ISSUES IN ACADEMIC ETHICS

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Ethics of Scientific Research

Kristin Shrader-Frechette

Distinguished Research Professor
Environmental Sciences and Policy Program
and
Department of Philosophy
University of South Florida
Tampa, FL 33620-5550

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The Importance of Research Ethics: History and Introduction

In May 1953, the U.S. government conducted two atomic bomb tests in Nevada. Fallout rained on ten herds of sheep grazing nearby. Although 4,500 sheep died, and many ranchers went out of business, researchers employed by the U.S. Atomic Energy Commission (AEC) argued that the two weapons tests had not caused the livestock deaths. As a result, federal courts dismissed ranchers' claims for compensation. Years later, both the scientists and the AEC were implicated for perpetrating a fraud upon the court. Their deception came to light in 1980 after the governor of Utah obtained the release of previously classified federal documents concerning the sheep deaths. The documents showed that the AEC researchers and officials—including Bernard Trum, a scientist who later became director of a primate research laboratory at Harvard University—had induced the original scientists to deny their conclusions that radiation had indeed caused the fallout deaths.[1] Researchers' fraud in the weapons testing case, however, has harmed more than sheep. Between 1951 and 1963, the United States conducted more than one hundred above-ground tests of atomic bombs in Nevada. Despite the tests' scientific, military, and national-security benefits, a 1991 study by physicians concluded that an additional 2.4 million cancer deaths, worldwide, will have been caused by these twelve years of U.S. weapons testing.[2] In 1990 the U.S. Congress decided to compensate many of the citizens who could prove that they or their family members were harmed by fallout.[3]

As the weapons tests illustrate, along with the monumental intellectual advances and the economic technocopia scientific experimentation creates, research in scientific and engineering disciplines has raised serious ethical questions, some of which concern risks to thousands of people. In 1986, for example, Soviet scientists and technicians were performing an unauthorized experiment at the Chernobyl nuclear power station. They accidentally cut off the water supply, triggering a massive reactor meltdown, explosion, and fire that spewed radioactive materials into the atmosphere. Some experts predict that these materials, circulated around the globe, will cause up to 475,500 additional cancer deaths, worldwide, over the next several decades.[4]

What is Research Ethics?

Despite the enormous benefits and the potentially serious consequences associated with research science, even members of national commissions dealing with research ethics find it difficult to define "research."[5] One way to understand the term is to distinguish it from "practice." For the most part, "research" refers to an activity enabling us to test some hypothesis or to draw conclusions and contribute to knowledge. In the case of nuclear weapons tests in the United States, for example, one hypothesis tested was that adding deuterium and tritium gas to an atomic bomb's fissile core would boost the efficiency, and therefore the yield, of the weapon.[6] Professionals' practice, however, unlike their research, does not test some hypothesis but rather enhances the welfare of clients through an action already expected to be successful, an action not taken merely as a hypothesis.[7] Although both professionals' research and practice are governed by ethics, the "ethics" of research ethics refers to individual and communal codes of behavior based on a set of principles for conducting research.[8] "Research ethics" thus specifies the way researchers ought to conduct themselves when they investigate fields such as astronomy and zoology. In this volume we are concerned with the conduct of all scientific researchers.

Scholars have been interested for some time in the norms appropriate to *science*, as evidenced by books such as Charles Babbage's *Reflections on the Decline of Science in England* (1830). Likewise, although doctors in the 1800s were punished for experimenting on their patients without those patients' consent, only recently has anyone begun to discuss the norms of research in general. Few wrote about research ethics until a series of scandals, involving fabricated experiments and deception of research subjects, occurred in the 1960s and 1970s. In 1974 the U.S. Congress required institutions receiving federal research grants to have research ethics committees—institutional review boards. By 1983,

major research universities, such as Harvard, Yale, and Stanford, had guidelines for dealing with misconduct in research, in part because of a report of the Association of American Universities (AAU) calling for clarification of research policies. By the mid-1980s most hospitals and research institutions throughout western Europe and the United States had research committees. The governments of Sweden, the Netherlands, and the United States require that an independent research review committee approve research protocols, especially in the biomedical sciences. For example, all federally funded research in the United States involving human and animal subjects must be reviewed for both scientific design and ethical adequacy. Researchers seeking funding from U.S. government agencies now must explicitly address questions of research ethics such as whether humans or other animals will be research subjects and whether an institutional review board has evaluated the research protocols or procedures.

In 1982 the Swedish Council for Research in the Humanities and Social Sciences published four research ethics principles:

- Experimental subjects ought to give free informed consent to the research.
- They have the right to decide the conditions under which they will participate.
- No unauthorized persons will have access to research data.
- The data cannot be used outside the research project for commercial or nonscientific purposes.

Despite such widespread and recent progress in research ethics, however, there are at least two fundamental problems. Most countries do not have government-mandated regulation of research; even where such regulation exists, often it covers only drug experimentation. A second difficulty is that even if a nation has research ethics committees, many times they are associated only with a particular institution and typically they cover only cases involving human and animal subjects of medical or scientific experimentation.[9]

To remedy some of the incompleteness in the discussion of ethical issues, in 1975 the U.S. National Science Foundation began funding studies of ethics and values in scientific and technological research. This program has continued to the present under the direction of Dr. Rachelle Hollander.[10] The U.S. National Academy of Science (NAS), National Academy of Engineering (NAE), and Institute of Medicine (IM) also have attempted to direct more attention to the ethics of the research process. In 1992 and 1993 the joint NAS/NAE/IM Panel on Scientific Responsibility and the Conduct of Research published a two-volume landmark study, *Responsible Science*, which describes the contemporary research environment and suggests methods for encouraging responsible research and for dealing with misconduct.[11]

Two broad categories of ethical problems arise in connection with scientific research: those related to *processes* and those related to *products*.[12] Research processes may harm people, for example, if subjects do not give free informed consent to the procedures they undergo or if they are recruited by deceptive means. They also may be harmed by the products of research, as were the "downwinders" in Nevada, Utah, Arizona, and California, victims of radioactive fallout produced by above-ground nuclear-weapons testing.[13] Radioactive products of U.S. nuclear weapons testing have caused epidemics of leukemia and other cancers throughout the areas receiving the heaviest fallout. For example, the movie *The Conqueror* (1954) was filmed in a windy, dusty canyon near St. George, Utah. No testing took place in this canyon, but the location was downwind from the Nevada test site. When actors such as Pedro Almendariz, Dick Powell, Jeanne Gerson, Susan Hayward, and John Wayne succumbed to cancer, Agnes Moorehead remarked: "Everybody in that picture [*The Conqueror*] has gotten cancer and died."[14]

Scientific Research, Harm, and Free Informed Consent

Just as research *products* may hurt selected groups of persons—such as the cast of *The Conqueror*—so also research *processes* tend to harm those already socially disadvantaged. Typically, experimental subjects for research are in positions of relative disadvantage, both within the larger social system and within the research situation itself.[15] As the example of Nevada victims of nuclear-weapons tests showed, research can threaten the welfare of thousands of people who may have no idea that their lives are at risk. Moreover, the number of people put at risk by research may be greater than we think, because research misconduct is probably underreported. Less than half of all burglaries in the United States are mentioned to the police, and most embezzlements are never reported.[16] If misconduct in research—such as unauthorized experimentation or testing—is as underreported as embezzlement, then serious ethical problems exist. For example, when the Bureau of Drugs of the U.S. Food and Drug Administration (FDA) recently carried out 496 inspections of clinical studies, it found numerous problems with research processes and practices. These problems included lack of patient consent, inadequate drug accountability, protocol nonadherence, record inaccuracy, and record nonavailability; since 1962 FDA investigations undertaken in response to reports of suspected research misconduct have resulted in the disqualification of one in every four investigated researchers.[17]

If the FDA's statistics are typical, then unethical research practices, processes, and consequences cause more serious and more widespread harm than is immediately evident. A 1986 General Accounting Office (GAO) report revealed that 90 percent of the Department of Energy's 127 nuclear facilities—many of which conduct research—had contaminated groundwater that exceeded regulatory standards by a factor of up to 1,000. The report also revealed that environmental violations at U.S. Department of Energy and Department of Defense installations will cost $300 billion to clean up.[18] Typically, however, the public does not know of the dangers posed by government facilities. The deaths resulting from the Chernobyl experiments are known only because the magnitude of the disaster was unavoidably public. The "statistical casualties" would have been easier to cover up if one could not attribute the increases in cancer deaths to a known event or if one could not trace the causal chain of harm.[19] Such tracing is difficult because the dangerous effects of experimental research often occur after the end of the project, are never studied, or are misattributed to other causes.[20] For instance, when the government engaged in above-ground testing of atomic bombs in the western United States, officials adamantly denied that the tests caused any negative consequences on "downwinders." Epidemiological studies, performed years later, finally exposed the connection between government testing and health effects.[21] Hence, in research ethics as elsewhere in life, what the people don't know *can* hurt them. Yet, if people have basic human rights to bodily security and rights to life, then they also have rights to information necessary to safeguard those basic rights.

Because scientific and technological research involves potential risks as well as benefits, people should have the right to exercise free informed consent regarding such research and technical activities. After all, consent (either implicit or explicit) is a precondition of most just laws and policies and indeed a general precondition of governmental power over citizens. One may thus argue that researchers have the duty to secure public consent to the imposition of research-related risks, just as doctors must obtain patients' consent before performing risky medical procedures.[22]

Investigating research ethics is important not only because the failure to do so could lead to public harm but also because individual research subjects are frequently threatened. Obviously most people would not knowingly put themselves at grave risk, especially if they stood to gain no significant benefits. Hence the main reason that research subjects are often at risk is that they have not been informed and have not consented to the risk. Most of the "Instructions to Contributors" in journals that publish research on human beings do not mention informed consent, and most journal editors do not require guarantees that authors have met standards of free informed consent in their work.[23] Consequently, consent-related violations of research ethics may occur frequently. In one recent experiment at Stanford University, psychologists had to terminate prematurely (after a week) a role-playing situation because the research subjects had not given free informed consent to the harmful consequences of the research. The researchers assigned volunteer subjects roles as either "prisoners" or "guards," and allowed the guards to brutalize and degrade the prisoners. The guards themselves were harmed (in less obvious ways) by learning that they enjoyed being powerful and using their power to make others suffer.[24]

Like S. Milgram's experiment on obedience to authority (in which subjects followed directives to torture other persons),[25] the Stanford experiment harmed subjects physically as well as psychologically. Both experiments also jeopardized subjects' value systems by inducing some of them to do what they believed was wrong. By encouraging subjects to behave unethically, the studies illustrated the fragility of an individual's ethical strength and independence. The research also showed that when we study human behavior in an experimental situation, we can put subjects at risk in a variety of ways: through coercion, deception, violations of privacy, breaches of confidentiality, stress, social injury, failure to obtain free informed consent, or threatening their values.[26] Because this volume does not deal primarily with biomedical ethics, we do not discuss in great detail threats to experimental subjects. Instead our emphasis is on scientific research generally. Nevertheless, many of the most significant harms to research subjects come from experimenters' failures to obtain subjects' free informed consent. Analogously, many of the significant public harms arising from scientific research generally come from scientists' failures to obtain the public's free informed consent.

According to most authorities, "free informed consent" includes four analytical components: disclosure, understanding, voluntariness,

and competence. These components require that the researcher provide full information about possible research hazards; that the subject understand and assent to the research; and that the subject be emotionally, mentally, and physically competent to give consent.[27] Because researchers have a built-in conflict of interest—they need subjects in order to obtain information—they must also be careful to protect subjects' well-being. External controls, such as research-ethics committees, are often necessary to guarantee experimental subjects' rights to free informed consent.[28] In many situations, however, free informed consent may be difficult, even impossible, to achieve. Florence Kluckhohn's covert research or participant observation of Navajo Indians and Laud Humphreys's study of male homosexual activities in public toilets were both possible because the researchers deceived the subjects they were studying.[29] Certainly researchers could not have obtained accurate data on phenomena such as trustworthiness and obedience without some level of deception. Likewise, documenting sexist behavior would probably require observance of social interactions in situations in which the subjects remain unaware that they are being monitored with respect to sexism. More generally, to the degree that researchers feel pressure to violate ethical norms regarding deception in order to obtain reliable results, it might be difficult for them to satisfy standards of research ethics.[30] Max Weber suggested that living an ethically blameless life was impossible for a politician; it might be as difficult for certain types of researchers. Some researchers thus may face the classical political problem of "dirty hands," of being unable to function both effectively and innocently, of being unable to do accurate research while remaining respectful of the rights of subjects and the public.[31]

Recognizing the frequently incompatible requirements of free informed consent and socially beneficial research necessitating some level of deception, moral theorists have devised a number of modified forms of consent that aim to satisfy both requirements. These include *ex post facto* consent (getting approval of research subjects retroactively), proxy or presumptive consent (getting approval from mock subjects), and prior general consent (getting general approval for deceptive procedures before the experiment).[32] Although many researchers have rejected the idea of deceptive research and have cited the abuses that can occur when experimenters do not obtain *direct* informed consent, there is still debate concerning alternative forms of consent that might justify deceptive research procedures. Regardless of their positions on the defensibility of deception and modified forms of consent in research situations, virtually no moral theorists justify deception in cases in which it seriously jeopardizes the welfare of research subjects. Experts also agree that although deception for the purpose of ensuring spontaneous reactions may be justified, deception for the purpose of avoiding refusals to participate is never justified.[33] Because deception deprives research subjects of the respect to which they are entitled, and because it undermines trust between researchers and subjects and perhaps within society at large, it is very difficult to justify deception in research. Research ethics analyzes experimental situations, aiming to minimize deception, to evaluate the importance of deceptive research, and to ensure adequate ''debriefing'' procedures after the research is finished.[34] We shall not discuss these themes in detail, in part because there are numerous excellent volumes that deal with biomedical ethics,[35] and there is no need to repeat their insights here. Rather than focusing on duties to research subjects, the primary emphasis of our discussion of the ethics of scientific research is on objectivity, on ways of dealing with uncertainty, and on duties to second and third parties.

For scientists engaged in university-based research, students may be some of the second or third parties to whom researchers owe duties. For one thing, university scientists face a conflict of commitment between teaching and research that may cause them to shortchange their students because of the time scientific investigations require. Ignoring student needs is particularly likely in universities that base salary increments primarily on research productivity.[36] A scientist's over-commitment to scholarly activity may harm graduate research assistants if the researcher spends inadequate time helping them with their own work or channels graduate research and course content along lines profitable to the professor rather than along avenues basic or useful to the student. When scientists derive profit from outside consulting or grants, or when they begin their own companies, they are especially likely either to ignore student needs or to direct their own teaching, student research, and subject interests along the lines of their own profits. In such a situation, a researcher may use graduate students to further outside economic commitments. Moreover, because university scientists typically wield power over students' grades and recommendations, their emphasis on their own research and profits creates a situation of student dependency from which it is difficult to escape.[37] In joint projects among professors and students or in graduate-student research, professors may also cause harm by failing to give students' research adequate recognition or by stealing student work and publishing it as their own.[38]

Scientific Research, Conflicts of Interest, and Intellectual Property Rights

Research ethics is important not only because it helps students, the public, and experimental subjects avoid research-related harm, but also because it provides a framework for examining the ends and goals that research serves. Because taxpayers ultimately fund much university-based scientific work (especially at public institutions), academic researchers have a special duty to ensure that their work serves socially desirable ends and goals, such as democratic freedom, societal welfare, equity, and growth in knowledge. Indeed, as we shall argue in chapter two, under the ''trusteeship model'' for research professionals, *all scientists* have a duty—to varying degrees—to ensure that their work serves socially desirable ends. Without ethical scrutiny, however, scientists could too easily lose sight of their societal responsibilities and duties to taxpayers. Instead, they might choose work with narrow industrial, economic, or military ends, rather than projects that benefit the public at large. For example, although there are numerous benefits from cooperation between university researchers and industry,[39] including development of relevant knowledge and applications, funding to purchase expensive scientific equipment, and helping students obtain future employment, sometimes this cooperation can result in threats to public values, freedom, equity, and authentic growth in knowledge. In 1981, for instance, the West German pharmaceutical company Hoechst gave $70 million to Harvard's Department of Molecular Biology in exchange for rights to market all research discoveries made in the department and to exclude all funding and research that interfered with Hoechst's proprietary position. As one observer put it, ''Hoechst . . . purchased . . . control of an entire university department. . . . [E]veryone in that lab is an indentured servant to Hoechst.''[40] In the past, Harvard's patent policy required that all health-related discoveries made in its labs be dedicated to the public. In the last decade, because of deals with companies like Hoechst and Monsanto, Harvard has assigned patent rights—intellectual property rights—in exchange for financial support.[41] During the same year as the Harvard deal with Hoechst, Massachusetts Institute of Technology (MIT) signed a contract with entrepreneur Jack Whitehead to establish a biomedical research center. Whitehead gave MIT $125 million in exchange for MIT's relinquishing patent rights and control over finances, hiring, and choice of research. The agreement gave Whitehead's children the majority of positions on the financial committee of the institute's board.[42]

Research being diverted from public to private ends—serving special rather than societal interests—is not just a problem in the West.[43] Several corporations and countries, interested in African mineral resources, have literally "bought" entire universities in Nigeria, Zaire, and Ethiopia by virtue of paying scientists to do corporate research. At some African institutions, as many as 80 percent of the professors have been supported by a single corporation.[44] Industrial influence over university research also continues to be very great in Japan, where the government recently awarded more than $100 million in taxpayer monies to fund university–industry research cooperation so as to ensure that Japanese companies dominate the international biotechnology market.[45] Whether such a situation is ethically desirable, as we shall see in later chapters, partially depends on who benefits from such an arrangement and what the relevant duties and consequences are.

Profits and financial investments interfere with research not only in cases where outside interests "buy" researchers, but also in situations where scientists are not as objective as possible because of their personal investments of time and money in a particular area of research. Michael Gold's *Conspiracy of Cells* tells the story of how researchers ignored warnings that a particular cell line was contaminated and would give erroneous results if used in culture experiments. Researchers who had spent money, time, and careers on this contaminated line ignored the warnings published in both *Nature* and *Science*.[46] If such examples are typical, then some researchers may be selling their integrity in much the same way as the medieval Church sold pardons and indulgences.[47] If university scientists move from being public servants to entrepreneurs,[48] then they may lose some of their accountability to the public. They may help to blur the lines between disinterested scholarship and personal profit.[49] Nobel Laureate and MIT faculty member David Baltimore owns more than one million dollars in shares in a biotechnology company designed to commercialize his inventions. Other university scientists have similar conflicts of interest, such as owning shares of more than $10 million each, because of businesses supported by their research.[50]

Investigating questions of research ethics in this context is important because academic researchers may be more loyal to their businesses than to their universities. Also, they may divert university resources in order to support their personal consulting. Their interests may lie more with profits than with scientific research, which suggests a third problem: secrecy. Because of some funders' proprietary privileges, scientific colleagues may no longer be free to exchange information, for fear that a rival commercial interest might obtain it.[51] For some scientific researchers, knowledge has become intellectual property. For example, all U.S. Department of Defense (DOD) contracts include pre-publication review or license to censor.[52] This secrecy may be an enormous problem because more than 50 percent of all American scientists and engineers have defense contracts, and more than 65 percent of all U.S. federal research money pours into defense-related projects. The DOD and the National Aeronautics and Space Administration (NASA) together account for more than 70 percent of all federal research and development dollars.[53] These statistics suggest that research secrecy and fear of industrial espionage limit societal benefits and growth in knowledge. Also, a few scientific researchers, able to monopolize a certain area of work due to funders' secrecy requirements, have an unfair advantage over their colleagues. In several countries, some areas of university research likewise may run the risk of becoming conduits for the military–industrial complex.

Despite its practical benefits, scientific research in some cases may be jeopardizing both progress in basic science and important democratic values.[54] If military spending and economic growth have an inverse relationship,[55] and if secrecy and censorship can stifle scientific progress, then military spending at research universities may lead to massive cultural and intellectual distortions.[56] Researchers who depend on industry or military monies to supply their labs or to pay their graduate students are unlikely to bite the hand that feeds them. They may perform their research and interpret their results in a way favorable to their funders, rather than remain as objective as possible. Moreover, because industry and the military control so much university research funding, they already may have succeeded not only in shaping basic, long-term research along the lines of short-term tasks[57] (thus threatening academic freedom) but also in redefining research.[58] Science and research may have become limited to projects that receive outside funding and profit the university, rather than what is judged important by one's peers.[59] Scientific researchers' becoming more interested in profit, patents, and intellectual property rights—rather than in knowledge—may also cause graduate students, eager for financial support, to be channeled not into basic research or areas of greatest academic or societal merit, but into projects having limited intellectual importance but great commercial potential.[60] Research scientists must ask themselves: "What would have happened to Einstein and the general theory of relativity if a businessman had come up to him when he was 20 and said, 'Don't bother with relativity—it'll never make any money. Why don't you work with my company on something profitable instead?' "[61]

If business, rather than academic peers, defines "quality research," scholars who have not been "bought by industry" may be placed at a disadvantage. Abundant evidence shows that professors have been discriminated against because of lack of favor by corporate sponsors.[62] At many major universities, the departments that are expanding are those with industrial funding. Departments suffering the most cuts are those "unprofitable" areas that do not interest the business world.[63] Although much can be said for commercial relevance, university researchers also ought to consider the words of noted Harvard biologist Richard Lewontin. As Lewontin put it, when he heard about the Harvard arrangement with Hoechst: "What about the rest of us who are so foolish as to study unprofitable things like poetry, Sanskrit philology, evolutionary biology, and the history of the Chansons? Will . . . [the dean] have time to hear our pleas for space, colleagues, funds, and students between meetings with the University's business partners?"[64]

Many private research laboratories likewise have complained that university scientists, subsidized in a variety of ways by taxpayers, have unfair competitive advantages.[65] Antitrust legislation prevents collaboration among corporations desiring to apply new discoveries, yet collaboration between university researchers and industry presents some of the same ethical difficulties. Moreover, because university research dollars in the United States result in two to four times as many patent applications as do research dollars from all other sources, including businesses' own corporate laboratories,[66] any company working alone is likely to be disadvantaged. This disadvantage thus propels an even greater push for corporations to "buy" certain departments in an effort to monopolize researchers' knowledge, the intellectual capital of the future.[67] In situations where scientific research is often a commodity, raising numerous questions of research ethics—especially questions about who profits from the research and whether public research resources have been converted to private gain—is essential not only to justice but also to the health of research, society, and democracy. In order to balance researchers' institutional and private duties, scholars have suggested developing conflict-of-interest guidelines for university scientists who work on projects having commercial value.[68]

Scientific Research and the Environment

Research ethics is important not merely to help prevent harm to the public, to research subjects, and to democratic institutions, but also to help protect the environment. Practicing questionable research ethics can threaten the environment in at least three ways:

- Choosing research (or agreeing to do paid research) on unsustainable products and processes may indirectly harm the environment and decrease the probability that sustainable products and processes will be available. (Sustainable products and processes satisfy economic needs without jeopardizing the prospects of future generations.)[69]
- Certain types of research may be direct causes of environmental pollution and degradation, as in the case of space exploration and experimentation littering low-earth orbits (120–250 nautical miles above the earth) with numerous projectiles from previous launches and spacecraft.
- Some research methods, especially in economics, indirectly cause environmentally suspect decisionmaking.

The previous section of this chapter illustrated how private interests sometimes have threatened the public birthright of university research. (Subsequent chapters define and defend this "public birthright" in more detail.) These same private interests, frequently concerned with maximizing short-term gain, also may direct and pay researchers for work on processes and products that bring profit despite their environmental unsustainability. Hence, the choice of problematic research topics and practices is a concern of research ethics. Some areas of biotechnology provide a good example of how scientists work in environmentally questionable areas. For instance, U.S. researchers are purposefully modifying at least 30 crop and forest tree species to withstand lethal doses of herbicides. Such research goals raise the ethical question of whether we should use biotechnology to further pest-management strategies that rely on greater doses of toxic chemicals. These chemicals are extremely hazardous to humans and to other members of the biosphere (who have not been genetically engineered to withstand them). Apart from the 27 corporations—mainly chemical companies such as Dow, Monsanto, and Dupont—that have initiated herbicide-tolerant plant research on most agricultural crops, more than $10.5 million of taxpayer money has been used to fund state and federal genetics research on herbicide-resistant crops.[70] Because of their threat to humans, wildlife, and ecological welfare, use of hazardous chemical pesticides may not contribute to sustainable agriculture. By doing genetic-engineering research on herbicide-tolerant crops, researchers thus may help to perpetuate the high chemical dependence of conventional farming, a dependence that does not always reflect a correct understanding of the basic biological systems that make agriculture possible. Researchers also may help promote a temporary approach to weed control, as opposed to an ecological approach to weed management. Moreover, by using monies to create herbicide-resistant crops, researchers do not have those funds available to develop weed-management strategies that contribute to long-term sustainability and conservation of natural resources.[71] Scientists ought to assess carefully their research on herbicide-tolerant crops and determine whether such research is an ethically desirable use of biotechnological skills. From a purely human point of view, research on herbicide-tolerant crops may be analogous, in part, to research on how to kill the canaries in coal mines. Knowing that canaries succumb to methane poisoning before humans do, miners use canaries as "early warning" signals of dangerous levels of gas. If researchers make crops genetically resistant to herbicides, those plants may be unable to function as early warning signals for dangerous levels of chemicals in our food.

A second environmentally problematic effect of some research is pollution. One of the most well-known cases of how researchers may have failed to practice research ethics and may have caused environmental degradation has occurred in the Antarctic. Science reigns supreme in Antarctica. Research has ruled the ice since the mid-1950s, and the U.S. National Science Foundation (NSF) alone currently spends $221 million annually on Antarctic research.[72] Established in 1955, McMurdo Station is the largest U.S. base for scientific research in Antarctica. For decades, however, U.S. research teams have bulldozed garbage, old machinery, and drums of toxic waste over the hill and into nearby Winter Quarters Bay, the anchorage used by Robert F. Scott in his first expedition in 1902. Although McMurdo sits on a continent largely untouched by humans, it is one of the world's most polluted spots. In 1990, the NSF embarked on a $30 million program to clean up McMurdo, and in 1991 the 26 nations active in the Antarctic ratified a treaty to protect the continent's fragile ecosystems. The 1991 protocol refers to the continent as "dedicated to peace and science."[73] Despite the researchers' shift toward environmental responsibility, the past practices of scientists working for the NSF suggest that research-induced environmental damage should remain a concern of those interested in research ethics. In 1991 the Environmental Defense Fund sued the NSF to try to stop it from incinerating waste in Antarctica prior to completing an environmental impact assessment. (Other nations doing research in the Antarctic routinely remove their waste by ship.) If the most educated scientists from the wealthiest nations can perform research activities in ways that have contaminated Antarctica with PCBs, hydrocarbons, and sewage, then such problems of research ethics seem likely to occur again.[74]

Scientific researchers also may contribute to environmental problems by using research methodologies biased against environmental protection. Much of contemporary economics, for example, especially if practiced in particular ways, leads to policy conclusions that appear to be biased against accounting for environmental costs and benefits of societal policies. Several years ago, for example, U.S. government economists did important research on the relative costs of coal- versus nuclear-generated electricity. Following the standard benefit–cost practice of including only market-based parameters in their study, the researchers ignored the millions of taxpayer dollars spent annually on U.S. nuclear waste storage because these dollars represented a government subsidy, not a market-based cost. After ignoring one of the major costs of nuclear generation of electricity, the researchers concluded that a 1000-Mwe coal plant was $200,000 cheaper per year than a 1000-Mwe nuclear plant, when both produced the same amount of electricity.[75] However, if one takes into account the cost of waste storage, one can show that the coal plants are $2 million cheaper per year than the nuclear plants when both generate the same amount of electricity.[76] As this example indicates, researchers who employ questionable economic techniques and assumptions encourage problematic policy decisions.

Smoking provides another excellent example of how researchers' questionable economic methods may encourage environmental and human threats. Tobacco causes more death and suffering among adults than any other toxic material in the environment; tobacco addiction accounts for 2.5 million deaths annually. Yet global tobacco use has grown by 75 percent during the last two decades. In the United States, nearly one-fifth of all deaths are attributable to cigarette smoke. Although the health consequences of tobacco use are well known, policies to avoid them lag behind, in part because economic methods of computing the costs and benefits of tobacco use do not take account of externalities, nonmarket costs and benefits. Even if one does not cost the suffering tobacco victims and their families bear, but instead measures the economic benefits of the jobs and incomes the tobacco industry creates against the economic costs of increased health care and lost workdays of smokers, tobacco's economic costs alone would exceed its benefits by two to one. Researchers do not always point up this fact because most of these economic costs are external to the current methods of economic accounting. If all the "external" costs of smoking—such as increased health care—were included, they would amount to between $1.25 and $3.15 per pack. If researchers paid more attention to the unbiased presentation of all the data on smoking, and if they noted the real costs of tobacco, then government policy regarding smoking might change. Moreover, with heavy taxing of tobacco, government could cover more health costs associated with its use and also prevent the needless loss of lives and environmental pollution smoking causes. In short, if scientists (economists, for instance) accepted responsibility for the policy decisions (regarding taxing tobacco, for example) following indirectly from their research methods, then their research might not contribute to so much (tobacco-induced) human and environmental misery.[77]

Our existing accounting system makes it almost impossible for researchers to assess the effects of externalities on the economy. These effects include, for example, polluting the air with tobacco smoke or exceeding the carrying capacity of the earth. Because researchers who employ traditional techniques—associated with determining benefit–cost ratios and the GNP—ignore these effects, they cannot measure accurately economic progress or decline. In some cases, however, ethics seems to require researchers to admit the questionable assumptions in their economic and other methods and to help prevent the environmental damages caused by uncritical use of such research methods. The energy assessment of Herbert Inhaber is a famous example of a research report that employed highly evaluative, ethically questionable assumptions that led to environmentally damaging policy conclusions. Commissioned by the Canadian Atomic Energy Control Board and summarized in *Science*, Inhaber's research estimated the dangers from alternative energy technologies. He concluded that the risk from conventional energy systems, like nuclear or coal power, is less than that from nonconventional systems, like solar or wind energy, and that noncatastrophic risks (like those from solar) are greater than catastrophic (like those from nuclear power).[78]

How did Inhaber arrive at his surprising conclusions? He made some suspect evaluative assumptions. For instance, in *estimating* the risk posed by particular energy technologies, he assumed that all electricity was of utility-grid quality, i.e., able to be fed into a power grid.[79] This means that he ignored the low-risk benefits of solar space heating and hot-water heating, neither of which can be fed into a power grid. Indeed he ignored the wide variety of low-temperature forms of solar energy which could supply *40 percent of all U.S. energy needs*, at competitive

prices and at little risk.[80] Another highly evaluative assumption central to Inhaber's risk estimates is that all nonconventional energy technologies have coal backups.[81] This means, in the case of solar thermal electric, he attributed 89 percent of the risk to solar effects (especially construction of components) even though the coal backup caused them. Moreover, Inhaber assumes that nuclear fission requires no backup,[82] even though these plants have a down time of 33 percent per year for check-ups, refueling, and repairs.

In the area of *risk evaluation*, Inhaber's assumptions are just as unreliable. When he aggregates and compares all lost work days, for all energy technologies, he ignores the fact that lost work days are more or less severe, depending on the nature of the accident causing them and whether or not they are sequential. On Inhaber's scheme, a lost work day due to cancer or acute effects of radiation sickness is no different than a lost work day from a sprained ankle.[83] Yet obviously the cancer could result in premature death, and the radiation exposure could result in mutagenic effects on one's children. Neither is comparable to a sprained ankle. Inhaber made a similar questionable assumption in his research evaluating the severity of risks. Unlike other hazard assessors, he totally ignored the distinction between catastrophic and non-catastrophic risks; he assumed that 1,000 construction workers, each falling off a roof and dying, in separate accidents, was no different than 1,000 worker fatalities because of a catastrophic accident in a nuclear fuel-fabrication plant.[84] Numerous risk assessors, however, typically distinguish between catastrophic and non-catastrophic accidents. They suggest that because of increased societal disruption, n lives lost in a single catastrophic accident should be assessed as a loss of n^2 lives.[85] Regardless of whether or not this n^2 interpretation is a reasonable one, the point is that Inhaber made numerous subjective judgments, such as assuming that the distinction between catastrophic and non-catastrophic accidents could be ignored. In so doing, he passed off his results as purely objective science. Instead, tracing Inhaber's methods, step by step, shows that virtually every assumption he made in estimating and evaluating alternative risks increased his alleged nonconventional risks (associated with more environmentally sustainable technologies) and decreased his alleged conventional risks (associated with more environmentally degrading technologies). The Inhaber work illustrates clearly that attention to objectivity (see chapter three) and to research ethics may help to prevent both environmentally questionable research and problematic environmental policies.

Scientific Research and Biases Such as Sexism and Racism

Research ethics not only attempts to prevent harm to the public, to research subjects, to democratic institutions, and to the environment, but also encourages more objective practices, procedures, and methods in obtaining knowledge. In other words, research ethics strives to prevent bias. Despite its drawbacks[86]—such as increasing bureaucratic control over scholarship—research ethics is important because reducing bias enhances virtually all social and intellectual values. If one reduces bias in research, thanks to careful attention to ethics, then one serves the intellectual value of objectivity and the social value of having accurate information on which to base policy decisions.

Bias will likely arise when researchers do not see their methods and practices as subject to ethical constraints. Sometimes this bias takes the form of social and political prejudices that infect work in the humanities and social sciences.[87] In the natural sciences, such bias often takes the form of interpreting research results in ways consistent with the philosophies of particular funding groups. For example, 25 different scientists, all employed by Exxon Company USA, argued at an April 1993 meeting of the American Society for Testing and Materials that Alaska's Prince William Sound has almost fully recovered from the 1989 *Exxon Valdez* oil spill. Other scientists at the meeting argued that the Exxon scientists were able to draw such a conclusion because of the way they interpreted their data on oil contamination. Exxon researchers likely ascribed to other sources a portion of the oil that actually came from the *Exxon Valdez* spill, according to other scientists. They also accused the Exxon researchers of ignoring findings that conflicted with their biased conclusions, findings based on much longer observations and on larger sample sizes. One scientist compared Exxon's efforts to "looking at one tree" and then generalizing that conclusions drawn from it could "represent the whole forest."[88] To the extent that the Exxon researchers or any of the other scientists have interpreted the oil-spill data in biased ways, their interpretations and conclusions are open to ethical question. As the controversy over the oil-spill research illustrates, research ethics requires investigators to look at the ethical constraints on their selection, use, and interpretation of data.

As the discussion (in chapter two) of the famous Tuskegee syphilis experiment illustrates, racist bias also can infect both the procedures and the products of research, in part because experimental subjects are so vulnerable. Moreover, socially disenfranchised groups—such as

women and blacks—are more likely to be harmed by questionable research practices and products, even after researchers become aware of their racist or sexist bias. For example, in 1986 the U.S. government issued a policy requiring biomedical researchers to ensure that their study populations did not underrepresent women, African-Americans, Latins, and other racial and ethnic groups. Despite this explicit directive, in June 1990 U.S. congressional investigators issued a startling report that confirmed continuing bias against using women and members of various racial and ethnic groups as research subjects. The General Accounting Office issued a report showing that the failure to have representative research populations is widespread and continuing. For instance, the National Institute of Health (NIH) sponsored a study showing that heart attacks were reduced by taking an aspirin a day. The research subjects were all men. Other studies showing the relationship between cholesterol and cardiovascular disease have been conducted almost exclusively on men, even though heart disease is the leading cause of death among women. Such exclusionary research practices lead to damaging consequences; for example, male-only studies of heart disease led the American Heart Association to recommend a diet that could actually increase the risk of heart disease for women. Likewise, another study found that due to physiological differences, African-Americans given the "normal" dose of lithium (established by research only on white males) frequently had toxic reactions and a higher risk of renal failure.[89]

Charles Babbage, professor of mathematics at Cambridge University, was very concerned with avoiding bias in research. In 1830 he described various forms of scientific bias and dishonesty, among them "trimming," "cooking," and "forging."[90] Trimming consists of smoothing irregularities in the data to make them look accurate and precise. Cooking occurs when one discards some data and retains only evidence that fits the theory. Forging is inventing some or all of the research data reported. However, not all data gathered in a study can be used, and most researchers must simplify their problems and their data—studying only white men, for example—in order to make the studies tractable. Hence, one scientist's "cooking" may be another researcher's simplifying the data for managability. The existence of problems like cooking and trimming, and the flare of controversies like those over choosing research subjects or interpreting the *Exxon Valdez* data, argue for analysis of the ethical issues inherent in the practice of research. Without such analysis, we open the way not only for widespread anti-science sentiment, but also for policy based on bad research and for countless harms to humans and the environment. Without the analysis that characterizes research ethics, we open the way for devaluing the truth, the foundation upon which all human effort rests. Without this foundation, we shall lose our way in the very world that science seeks to understand.

Overview

How can research ethics help us find our way in the world of research science? For one thing, it points out what can go wrong[91] if one does not pay attention to the constraints on experimental practice, its products, and its goals. But how does one practice research in an ethical way? Perhaps first of all, those trained and paid to research ought actually to do it. One of the first tenets of research ethics, as we explain in chapter two, is that certain scientists have a duty to do research. They also have duties not to do specific kinds of research. Chapters three and four focus on the basic principles that govern how to perform research in an ethically acceptable way. This performance is constrained primarily by the demands of professional ethics, that is, by duties to the profession, to society, and to clients/employers. In chapters three and four, we develop three main principles of research ethics and show that they focus either on epistemological requirements of *objectivity* (the subject of chapter three) or on the ethical requirements of avoiding harm in the use, interpretation, and dissemination of research and thereby *promoting societal welfare* (chapter four).

Because objectivity is a major goal of research ethics, in chapter three we discuss what it means to do objective research and how the unavoidable value judgments necessary to all research hinder objectivity even in the purest areas of science. We also discuss the "ethics of belief" and whether it is reasonable to hold scientists ethically responsible for their research conclusions. In chapter four we investigate the ethical basis for the principle that scientists have a duty not to jeopardize societal welfare in their research. Maintaining objectivity and avoiding harm to public welfare would be relatively easy if we always understood research situations clearly. But because research is, by definition, at the frontiers of knowledge, the subjects under investigation and the consequences of scientific research are never completely foreseeable. Indeed, much decisionmaking about how to practice research focuses on how to behave ethically in situations of factual uncertainty. As a result, one of the main ethical problems of researchers—a problem that we emphasize—is developing guidelines for how to behave in such situations of

conflict and uncertainty. We do not spend much time discussing clearly reprehensible behavior because it is obviously wrong. We all know, for example, that falsifying data is wrong. It is much less clear what behavior is ethically justified in a situation of uncertainty. In chapter five, we attempt to develop guidelines for researchers' behavior under uncertainty. We evaluate the duties and consequences associated with each of the three basic principles of research ethics outlined in chapters three and four. We argue that, in most cases of conflict in research ethics, our first priority should be to protect public welfare; duties to clients or employers and to the profession are secondary. We also explain that duties to objectivity need not conflict with duties to protect the common good, and that researchers have the responsibility to adhere to principles of "ethical objectivity" as well as "epistemic objectivity." In chapter six we continue to discuss ethical conflicts in research, and we attempt to develop additional principles to deal with uncertain situations such as incomplete research data or underdeveloped theories. We argue that different norms govern applied research as opposed to pure research. In particular, we argue that in cases of applied research under uncertainty, in which both types of errors cannot be avoided, we ought to minimize type-II errors (false negatives) rather than type-I (false positives).

To illustrate our discussion of duties to the public and duties to minimize type-II statistical errors, in chapter seven we provide a case study in research ethics, a conflict over how to interpret data on species extinction. We show how the principles for which we have argued in earlier chapters provide a framework for solving this conflict. Chapters eight, nine, and ten present case studies authored, respectively, by Helen Longino of Rice, Carl Mitcham of Penn State, and Carl Cranor of the University of California, Riverside. These case studies illustrate how to resolve and analyze ethical problems associated, respectively, with sexist bias, engineering design, and methods of assessing risks from toxics. Together these chapters should provide the reader with a beginning understanding of what might go wrong in scientific research and how ethical analysis can help to prevent it.