INTRODUCTION TO THE RESPONSIBLE CONDUCT OF RESEARCH

Climatologist Inez Fung's appreciation for the beauty of science brought her to the Massachusetts Institute of Technology where she received her doctoral degree in meteorology. "I used to think that clouds were just clouds," she says. "I never dreamed you could write equations to explain them—and I loved it."[1]

The rich satisfaction of understanding nature is one of the forces that keeps researchers rooted to their laboratory benches, climbing through the undergrowth of a sweltering jungle, or following the threads of a difficult theoretical problem. Observing or explaining something that no one has ever observed or explained before is a personal triumph that earns and deserves individual recognition. It also is a collective achievement, for in learning something new the discoverer both draws on and contributes to the body of knowledge held in common by all researchers.

Scientific research offers many satisfactions besides the exhilaration of discovery. Researchers seek to answer some of the most fundamental questions that humans can ask about nature. Their work can have a direct and immediate impact on the lives of people throughout the world. They are members of a community characterized by curiosity, cooperation, and intellectual rigor.

However, the rewards of science are not easily achieved. At the frontiers of research, new knowledge is elusive and hard won. Researchers often are subject to great personal and professional pressures. They must make difficult decisions about how to design investigations, how to present their results, and how to interact with colleagues. Failure to make the right decisions can waste time and resources, slow the advancement of knowledge, and even undermine professional and personal trust.

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[1]Skelton, R. *Forecast Earth: The Story of Climate Scientist Inez Fung*. Washington, DC: Joseph Henry Press, 2005.

Over many centuries, researchers have developed professional standards designed to enhance the progress of science and to avoid or minimize the difficulties of research. Though these standards are rarely expressed in formal codes, they nevertheless establish widely accepted ways of doing research and interacting with others. Researchers expect that their colleagues will adhere to and promote these standards. Those who violate these standards will lose the respect of their peers and may even destroy their careers.

Researchers have three sets of obligations that motivate their adherence to professional standards. First, *researchers have an obligation to honor the trust that their colleagues place in them.* Science is a cumulative enterprise in which new research builds on previous results. If research results are inaccurate, other researchers will waste time and resources trying to replicate or extend those results. Irresponsible actions can impede an entire field of research or send it in a wrong direction, and progress in that field may slow. Imbedded in this trust is a responsibility of researchers to mentor the next generation who will build their work on the current research discoveries.

Second, *researchers have an obligation to themselves.* Irresponsible conduct in research can make it impossible to achieve a goal, whether that goal is earning a degree, renewing a grant, achieving tenure, or maintaining a reputation as a productive and honest researcher. Adhering to professional standards builds personal integrity in a research career.

Third, because scientific results greatly influence society, *researchers have an obligation to act in ways that serve the public.* Some scientific results directly affect the health and well-being of individuals, as in the case of clinical trials or toxicological studies. Science also is used by policy makers and voters to make informed decisions on such pressing issues as climate change, stem cell research, and the mitigation of natural hazards. Taxpayer dollars fund the grants that support much research. And even when scientific results have no immediate applications—as when research reveals new information about the universe or the

fundamental constituents of matter—new knowledge speaks to our sense of wonder and paves the way for future advances.

By considering all these obligations—toward other researchers, toward oneself, and toward the public—a researcher is more likely to make responsible choices. When beginning researchers are learning these obligations and standards of science, the advising and mentoring of more-experienced scientists is essential.

Terminology:
Values, Standards, and Practices

Research is based on the same ethical values that apply in everyday life, including honesty, fairness, objectivity, openness, trustworthiness, and respect for others.

A "scientific standard" refers to the application of these values in the context of research. Examples are openness in sharing research materials, fairness in reviewing grant proposals, respect for one's colleagues and students, and honesty in reporting research results.

The most serious violations of standards have come to be known as "scientific misconduct." The U.S. government defines misconduct as "fabrication, falsification, or plagiarism (FFP) in proposing, performing, or reviewing research, or in reporting research results." All research institutions that receive federal funds must have policies and procedures in place to investigate and report research misconduct, and anyone who is aware of a potential act of misconduct must follow these policies and procedures.

Scientists who violate standards other than FFP are said to engage in "questionable research practices." Scientists and their institutions should act to discourage questionable research practices (QRPs) through a broad range of formal and informal methods in the research environment. They should also accept responsibility for determining which questionable research practices are serious enough to warrant institutional penalties.

Standards apply throughout the research enterprise, but "scientific practices" can vary among disciplines or laboratories. Understanding both the underlying standards and the differing practices in research is important to working successfully with others.

THE RESEARCHER IN SOCIETY

The standards of science extend beyond responsibilities that are internal to the scientific community. Researchers also have a responsibility to reflect on how their work and the knowledge they are generating might be used in the broader society.

Researchers assume different roles in public discussions of the potential uses of new knowledge. They often provide expert opinion or advice to government agencies, educational institutions, private companies, or other organizations. They can contribute to broad-based assessments of the benefits or risks of new knowledge and new technologies. They frequently educate students, policymakers, or members of the public about scientific or policy issues. They can lobby their elected representatives or participate in political rallies or protests.

In some of these capacities, researchers serve as experts, and their input deserves special consideration in the policy-making process. In other capacities, they are acting as citizens with a standing equal to that of others in the public arena.

Researchers have a 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, they may be perceived by their colleagues and by members of the public as biased. But researchers also have the right to express their convictions and work for social change, and these activities need not undercut a rigorous commitment to objectivity in research.

The values on which science is based—including honesty, fairness, collegiality, and openness—serve as guides to action in everyday life as well as in research. These values have helped produce a scientific enterprise of unparalleled usefulness, productivity, and creativity. So long as these values are honored, science—and the society it serves—will prosper.

Ending the Use of Agent Orange

In the early 1940s, a graduate student in botany at the University of Illinois named Arthur W. Galston found that application of a synthetic chemical could hasten the flowering of plants, enabling crops to be grown in colder climates. But if the chemical was applied at higher concentrations, it was extremely toxic, causing the leaves of the plants to fall off. Galston reported the results in his 1943 thesis before moving to the California Institute of Technology and then serving in the Navy during the final years of World War II.

Following the war, Galston learned that military researchers had read his thesis and had used it, along with other research, to devise powerful herbicides that could be used in wartime. Beginning in 1962, the U.S. military sprayed more than 50,000 tons of these herbicides on forests and fields in Vietnam. By far the most widely used mixture of defoliants was known as Agent Orange, from the orange stripe around the 55-gallon drums used to store the chemicals.

Galston later wrote that the use of his research in the development of Agent Orange "provided the scientific and emotional link that compelled my involvement in opposition to the massive spraying of these compounds during the Vietnam War." At the 1966 meeting of the American Society of Plant Physiologists, he circulated a resolution citing the possible toxic effects of defoliants on humans and animals and the long-term consequences for food production and the environment, which he sent to President Lyndon Johnson. During the next several years, as evidence for the toxic effects of Agent Orange accumulated, Galston and a growing number of other scientists continued to oppose the use of defoliants in the Vietnam War. In 1969, he and several other scientists met with President Richard Nixon's science adviser, whom Galston had known at Caltech, and presented him with information on the harmful effects of Agent Orange. The science adviser recommended to the president that the spraying be discontinued, and the use of defoliants was phased out in 1970, five years before the end of the war. Galton later wrote, "I used to think that one could avoid involvement in the anti-social consequences of science simply by not working on any project that might be turned to evil or destructive ends. I have learned that things are not that simple. . . . The only recourse is for a scientist to remain involved with it to the end."[a]

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[a]Galston, Arthur W. Science and Social Responsibility: A Case History. *Annals of the New York Academy of Science* (1972):196:223.