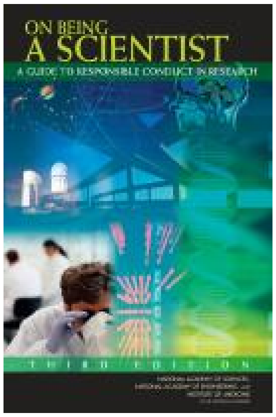

ON BEING A SCIENTIST

A Guide to Responsible Conduct in Research
Third Edition (2009)

The scientific research enterprise is built on a foundation of trust. Scientists trust that the results reported by others are valid, and society trusts that the results of research reflect an honest attempt to describe the world accurately and without bias. But this trust will endure only if the scientific community exemplifies and transmits the values associated with ethical scientific conduct.

On Being a Scientist presents an overview of the professional standards of scientific research and explains why adherence to those standards is essential for continued scientific progress. Designed to supplement the lessons in ethics provided by research supervisors and mentors, the guide describes the ethical foundations of scientific practices and some of the personal and professional challenges that researchers encounter in their work. The guide is relevant to all forms of research—whether in academic, industrial, or governmental settings—and to all scientific disciplines. And although directed primarily toward graduate students, postdocs, and junior faculty in an academic setting, its lessons apply to scientists at all stages in their education and careers.

Using case studies, the authors discuss twelve different issues in scientific conduct. They explore the reasons for specific actions, rather than stating definite conclusions about what should or should not be done.

Advising and Mentoring. While beginning researchers have advisers who oversee their research, they also need mentors who take a personal interest in their professional development. Advisers and mentors often have considerable influence on the lives of beginning researchers, and they must be careful not to abuse their authority. Beginning researchers also have responsibilities toward their advisers and mentors. Relationships between an adviser and advisee can be complex, and conflicts can arise. Guidelines spelling out the expectations of each party can help define these relationships. A list of questions is provided that could be asked when a scientist is deciding whether to join a particular research group.

The Treatment of Data. Over time, researchers have developed and continually improved methods and tools designed to maintain the accuracy of data and the integrity of research. Some of these methods, such as statistical tests of significance, double-blind trials, and proper phrasing of questions on surveys, are used only in specific fields. Others apply across all research fields, such as describing to others what one has done so that research data and results can be verified and extended. All researchers have a fundamental obligation to create and maintain an accurate, accessible, and permanent record of what they have done in sufficient detail for others to check and replicate their work. Although most researchers are not required to share data as soon as it is generated, when a scientific paper or book is published, others must have access to the data and research materials used to support any conclusions that were reached. Examples are given of new issues in the treatment and sharing of data as scientific disciplines evolve and new technologies appear.

Mistakes and Negligence. Scientific research is susceptible to error in a number of different ways, and scientific disciplines have developed methods and practices to minimize the possibility of mistakes. Failing to observe these methods violates the standards of science. Researchers have an obligation to the public, to their profession, and to themselves to be as accurate and careful as possible. Beyond honest errors are mistakes caused by negligence. The guide describes how to correct mistakes in the scientific record, regardless of the cause.

Research Misconduct. Some research behaviors are so at odds with the core principles of science that they are treated very harshly by the scientific community and by institutions that oversee research. These behaviors go beyond mistakes and negligence because there is an intent to deceive. Research misconduct—most commonly defined as fabrication, falsification, and plagiarism—has the potential to weaken the self-regulation of science, shake public confidence in the integrity of science, and forfeit the potential benefits of research. The guide discusses difficulties in establishing intent and the effects of misconduct on the scientific community.

Responding to Suspected Violations of Professional Standards. Researchers discourage questionable practices through a broad range of formal and informal methods. Anyone who witnesses a colleague engaging in research misconduct has an obligation to act. Research institutions that receive federal funds must have policies and procedures in place to investigate and report research misconduct, including designating an official who is available to discuss and pursue situations involving suspected misconduct.

Human Participants and Animal Subjects in Research. Any scientist who conducts research with human participants or with animal subjects needs to protect the interest of those research subjects by complying with federal, state, and local regulations and with relevant codes established by professional groups. The U.S. federal regulations known as the Common Rule as well as Institutional Review Boards set the standards for research involving human participants. The use of animals in research and research training is subject to guidelines and regulations in the federal Animal Welfare Act, the U.S. Public Health Services *Policy on the Humane Care and Use of Laboratory Animals*, the National Research Council's *Guide for the Care and Use of Laboratory Animals*, the "three R's" of animal testing alternatives, and Institutional Animal Care and Use Committees. The guide poses some of the difficult questions raised in research on human participants or animal subjects.

Laboratory Safety in Research. Laboratory safety is an aspect of research covered by governmental regulations and professional guidelines. Researchers should review information and procedures about safety issues at least once a year. A short checklist of subjects to cover is provided.

DISCOVERING AN ERROR

Two young faculty members -- Marie, an epidemiologist in the medical school, and Yuan, a statistician in the mathematics department -- have published two well-received papers about the spread of infections in populations. As Yuan is working on the simulation he has created to model infections, he realizes that a coding error has led to incorrect results that were published in the two papers. He sees, with great relief, that correcting the error does not change the average time it takes for an infection to spread. But the correct model exhibits greater uncertainty in its results, making predictions about the spread of an infection less definite.

When he discusses the problem with Marie, she argues against sending corrections to the journals where the two earlier articles were published. "Both papers will be seen as suspect if we do that, and the changes don't affect the main conclusions in the papers anyway," she says. Their next paper will contain results based on the corrected model, and Yuan can post the corrected model on his web page.

1. What obligations do the authors owe their professional colleagues to correct the published record?

2. How should their decisions be affected by how the model is being used by others?

3. What other options other than publishing a formal correction?

Sharing of Research Results. Even though publication practices vary from field to field, and digital technologies are creating new forms of communication, publication in a peer-reviewed journal remains the most important way of disseminating a complete set of research results. Once results are published, they can be freely used by other researchers to extend knowledge. But until the results are so widely known and familiar that they have become common knowledge, people who use them are obliged to recognize the discoverer by means of citations. The guide discusses proper citation, alternatives to peer-reviewed research articles, and the advantages and pitfalls of using new technologies to distribute research results.

Authorship and the Allocation of Credit. When a paper is published, the list of authors indicates who has contributed to the work. Apportioning credit for work done as a team can be difficult, but the peer recognition generated by authorship is important in a scientific career and needs to be allocated appropriately. Authorship conventions may differ greatly among disciplines and among research groups. Many journals and professional societies have published guidelines that lay out the conventions for authorship in particular disciplines. The guide discusses considerations to be weighed in determining the proper division of credit among researchers working on a project and other authorship issues.

WHO SHOULD GET CREDIT FOR THE DISCOVERY OF PULSARS?

A much-discussed example of the difficulties associated with allocating credit between beginning and established researchers was the 1967 discovery of pulsars by Jocelyn Bell, then a 24-year-old graduate student. Over the previous two years, Bell and several other students, under the supervision of Bell's thesis adviser, Anthony Hewish, had built a 4.5-acre radio telescope to investigate scintillating radio sources in the sky. After the telescope began functioning, Bell was in charge of operating it and analyzing its data under Hewish's direction. One day Bell noticed "a bit of scruff" on the data chart. She remembered seeing the same signal earlier and, by measuring the period of its recurrence, determined that it had to be coming from an extraterrestrial source. Together Bell and Hewish analyzed the signal and found several similar examples elsewhere in the sky. After discarding the idea that the signals were coming from an extraterrestrial intelligence, Hewish, Bell, and three other people involved in the project published a paper announcing the discovery, which was given the name "pulsar" by a British science reporter.

Many argued that Bell should have shared the Nobel Prize awarded to Hewish for the discovery, saying that her recognition of the signal was the crucial act of discovery. Others, including Bell herself, said that she received adequate recognition in other ways and should not have been so lavishly rewarded for doing what a graduate student is expected to do in a project conceived and set up by others.

Intellectual Property. Researchers should be aware of the potential value of discoveries made through their work and of the interest of their laboratories and institutions in profiting from them. They should be familiar with rules governing the establishment of intellectual property rights and know how to protect their own interests. Most research institutions have policies that specify how intellectual property should be handled, including how research data are collected and stored, how and when results can be published, how intellectual property rights can be transferred, how patentable inventions should be disclosed, and how royalties from patents are allocated. As patent law differs from country to country, researchers working on projects or with colleagues in other countries need to take these differences into account. New laws, regulations, and policies are also influencing intellectual property rights, with important implications for researchers.

Competing Interests, Commitments, and Values. The term "conflict of interest" refers to situations where researchers have interests that could interfere with their professional judgment. Managing these situations—particularly those involving financial gain and personal relationships— is critical to maintaining the integrity of the researchers and science as a whole. Regulations and codes of conduct specify how some of these conflicts should be identified and managed, and funding agencies, research organizations, and many journals have policies that require researchers to identify their financial interests and personal relationships. Researchers should be aware of these policies as well as those that offer guidance on conflicts of commitment. In addition, although individual values cannot—and should not—be separated from science, strongly held values or beliefs can distort researchers' work and compromise their science.

The Researcher in Society. Researchers have a responsibility to consider how their work and the knowledge they are generating might be used in the broader society. In public discussions of the potential uses of new knowledge, they may provide expert advice or educate others on scientific or policy issues. Researchers also have the right to express their convictions and work for social change, in tandem with their professional obligation to perform research and present the results of that research as objectively and as accurately as possible. When they become advocates on an issue, others may perceive them to be biased. A case study about efforts to end the use of Agent Orange in Vietnam illustrates that the decision to engage in advocacy need not undercut a rigorous commitment to objectivity in research.

The Appendix contains observations on each of the twelve case studies in the guide, designed to serve as a springboard for further discussion on the professional standards of scientific research. Also, the "Additional Resources" section lists publications, Web sites, and other materials on scientific ethics and professional standards.

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For More Information
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