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ETHICS IN PHYSICAL SCIENCE

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ABSTRACT—Scientific ethics, a subset of professional ethics, is discussed in light of the concept of a profession which is defined in terms of two bargains, one internal and one external, that are based on trust in human behavior. Five reasons for the breakdown of public trust in science are discussed. Arguments are made for teaching scientific ethics within the discipline using the case method.

Scientific ethics differs significantly from everyday personal ethics. It is a subset of professional ethics which is concerned with the special codes of conduct adopted by people engaged in those occupations known as professions. Examples of professions include medicine, law, engineering, and science. To understand the origin of these codes of conduct, we need to examine the concept of a profession.

In my view, a profession is defined by two bargains or contracts: an internal bargain that members of the profession make with themselves; an external bargain that the profession makes with society. These bargains may be quite formal, sometimes even written into law, or they may be more informal understandings that have developed over time by tacit agreement. The details of the agreements depend on the specific profession, but a number of general features are common to all.

The internal bargain consists of several parts. First, the profession sets standards of education and training. Some professions have a formal accreditation process for the institutions that provide this training. For example, lawyers are required to attend an accredited law school and to pass a bar examination. In science, an earned doctorate from a reputable university ordinarily is considered to be acceptable training for research, but it also is possible to be accepted into the profession with lesser academic credentials after the publication of research papers in refereed journals.

Along with the standards of training, the profession adopts an internal code of practice, a set of standards or expectations about how practitioners operate on a day-to-day basis. The internal code of practice often includes a written code of ethics. Some of the most important aspects of the internal code of practice in science are: 1) experimental and theoretical procedures are reported accurately so that independent investigators can replicate the work if they so choose; 2) the data reported are complete and correct, and scientists should not suppress data that do not agree with their expectations; 3) the interpretation of that data is done objectively; 4) credit is given where credit is due, i.e., scientists are expected to cite previous work where appropriate and to give credit to those who have aided in the research, and, conversely, it is assumed that all the authors of a scientific paper have contributed to the research. These and other standards of conduct define proper scientific investigation. While they have never been formally adopted by any scientific society, all working scientists understand and support them. In addition, various scientific societies have adopted formal codes of ethics. For example, the American Chemical Society has adopted "The Chemist's Code of Conduct" (American Chemical Society, 1994) and "Ethical Guidelines for the Publication of Chemical Research" (American Chemical Society, 1985), and the American Physical Society has adopted a set of professional guidelines (APS Panel on Public Affairs, 1992).

A profession also has a bargain with society. The profession lays claim to certain specialized knowledge and training not easily accessible to the general public. In return, the profession agrees to use that knowledge and training in the service of society and to render professional judgements when asked. For some professions such as law, medicine, and engineering, the contract with society is highly structured; in science, the agreement is more informal. Scientists have claimed the knowledge we call scientific and the methods of investigation that produce that knowledge. They also have promised society that they will use that knowledge for the public benefit. "Let us carry out our research," scientists say, "and we will eradicate disease, invent amazing new materials, clean up the environment, improve agriculture and reveal the secrets of the universe."

In any agreement between people, the key to success is trust. In a profession, the internal bargain breaks down if practitioners cannot trust that others in the profession are following the standards of conduct. As the internal bargain breaks down, society begins to mistrust the profession. A clear statement of the importance of trust in science was given in 1983 by Arnold S. Relman, Editor of the *New England Journal of Medicine*: "It seems paradoxical that scientific research, in many ways one of the most questioning and skeptical of human activities, should be dependent on personal trust. But the fact is that without trust the research enterprise could not function. (Djerassi, 1991)".

In recent years, there has been a breakdown of trust in the scientific enterprise. I can think of at least five reasons for the growing mistrust: 1) harmful effects of science and technology—The atomic bomb attacks on Hiroshima and Nagasaki demonstrated the potential of science to do enormous harm as well as good. The current environmental crisis has made many people skeptical of the claims that science is a positive force in society. 2) misunderstanding of the process of science—Most lay people regard science as a way to discover truth. They do not realize that science is filled with partial truths and even with errors. As errors are revealed, they lose trust in the entire enterprise. 3) "critiques from the margin"—Women, African-Americans, and others have raised questions about the process of science. These critiques contribute to the public mistrust of science. 4) influence of money on science—The rise of biotechnology has made science enormously profitable, at least for a

few. Legitimate concerns can be raised about the effects of money on the objectivity of research. 5) scientific misconduct—Recent highly-publicized incidents of scientific misconduct, such as the one involving Nobel Laureate David Baltimore, have raised serious questions about misconduct in research. Even if misconduct is not widespread, a few dramatic examples can destroy trust (Broad and Wade, 1982; Bell, 1992: Lafollette, 1992).

In response to the breakdown of trust in science, The National Academy of Sciences has issued a report entitled *Responsible Science* (Panel on Scientific Responsibility and the Conduct of Research, 1992, 1993). This report examines the problem of misconduct in research in detail and makes a number of recommendations. In my view, the most important is recommendation 2: "Scientists and research institutions should integrate into their curricula educational programs that foster faculty and student awareness of concerns related to the integrity of the research process." In other words, we need to teach scientific ethics.

Why have we not explicitly introduced scientific ethics into our curriculum? I think it is because we have begun to believe our own propaganda. We teach students that the scientific method is a reliable and objective method for gaining knowledge but forget that science is conducted by human beings, some of whom are dishonest. We remember the days when research groups were small and intimate and discussions of ethical concerns between advisors and students occurred at the laboratory bench or in the coffee lounge and forget that many modern research groups are so large that students may not see their major professor for weeks on end. We remember the days when the scientific profession was a rather homogeneous white male community with common values and experiences and forget that a more diverse community means a diversity of values and expectations.

If we are to teach scientific ethics, how should we do it? One possibility is to send students to the philosophy department to take a course in elementary ethics. While courses in ethics are interesting and important, they tend to focus on ethical theory rather than ethics as applied to the day-to-day life of the professional. It is better to integrate ethics into the teaching of the discipline. After all, science is filled with ethical choices. Discarding a seemingly erroneous data point is an ethical choice. Writing a scientific paper involves ethical choices. Where do I put that nagging piece of evidence that does not quite fit my model? Do I put it in the body of the paper or bury it in a footnote? We must introduce our students to the ethical problems that working scientists face.

Ethical decision-making is a skill that can be learned. I do not think that we can alter students' basic values, but we can teach them how to analyze ethical issues, how to identify the values that come into question, and how to devise a solution to an ethical problem. I believe this is best done using the case method.

In the case method, students discuss hypothetical cases based on the real situations that scientists encounter. In the discussion, the ethical issues and values are identified and possible courses of action are suggested and evaluated. Various points of view will come out quite naturally, and students can see that ethical questions do not always have a single simple answer. The instructor can guide students through the evaluation of various solutions to the ethical problems showing, in some cases, how different values can lead to different acceptable courses of action. It is an effective teaching method that also is fun for both students and teachers.

Materials for teaching scientific ethics using the case method are becoming more widely available. I have developed a set of cases for use in undergraduate and graduate chemistry education which could be adapted for other disciplines (Kovac, 1993). In addition, a casebook for introducing scientific ethics to high-school students also has been written (Frase et al., 1994).

Science is a human enterprise involving both technical and moral questions. As science educators, we have focussed on the technical and ignored the moral aspects. As a result, we have shortchanged the public and our students. To serve both properly, we must reintroduce ethical considerations into the teaching of science. I regard the teaching of ethics as part of our professional responsibility.

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