the misuse of statistics, poor experimental design, and other elaborate follies. Sometimes it takes many years to discover these mistakes and scientists may repeat them over and over again. One reason why it is often so difficult to eliminate these more subtle errors is that scientists, like other people, are gullible (Broad and Wade 1993). Although scientists attempt to be skeptical, rigorous, honest, critical, and objective, they may fail to see their own errors as a result of self-deception. Several cases illustrate these kinds of errors.

The debate over cold fusion, according to many writers, is a classic case of scientific self-deception (Huizenga 1992). Self-deception is usually a combination of carelessness and wishful thinking: researchers want so much for an hypothesis to be true that they do not subject it to rigorous testing or careful scrutiny. Pons and Fleischmann wanted to believe in cold fusion for obvious reasons: if they could perfect the process they would obtain a great deal of money, status, and prestige. But they failed to subject their experiments to rigorous tests and careful scrutiny. For example, one of the key "results" of their experiment was that they were getting more heat out of the system than they were putting into it. This heat was measured near the electrode where cold fusion was allegedly taking place. However, other scientists have analyzed the thermodynamics of cold fusion and have claimed that ordinary chemical reactions will cause heat build-up near this electrode if the solution is not mixed properly (Huizenga 1992). Thus, Pons and Fleischmann have been charged with failing to understand their experiment's design.

The examples discussed thus far suggest that only individual scientists or research teams succumb to self-deception, but the infamous N-Ray affair was a case where an entire community of scientists deceived themselves. During the late 1800s and early 1900s, scientists discovered some new forms of radiation, such as X-rays, radio waves, and cathode rays. As a result of these discoveries, many scientists became interested in new forms of radiation and a "scientific bandwagon" started rolling. N-rays were "discovered" in 1903 by the French physicist Rene Blondlot. These rays could be detected by an increase in brightness from an electric spark, which could only be observed by the naked eye. Soon other French physicists reported similar observations, and N-rays were also "discovered" in gases, magnetic fields, chemicals, and the human brain. Between 1903 and 1906, over 100 scientists wrote more than 300 papers on N-rays. Many of the scientists who studied N-rays, such as Jean Bacquerel, Gilbert Ballet, and Andre Broaa, were highly respected men who made important contributions to science. Blondlot even received the French Academy of Sciences' Leconte Prize for his work on N-rays. However, an American physicist R.W. Wood demonstrated that N-rays were an illusion after he visited Blondlot's laboratory. In his "experiment" Blondlot said that he could "observe" the splitting of N-rays into different wavelengths upon passing through a prism. In a darkened room Blondlot claimed to observe this effect, even after Wood had removed the prism. N-rays turned out to be nothing more than an "observer effect."' Shortly after Wood's expose the rest of the scientific community lost interest in N-rays, although French physicists continued to support Blondlot's work for several years. Although some historians consider the N-ray affair to be a case of pathological science, other historians argue that it more closely resembles ordinary science than some scientists might be willing to admit (Broad and Wade 1993). All scientists — even some of the most respected scientists — can succumb to various forms of self-deception during research. To prevent self-deception, scientists need a strong commitment to carefulness, skepticism, and rigor.

Before concluding this section I think we need to place self-deception in an historical perspective, since research methods may change over time and scientists may uncover previously unknown errors in reasoning. From our modern viewpoint, ancient Greek astronomers may have seemed self-deceived, since they believed that the planets had to move in perfect circles; and phrenologists may have seemed self-deceived, since they believed that head shapes determine intelligence and personality. Even some great scientists, such as Copernicus and Newton, could be considered self-deceived, since Copernicus believed that the planets move in perfect circles and Newton believed that the geometry of the universe is Euclidean. But it would be unfair and uncharitable to draw these conclusions. Scientists have to be judged according to the research practices that are accepted during their time. If we learn that those practices generate errors, then those practices can and should be changed, and scientists have an obligation to conduct research in light of these improvements. It is only when scientists make errors as a result of failing to conform to accepted practices that we may consider them self-deceived; being mistaken is not the same as being self-deceived. Even those scientists who believe a correct theory could still be self-deceived if their correct conclusions are based on unacceptable research practices. The difference between self-deception and intellectual integrity in research does not reduce to the difference between getting the wrong or right results. Scientists have intellectual integrity insofar as they strive to follow the highest standards of evidence and reasoning in their quest to obtain knowledge and avoid ignorance.

## Bias in Research

In the past two decades, many scholars have argued that various types of biases have infected and continue to infect scientific research. Though biases often lead to errors, there are several reasons why it is useful to distinguish between biases and errors. First, biases are systematic flaws in research. Biases, like rotten apples, can spoil the whole research barrel. Errors might have isolated effects. For example, a Nissan speedometer would be biased if it always underreported a car's speed by 10 percent. A speedometer that merely makes errors might give inaccurate readings in specific circumstances, e.g. when the car is accelerating at a very high rate. For a striking example of biased research, consider the "science" of craniometry practiced during the 1800s (Gould 1981). The craniometrists believed that human head sizes and shapes determine personality traits and intelligence: people with ape-like heads or small craniums were believed to be intellectually inferior. This false assumption invalidated the entire field of craniometry.

Second, biases can be highly controversial; scientists can usually agree when research contains errors, but it is more difficult to reach agreement concerning biases. One person's bias may be another person's valid assumption or methodology. It can be difficult to detect biases in research because one often needs an independent source of evidence or criticism to detect a bias. For example, if you have want to know whether your Nissan speedometer is biased, you cannot check it against other Nissan speedometers; you need a measurement that is independent of your particular speedometer or its type. It is not always easy to achieve this independence in science, since institutional, political, and social factors can militate against it. It might happen that all scientists in a particular field, such as craniometry, accept the same research bias.

Third, since it is often so difficult to agree on when or whether research is biased, it may not be appropriate to regard biased research as unethical. Although all researchers should strive to avoid biases, it may not be useful to assign moral or ethical blame to a person or research group if their research is judged to be biased. The person who conducts biased research is more like the person who defends an hypothesis that is later proven wrong than the person who makes a mistake or attempts to deceive her audience. The craniometrists, as mistaken as they were, may have conducted careful, honest research. Craniometrists appeared to be doing good science.

Fourth, biases often result from political, social, and economic aspects of science. For example, feminist scholars have argued that some research on human evolution is biased insofar as it reflects patriarchal assumptions (Longino 1990).[4] Since craniometrists claimed that a study of craniums could show that some races were intellectually inferior, many writers have claimed that craniometry's biases resulted from racist assumptions (Gould 1981). A more in-depth discussion of the social, political, and economic aspects of silence takes us beyond the present scope of this book.'

I would like to mention at this point, however, that freedom and openness in research can help science to eliminate some of its biases. Science is more likely to achieve objective, unbiased knowledge when scientists pursue different ideas and are open to criticism (Longino 1990). I will discuss openness in more depth shortly.

## Conflicts of Interest

Sometimes scientific objectivity can be compromised not by error, bias, self-deception, or dishonesty but by conflicts of interest. Before discussing conflicts of interest in science, I will give a brief explication of the notion of a conflict of interest. A conflict of interest occurs when a person's personal or financial interests conflict with their professional or institutional obligations. This conflict undermines or impairs their ability to make reliable, impartial, and objective decisions and judgments (Davis 1982). Impaired judgment is not the same as biased judgment, and a person who has a conflict of interest may make a variety of errors that are not slanted in any particular way. A person with impaired judgment is like an unreliable speedometer; sometimes it overestimates speed, sometimes it underestimates it, and so on.

For example, a father who is asked to referee his daughter's basketball game has a conflict of interest: his relationship with his daughter, a personal interest, conflicts with his duty to be an impartial referee, an institutional obligation. One might expect the father to make too many calls in favor of his daughter's team, but he also might try to compensate for his impairment and make too many calls against his daughter's team. Since his judgment is impaired, his calls are unreliable and untrustworthy. A city council member making a zoning decision that would affect the value of his property — it would increase in value by $50,000 if a new zoning proposal is approved — has a conflict of interest because his economic interests conflict with his obligations to make objective decisions in government. Finally, a person who serves on a jury would have a conflict of interest if the defendant is a close, personal friend because her relationship with the defendant could prevent her from making a fair and impartial decision. It is important to understand that conflicts of interest do not automatically invalidate judgments or decisions, since a person with a conflict can still make correct judgments or decisions. The father who referees his daughter's basketball game could try his best to be impartial and he could make correct calls for the entire contest. The problem with his refereeing the game is that his judgment is not reliable, given his conflict.

We should also note there is a difference between a conflict of interest, a conflict of commitment, and an apparent conflict of interest (Davis 1982). A conflict of commitment occurs when a person has professional or institutional obligations that may conflict. For example, a university pharmacy professor who is also president of the state's board of pharmacy would have obligations to the university and the board that might conflict. The board could take a great deal of the professor's time and energy and prevent her from being an effective professor. An apparent conflict of interest occurs when it might appear to an outside observer that a person has a conflict of interest when she does not. For example, suppose a state legislator has a retirement fund that invests 1 percent of its funds in a coal company located in his state. It might appear to an outside observer that this legislator cannot make any decisions that affect the company because he has an economic interest in the company. On closer examination, however, it turns out that the legislator would derive a minimal and indirect economic benefit from decisions he makes that affect the company, since these decisions would not have a significant impact on the value of his retirement fund. Apparent conflicts of interest can become real, however, if a person's personal interests change. For instance, if the retirement fund changed its investments so that 40 percent of its funds were invested in the coal company, then the legislator's apparent conflict of interest would be a real conflict of interest.

This discussion raises the thorny question of how we distinguish between real and apparent conflicts of interest. How much money needs to be involved before a person has a conflict of interest? What kind of relationships or personal interests can affect our judgment? These are important, practical questions that I will not try to answer here. Even if we do not answer these questions here, we should note that they give us some reasons for taking apparent conflicts seriously, since the distinction between apparent and real conflicts may not be as clear cut as one might suppose. Since the difference between real and apparent conflicts is not absolute, perhaps it is most useful to think of the difference as a matter of degree. We could grade conflicts as follows: (a) egregious real conflicts of interest, (b) moderate real conflicts of interest, (c) suspicious apparent conflicts of interest, (d) innocuous apparent conflicts of interest. In this classification, an egregious conflict is a situation where a person's judgment is definitely compromised; a suspicious apparent conflict is a situation where we have reasons to believe that a real conflict may arise.

Since people in professional occupations are expected to make objective decisions on behalf of their clients, the profession, or society, people in the various professions should avoid conflicts of interest (Davis 1982, Steiner 1996). The proper response to an apparent or real conflict of interest is to first disclose the conflict to the people who should know about it. If the conflict is real and not merely apparent, then the next step is to avoid making or even influencing decisions that involve this conflict. For example, the city council member should disclose his conflict of interest, he should not vote on the proposed zoning change nor should he influence the vote. He should remove himself from any debate about the zoning. If the conflict is only an apparent conflict, then the parties who are affected by the conflict should monitor this conflict since it could become a real conflict. For example, the state legislator, his constituents, and other people in government should keep track of his retirement fund's investments. Some people may decide to avoid even apparent conflicts of interest in order to protect their public image, avoid ethical problems, and so on. In order to do this, one would need to disclose all conflicts and remove oneself from decisions where such conflicts arise. People who have a lot of money invested in different companies and funds sometimes decide to place their investments in a blind trust in order to avoid even apparent conflicts of interest. (A blind trust is a way of turning over management of your investments to an outside agency that will not let you know how or where your funds are invested.)

Since most people have economic or personal interests that can conflict with their professional or institutional obligations, it is virtually impossible to avoid apparent conflicts of interest. Only a hermit could avoid apparent conflicts. Sometimes it is also difficult to avoid real conflicts of interest. For example, suppose the six out of nine members of the city council declare a conflict of interest. Should all of these members remove themselves from this zoning decision? Probably not, since it would not be in the best interests of the people of the town to have this decision made by only three members of the council. The best thing to do in this situation is to declare conflicts and to strive to be objective.

Although conflicts of commitment can adversely affect professional responsibilities, they do not by their very nature affect professional judgment. Hence, professionals should manage conflicts of commitment though they need not avoid them. The appropriate course of action is to disclose the conflict of commitment to the relevant people and to make sure that the conflict does not compromise one's primary professional commitments and loyalties. For example, the pharmacy professor should let her department chair know about her position on the board, and she should step down from this position if it prevents her from fulfilling her obligations to the university.

When conflicts of interest occur in science, they can compromise the objectivity of scientific judgments and decisions, such as the analysis and interpretation of data, the evaluation of scientific papers and research proposals, and hiring and promotion decisions. A scientist whose judgment has been compromised by a conflict of interest could overestimate the significance of data, she could exclude recalcitrant data, she could fail to subject her work to critical scrutiny, and so on. A scientist who has a conflict of interest could still strive to be objective and could still make correct decisions and judgments. Nevertheless, we have reasons to suspect that her judgments and decisions are unreliable, if she has a conflict of

interest. When a scientist makes a judgment that is affected by a real or apparent conflict of interest, other scientists who know about this conflict have reasons to scrutinize that judgment carefully.

A common kind of conflict of interest in science occurs when researchers stand to benefit financially from research results. These benefits might include salary increases, royalties on copyrights or patents, funding of additional research, shares of stock, dividends, and so on. All of these financial rewards can create apparent or real conflicts of interest in that they can compromise a scientist's ability to design experiments, conduct tests, or interpret data in an objective fashion. For a recent case, consider the Cleveland scientist, Michael Macknin, who had invested in a company that makes zinc throat lozenges. He bought stock in the company, Quigley Corporation, shortly after he obtained data showing that zinc lozenges can alleviate cold symptoms. The company's stock soared after Macknin published these results, and he profited $145,000 (Hilts 1997). In this case, it appears that Macknin only had a moderate conflict of interest, since he had some financial incentives for obtaining positive results and he was probably planning on buying stock in the company. If he had bought stock in the company before he conducted the research, he would have an egregious conflict of interest. The proper response to this conflict is to disclose it, which he did, and to monitor the conflict, which he and other parties should attempt to do.

If we apply my earlier analysis of conflicts of interest to science, it follows that scientists have an obligation to disclose conflicts of interest, including apparent conflicts. Although a conflict of interest might not undermine a paper or taint its results, other scientists (and the public) should know that the conflict exists. Even if Macknin's results are valid, other scientists may want to repeat his experiments or subject his work to further scrutiny, since they would have reasons to doubt the reliability of his judgments. Scientists who receive their funding from businesses should also disclose the source of their funding, since they could have financial incentives for obtaining profitable results. Many journals now require scientists to disclose sources of funding in order to deal with conflicts of interest (International Committee of Medical Journal Editors 1991).

Ideally, scientists, like other professionals, should avoid all conflicts of interest and they should monitor apparent conflicts. However, practical realities may prevent scientists from meeting these ideal standards. Research often yields financial rewards and it is often funded by business. Given these fiscal and economic realities, we can expect that conflicts of interest will often arise in science and that they may be unavoidable in many cases, e.g. when scientists work for industry or when they attempt to develop patentable inventions. If scientists avoided all conflicts of interest, then a great deal of research would never get done and many scientists would have to find employment elsewhere. Neither of these results would be in the best interests of society, business, or the scientific profession. Scientists should disclose all conflicts of interest (real or apparent), and they should avoid the most egregious ones. But moderate conflicts of interest can be tolerated in science, and apparent conflicts can be monitored. Science can tolerate some conflicts of interest since the scientific community can check and scrutinize the work of scientists who have conflicts. Peer review helps to insure that biases or errors that result from conflicts of interest can be corrected.

Many other kinds of conflicts of interest can arise in science besides the types discussed here. Some other situations where conflicts of interest can arise include peer review, government funding, hiring and promotion, and expert testimony. I will discuss these other situations in subsequent chapters.

## Openness

We have already seen how many different problems can compromise the objectivity of scientific research. These range from dishonesty and deception to error, bias, self-deception, and conflicts of interest. Peer review provides the common solution to all of these problems because it enables the scientific community to weed out various forms of deception, to catch human and experimental errors, to prevent and discover self-deception and bias, and to control conflicts of interest (Munthe and Welin 1996). It is often said that "science is self-correcting." What this means is that peer review and other key elements of the scientific method insure that the deceptions, errors, and biases that frequently occur in science will be eliminated in the long run. Although the scientific method is not perfect, it is our most useful tool in the quest for objective knowledge. But this method can only work when scientists practice openness by sharing data, ideas, theories, and results. Openness in science also implies that scientists should disclose sources of funding and financial interests, and that they should be open to new ideas, new methods, and new people. Openness should prevail in scientific research because it promotes objective inquiry and because it contributes to cooperation and trust in science.

It may come as a surprise to some students to learn that openness did not always prevail in science. During the later Middle Ages and the Renaissance, scientists kept secrets in order to prevent their ideas from being stolen and to avoid religious persecution. In order to protect his ideas, Leonardo Da Vinci wrote notes in mirror-writing (Meadows 1992).

Mathematicians often wrote proofs in secret code during this time, and alchemists guarded their secret formulas and techniques (Goldstein 1980). During the debate over Copernican astronomy, many scientists did not make their heliocentric views public out of fear of persecution. During this century, Soviet scientists kept their discussions about Mendelian genetics secret in order to avoid political persecution. Several important changes have taken place over the last 500 years that have allowed scientists to share their ideas openly, such as the formation of scientific societies and journals, the establishment of governments that value freedom of expression, and the promulgation of intellectual property laws. Since many of the same conditions and pressures that encouraged secrecy in science 500 years ago still prevail today, scientists should not take this current climate of openness for granted. Science could very easily become highly secretive once again if scientists do not safeguard openness.

Although today's scientists are not likely to keep secrets in order to avoid religious or political persecution, there are some powerful threats to openness, such as rampant careerism and economic self-interest. Some of the most difficult questions relating to openness also arise in the context of military and industrial research, since scientists who work under these circumstances are often required to keep secrets (Bok 1982). I will discuss these questions in more depth later on in the book. For our present purposes, it will be useful to ask if secrecy is ever justified in academic science.

In the previous chapter I argued that scientists are sometimes justified in keeping secrets in order to protect ongoing research. This seems like a good reason to allow for a limited form of secrecy in science. Consider Charles Darwin's reluctance to publish his theory of evolution by natural selection. Darwin's idea germinated while he served as the ship's naturalist on the five-year voyage of the HMS Beagle. From 1836 to 1859, he gathered more evidence for his theory and refined its basic concepts and principles. In 1842 Darwin wrote an essay on natural selection, which he showed only to Joseph Hooker. In 1856, Charles Lyell advised Darwin to write a book on the subject. But what prompted Darwin to finish the work was a letter from Alfred Wallace announcing his own theory of natural selection. The two men agreed to present their ideas together at a meeting of the Linnean Society, although Darwin was listed as the sole author of the *Origin of Species.* It is not difficult to understand why Darwin took so long to publish his work or why he kept it secret: he wanted to make sure that he could present a solid and convincing case for evolution. He knew that his theory would be subjected to a great deal of scientific and religious criticism, and he wanted to give it a good chance of succeeding (Meadows 1992). It is also likely that Darwin took a long time to publicize his research in order to protect his reputation and his ideas.

Although Darwin offers us an example of someone who had good reasons to guard his research carefully, today few scientists follow his example. In the current research environment you would be hard pressed to find a scientist sitting on a hypothesis for a few years, to say nothing of waiting more than two decades to publish an idea. Though Darwin erred almost on the side of hesitancy, today's scientists often err on the side of urgency. The "rush to publish" plays a large role in the propagation of errors, biases, and deceptions and other threats to the integrity and quality of research (LaFollette 1992). The cold fusion case provides an unfortunate example of this phenomenon: driven by a desire for priority, prestige, and money, the scientists publicized their work before it had been validated by peers.

There are several other reasons for secrecy in science in addition to the need to protect ongoing research. First, scientists are justified in not revealing the names and institutional affiliations of reviewers or authors in order to insure that peer review is candid and objective. This practice, which I will discuss later in the book, is known as blind review. Second, scientists are justified in suppressing the names, addresses, and other personal identifiers of human subjects in order to protect their privacy. (I will also discuss research on human subjects in Chapter 7.) Third, scientists may be justified in sharing ideas with only a limited audience, such as a group of specialists in a particular field; not all scientific theories need to be reported in the popular press in order to satisfy the demands of openness. I will also discuss various aspects of the relationship between science and the media later on in the book.

The final reason for secrecy I will discuss in this section concerns the issue of sharing scientific information among nations. From the scientific viewpoint, it would seem that international scientific collaboration and cooperation should not only be permitted but strongly encouraged (Wallerstein 1984). If collaboration and cooperation in science contribute to the advancement of knowledge, then international collaboration and cooperation should also promote this goal. This is especially true when science undertakes large-scale, multi-billion dollar projects that cannot be fully funded (or used) by any one nation, such as the high-energy physics laboratory, Conseil European pour la Recherche Nucleaire (CERN) in Geneva, Switzerland. Scientists from many different nations conduct experiments at this lab, and many different nations help to fund it (Horgan 1994). Although international collaboration and cooperation is especially important in "big science," it is also should be encouraged in "little science."

While openness implies both unilateral and multilateral sharing of information, one might argue that moral or political goals sometimes justify restrictions on international cooperation in science. These restrictions

would be limits on openness that extend beyond restrictions on classified, military information. For instance, during the height of the Cold War, there was virtually no scientific collaboration or cooperation between the United States and the Soviet Union. These restrictions on openness applied to many kinds of research that had little to do with nuclear weapons, such as computing technology, mathematics, physics, engineering, medicine, and chemistry. Both countries discouraged or even banned cooperation in order to gain a scientific and technological edge in the Cold War. Although the Cold War is over, one might argue that similar restrictions on international cooperation can be justified for political reasons. The United States could limit international scientific collaboration and cooperation in order to prevent renegade nations or terrorists from acquiring more scientific knowledge and technological power. If knowledge is power, then some nations may attempt to control knowledge in order to achieve political goals (Dickson 1984). These larger political issues take us beyond the scope of this book, however. While I will not attempt to criticize the United States' past or current foreign policies, I will observe that these policies can have an important impact on the flow of scientific and technical information (Nelkin 1984).

## Data Management

Questions about data management in science have a direct bearing on questions about openness, since in order to share data one must store it and make it accessible to others (PSRCR 1992). Data can be stored in many different forms, e.g. on paper, computer diskettes, tapes, microfilm, slides, videotape, and so on. Data should also be well organized in order to insure easy access and transmission: a library is of little use if no one can find or read its books. It is important to store data for several reasons. First, scientists need to store data in order to check their own work. Sometimes scientists want to take another look at the hard data or reanalyze it. Second, data should be stored so that critics and reviewers can scrutinize or verify research. The data serves as proof that the research was indeed done as it has been described. If someone wants to question the validity of a study, or even deride whether it is fraudulent, they need access to the data. Third, data should be stored so that other scientists can use the original data in their own research. Since original data often contain more information than can be gleaned from published data, those who want to benefit from previous research will often want access to original data. Finally, data are scientific resources that scientists should not mismanage or waste.' All of these reasons for storing data and making it accessible promote the objectivity of inquiry and cooperation and trust among scientists.

Although it is fairly obvious that data should be stored, it is not at all clear how it should be stored, for how long, or who should have access to it. Since laboratory space is limited, most scientists need to minimize the amount of space they devote to the storage of data. NASA has accumulated so much data from planetary exploration during the last two decades that it has vast storerooms of data that have not even been analyzed or interpreted. It is likely to take many years for planetary scientists to sort through all of the data from missions to Saturn, Jupiter, and Neptune. No matter how scientists decide to store data, they should be responsible for taking care of it and keeping it from being lost due to decay, contamination, or other difficulties. However, economic considerations also have an impact on data storage, since there are significant costs associated with data management. Laboratories often need to keep and maintain obsolete machines that are designed to read outmoded forms of data storage, such as computer tapes. Although it is sometimes possible to transfer data to new mediums, the transferring of data incurs its own costs. In an ideal world, scientists would have enough space and money to keep data forever. But limitations in economic and other resources require scientists to balance the goal of storing data against the goal of making efficient use their resources. Although scientists usually strive to keep data as long as possible, data are sometimes destroyed after only a few years in order to save space and money (PSRCR 1992). Many factors enter into decisions about data storage, and each decision to destroy or keep data needs to be made on its own merits. I mention some of the basic issues here, but the practical questions are best left to professional scientists.

Although academic scientists have an obligation to save data, scientists who conduct research on human subjects may have an obligation to destroy data after a period of time (American Psychological Association 1990). The reason for destroying data about human subjects is that researchers have an obligation to protect confidentiality, and one of the best ways of keeping information secret is to destroy it.

Finally, I should mention that some ethical questions can arise when scientists decide who should have access to data. The people who might reasonably request access to data include collaborators, colleagues in the same research group or laboratory, scientists working within the same field, scientists working in different fields, and representatives from funding agencies. Others who may request access to data include government officials, the press, scholars in non-scientific disciplines, and laypeople. Although openness implies unlimited access to data, there are some reasons for limiting access to data that do not undermine openness (Marshall 1997). For instance, scientists may be concerned that non-experts will accidentally destroy data, that rivals will steal data, that enemies will intentionally destroy data, or that other scientists or laypeople will misinterpret data. Data access may sometimes be denied for political reasons. All of these reasons for denying access to data suggest that data can be viewed as a kind of intellectual property. Although this property should be shared, scientists and other parties may legitimately claim a right to control its use. Just as a scientist has a right to control access to her laboratory, she also has a right to control access to her data. In making data access decisions, scientists need to balance the ethic of openness against other concerns and values, such as carefulness, prudence, fairness, respect for political interests, and accountability.