The Responsible Researcher: Paths and Pitfalls

Sigma Xi, The Scientific Research Society

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Research Triangle Park, North Carolina

About Sigma Xi

Founded in 1886, Sigma Xi, The Scientific Research Society is a non-profit membership society of more than 80,000 scientists and engineers who were elected to the Society because of their research achievements or potential. Sigma Xi has more than 500 chapters at universities and colleges, government laboratories and industry research centers. In addition to publishing *American Scientist*, Sigma Xi awards grants annually to promising young researchers, holds forums on critical issues at the intersection of science and society and sponsors a variety of programs supporting honor in science and engineering, science education, science policy and the public understanding of science.

Dedication

Development and publication of this document was funded by a generous bequest from the estate of long-time Sigma Xi member Edward F. Obert. The Society wishes to thank his widow, Helen Whitman-Obert, and Dr. Frederick Elder, a former graduate student who assisted with the distribution of the estate, for identifying that ethics and research were of particular interest and concern to Professor Obert, and therefore, an appropriate match for the use of the funds. A member of the University of Wisconsin-Madison Mechanical Engineering faculty for many years, the December 6, 1993 "Memorial Resolution of the Faculty of the University of Wisconsin-Madison on the Death of Professor Edward F. Obert" states that "Professor Obert believed that virtue is the only good and that its essence lies in self-control, independence and conformity to standard of morality. He wanted his colleagues and friends to remember him through his quote from Socrates '*When my sons grow up, I would ask you, my friends, to punish them if they care about anything more than virtue.*'"

 ISBN#: 0-914446-15-0

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Table of Contents

Preface

Ira B. Bernstein, Yale University, member, National Academy of Sciences, personal communication.

> "The practice of scientific research is governed by an implicit ethical code essential to its proper function. This code is a refinement of that which operates in society at large, but has its special features and problems. It is useful to those entering the field to have this ethos made explicit, and also to have discussed some of the characteristic difficulties encountered in its practice."

Ethics in research has been an important topic in the United States for at least the last thirty years. However, it probably became an issue with the first researcher and his or her assistants and funders.

Sigma Xi, by its very nature as an honor society for science and engineering research, has had a continuing interest in how to communicate good research practices and how to develop an understanding of the importance of sound practices. Articles in the Society's magazine, *American Scientist*, have discussed aspects of good practice as well as a study of the prevalence of bad practice. *Honor in Science,*[1] first published in 1984 and now in its sixth printing, has proved to be a valuable introduction for graduate students and is used in many graduate programs.

This publication originally was intended to be a revision of *Honor in Science*. However, the following factors indicated that another publication would be more valuable:

1. *Honor in Science* continues to be an important guide;
2. That document, written by a single author, has a flow that could be destroyed by substantial revisions;

3. and *Honor in Science* is not fundamentally flawed, but additional areas need to be covered that, for one reason or another, were not included in that document.

> "Now that the number of working scientists has grown so large and the metabolism of work has become so rapid, it may be well to have a handy document that explains what perhaps once was easier to treat by osmosis and example: that there is an honor system that guides the community of scientists; that bending its rules can endanger careers, public perception, even lives, and science itself; that there is a moral necessity to minimize both deliberate dishonesty and accidental error, not only in research but also in activities such as refereeing and peer review."

Gerald Holton, "Niels Bohr and the Integrity of Science," American Scientist*, 74, May-June 1986, pp. 237-243.*

Discussions at workshops at Sigma Xi annual meetings and with members of an advisory group, testing the concepts in a short course at Duke University, literature review, and comments on several drafts led to the material covered in this document.

Great scientists are similar to natural athletes-success seems to come more easily for them. Studying the careers of many famous scientists shows that, in addition to being bright, insightful, and often lucky, they worked very hard, continuously. This guide is for everyone, including the many present and future researchers who labor at their work, probably never achieve fame, but produce the small steps on which progress is based, and teach a large number of students about science. A researcher's path may be strewn with temptations to commit what will be called scientific misconduct and opportunities to see others doing such without apparent penalty. Researchers should keep in mind what a Connecticut newspaper reporter once remarked about the mayor of a major city. The mayor, in private conversation, said that he regretted giving in to special interests and covering up scandals in his administration. He said that when he began in politics some thirty years ago, he was idealistic and committed to good government. But in his first race, he was approached by someone who offered him a large sum of money to help his campaign if, when he got elected to councilman, he would ensure that a certain project was given to this individual. The future mayor told himself that this once he would succumb to the temptation, to get elected, but, in the future, he would be upright. Then the next election came along, for council chairman, and again he succumbed, but, he admitted, it was easier this time. And so on, until now, as a several-term mayor, he hardly winced when he committed what would have appalled him in his idealistic youth. The researcher early in his or her career must remember that small steps on a path eventually get you where that path is going.

Development and publication of this document was funded by a generous bequest from the estate of long-time Sigma Xi member Edward F. Obert. The Society wishes to thank his widow, Helen Whitman-Obert, and Dr. Frederick Elder, a former graduate student who assisted with the distribution of the estate, for identifying that ethics and research were of particular interest and concern to Professor Obert, and therefore, an appropriate match for the use of the funds. This document also was enabled by the continued encouragement and support of Sigma Xi, especially its Executive Director, Peter Blair.

Acknowledgments: In addition to the students and Sigma Xi members mentioned earlier, special thanks are due Ira Bernstein, Rosemary Chalk, Alicia Dustira, Sybil Francis, David Goodstein, Beverly Hartline, Cathryn Manduca, Richard McCormick, John Prados, Charles Putman, Vivian Weil, and Thomas Wooten. R. Apfel suggested the title. None of these should be blamed for anything with which the reader disagrees. That blame is mine. All should be complimented for things with which the reader agrees.

John F. Ahearne
Research Triangle Park, North Carolina
March 1999

Introduction:
What is Here and What is Not

The success of science rests mainly on the human values by which it is practiced....

- *Equality....As individuals, scientists are often intolerant and unfair. But in the rules of evidence that we apply to our practice of science, equality prevails....*
- *Respect for diversity.... By demonstrating the utility and beauty of diversity, science teaches tolerance....*
- *Honesty. Scientists depend upon the truthfulness of their colleagues: each of us builds our discoveries on the work of others: if that work is false, our constructions fall like a house of cards and we must start all over again. The great success of science in our time is based on honesty....*
- *Community....scientists do virtually nothing alone: we exchange ideas in frenzies of excitement; we design and perform experiments together; we rely upon one another day in and day out; we take pleasure in discoveries, no matter who has made them; we give credit where it is due....*
- *Commitment....We love the purposes of science, we love the practice of science, we love to teach the lore of science. Those passions give us gratification. And they inspire us to do our best-sometimes even to exceed ourselves....*
- *Courage....Most of the great discoveries in science come from bold acts of the imagination, intellectual daring of the highest order...*
- *Aesthetics....Scientists find beauty in every nook and cranny of the natural world. It is their inspiration to work....*
- *Imagination....The good scientist is not a pedant who collects facts and then assembles these into an image of nature. The good scientist looks at a mystery of nature, imagines what the answer might be, and then seeks evidence that the imagining is correct....*

...[T]he great secret of science: it proceeds by the formalities of rational thought, but its success is driven by human values.[2]

Nobel laureate Michael Bishop, 1990, used by permission.

Science research is a noble calling; sometimes a source of great satisfaction; for a true researcher, the best way to spend a life; and a demanding and often unforgiving master (or mistress). This booklet is a guide to why it matters for researchers to follow ethical practices and some issues that must be addressed along the way.

It can be argued that ethical practices in research are no different than ethical practices in any aspect of life-in business, in law, in teaching, in the home. To an extent that is true: lying should not be practiced;[3] stealing is wrong, whether of an idea or a material object; cheating is wrong; and laws should be obeyed (unless they are unjust, some would argue). While perhaps true that ethical practices are not a specific issue for research, it is in the context of research that this booklet addresses ethics. The larger societal issues must await another venue.

It also has been argued that these practices of ethics-good behavior, perhaps-are best taught in childhood[4] and in the home in formative precollege years. Those who make this argument do have a sound point: building a solid base of ethical practice in childhood makes it much easier to form good practices as an adult. However, it is obvious that many students reach college without understanding how the normal standards of society are applied in science and the professions. It is therefore important to develop good practices in those students. This booklet is concerned with those who go into research. Society should be concerned both about these and those who do not.

Beginning in the late 1980s, Congressional attention and media stories highlighted some cases of fraud and others of alleged fraud in research.[5] These episodes led to lengthy Congressional hearings by Congressman John Dingell, many newspaper and magazine stories, studies by the National Research Council[6] on misconduct, reexamination by the two science funding agencies, the National Science Foundation (NSF) and the National Institutes of Health (NIH), of what is scientific misconduct, and to a Congressionally chartered study.[7]

This booklet is aimed at providing guidance for good practice, not merely at avoiding charges of misconduct. The latter would be like a drivers' manual that gives the rules to be followed to avoid getting a ticket. The former would be a safe driving manual. This booklet is more the safe driving manual than the list of laws. It describes goals to achieve, not a floor below which you should not go.

"Scientific Conduct," statement approved by the Councils of the National Academy of Sciences, National Academy of Engineering, and Institute of Medicine, 2 February 1994, emphasis in original.

> "As members of the professional research community, we should strive to develop and uphold standards that are broader than those addressed by the governmental regulatory and legal framework for dealing with misconduct in science."

However, a few words about misconduct are appropriate. There has been a debate about what constitutes misconduct in science. Although not solely concerning funding, part of this debate is not over what is right and what is wrong but over what is so egregious as to trigger governmental sanctions when federal funds are involved. At one end of the scale is the position of Howard Schachman, an eminent researcher, NIH ombudsman, and (dissenting)[8] member of the NRC David committee. Schachman separates the individuals accused of misconduct into the crooks and the jerks. The former are those who *fabricate, falsify, or plagiarize*, the **ffp**[9] trio. He believes that such individuals should be subjected to governmental sanctions including disbarment for receiving federal funds. The jerks are those who make uncorrected errors, are sloppy in procedure and analysis, and whose work, based on peer review, would not warrant funding because of its poor quality.[10]

Rosemary Chalk, David Report Study Director, National Research Council, personal communication.

> "[T]here is a continuum between misconduct and questionable practices and there are many areas where it is difficult to distinguish between them....there are some areas that are clearly appropriate for institutional regulation and sanctions (misconduct), some areas that require educational approaches and professional guidance (questionable practices), and some areas where it is difficult to distinguish the two."

There are real differences between opinions and interpretations which later turn out to be wrong and deliberate misstatements, just as there are between experimental error and sloppy work.

> "The distinction [between error and mistake] is not trivial because error is an important and honorable part of science: every experimental paper includes (or should include) a meticulous analysis of error....error is not to be eliminated in science. It is inherent in all measurements and needs instead to be analyzed and understood. Mistakes are different from errors, and in that distinction lies much of the subtlety of scientific ethics."

David Goodstein, Vice-Provost and Professor of Physics and Applied Physics, California Institute of Technology, personal communication.

On the other end of the scale are those who endorse the NIH and NSF definitions, which include practices not the norm. Some also would like to include sexual harassment, racial discrimination, misappropriation of funds, and other actions that are punishable by civil or criminal statutes. Those who agree with Schachman argue that these practices definitely are wrong, but they are not *scientific* misconduct. There are other avenues to punish these people and including such actions under the misconduct in science label confuses what is and is not science.

This booklet does not attempt to resolve these issues.

Finally, although much of this booklet is devoted to process, ethics cannot be reduced to procedures. "[T]he most important aspect in ethics is character and character training."[11] Thus this booklet also stresses development of the researcher's fundamental principles of behavior. It is these that will be called upon when the researcher is faced with temptation to commit scientific misconduct or with evidence of scientific misconduct.

Representative J.C. Watts, quoted in National Journal, *18 April 1998, p. 869.*

> "Character is doing what is right when nobody's looking."

From the Report of the Committee on Academic Responsibility of the Massachusetts Institute of Technology, quoted in Responsible Science, Ensuring the Integrity of the Research Process, *Vol. II, National Academy Press, 1993, pp. 160, 171, 172.*

An MIT Committee on Academic Responsibility in 1992 wrote the following:

"We define three behaviors in the conduct of research that merit Institute attention. The first is research misconduct. We define research misconduct as fabrication, falsification, and plagiarism in proposing, conducting, or reporting research or other scholarly activities. Other types of misconduct that can occur in a research setting but which are not unique to research activities are differentiated from research misconduct and are defined as general misconduct. In addition, there is a range of questionable or improper research practices that we do not include in either research misconduct or general misconduct, but which can negatively affect the research enterprise, compromise the responsibilities of universities, and violate ethical standards.

Research misconduct does not include errors in judgment or mistakes in the recording, selection, analysis, or interpretation of data.... Between error and misconduct lies a range of attitudes and behaviors such as carelessness, negligence, reckless disregard, and deliberate disregard in the handling of research results that, while not falling within the scope of research misconduct, nonetheless are quite corrosive to the research establishment.

...general misconduct [includes] misappropriation of funds or equipment, harassment, vandalism, unreported conflicts of interest, etc. These are offenses that violate legal statutes or Institute rules and can be addressed through established mechanisms."

For completeness, the following are some of the existing or proposed definitions:

Department of Health and Human Services (includes NIH):

Misconduct in science is "...Fabrication, falsification, plagiarism, or other practices that seriously deviate from those that are commonly accepted within the scientific community for proposing, conducting, or reporting research. It does not include honest error or honest differences in interpretations or judgments of data." [12]

NSF

"'Misconduct' means (1) fabrication, falsification, plagiarism, or other serious deviation from accepted practices in proposing, carrying out, or reporting results from activities funded by NSF or (2) retaliation of any kind against a person who reported or provided information about suspected or alleged misconduct and who has not acted in bad faith." [13]

NAS proposed definition

"Misconduct in science is defined as fabrication, falsification, or plagiarism, in proposing, performing or reporting research. Misconduct in science does not include errors of judgment; errors in the recording, selection, or analysis of data; differences in opinions involving the interpretation of data; or misconduct unrelated to the research process." [14]

Commission on Research Integrity proposed definition

"Research misconduct is significant behavior that improperly appropriates the intellectual property or contributions of others, that intentionally impedes the progress of research, or that risks corrupting the research record or compromising the integrity of research practices. Such behaviors are unethical and unacceptable in proposing, conducting, or reporting research, or in reviewing the proposals or research reports of others." [15]

Medical Research Council (MRC) (England)

"MRC defines scientific misconduct as 'fabrication, falsification, plagiarism or deception in proposing, carrying out or reporting results of research and deliberate, dangerous or negligent deviations from accepted practices in carrying out research. It includes failure to follow established protocols if this failure results in unreasonable risk or harm to humans, other vertebrates or the environment and facilitating of misconduct in research by collusion in, or concealment of, such actions by others.'" [16]

2
Undergraduates

If precollege experiences are formative, college years can establish the attitudes and behavior that a person carries into graduate school and on into later research. Later sections will discuss the critical roles that professors have in establishing, correcting, and guiding student behavior. However, the two most important influences on the undergraduate student are peers and the student himself or herself.

Temptations to cheat are widespread-and some succumb. [17] Students remove required reading from libraries to make it more difficult for other students. Many-hundred student classes make passing information during tests relatively easy. Services are available to "ghost-write" papers. Archives of previous lab reports and tests make it possible for students to use "better data" and to prepare for the exact questions on a test rather than study all the material. Is this wrong? It clearly disadvantages those who do not have access to such material. But is it wrong? Are those who have the money to hire tutors committing unethical behavior? Are those who can afford courses on how to take the GREs, MCATs, or LSATs cheating? If these practices are in some sense unethical, does the primary fault lie with the student or with the professors who do not change the experiments or the tests and with the admission departments who rely on GRE, MCAT, and LSAT scores?

"Curbing Cheating and Restoring Academic Integrity," Leslie Fishbein, Associate Professor, Rutgers University, The Chronicle of Higher Education, *1 December 1993, p. A52.*

> "Although cheating has a long and dishonorable history in academic life,....modern academic life has promoted a campus climate conducive to cheating....[M]any more students see good grades as a competitive advantage-even if they have to cheat to get them."

Like so many issues in the ethical arena, there are no simple answers to these questions-except it is always wrong to cheat. Stealing copies of exams is wrong. Passing on or using passed on information during a test is wrong. Sneaking information into a test is wrong.

But "everyone does it" and "I need the grade to get into...."

These are real pressures and, as will be discussed in later sections, are not dissimilar to those produced by the need to make tenure, to get a grant, or to get promoted.

Science requires trust and lying is always wrong. But these arguments probably are only really effective with those who already accept them.

The threat of punishment may deter some. The rigidity of honor codes-if caught, out you go-is thought to be a preventative. This is much like the argument of why you should not drive drunk-you can get caught and punished. Unfortunately, proving cheating on tests is usually both extremely difficult and an onerous burden on the accuser. So, cheating thrives.

As mentioned above, the other main influence on the student is the student himself or herself. What kind of a person do you wish to be? It is easy to deny temptation if never tempted. It is easy to be honest if dishonesty is immediately obvious to all. But when temptation arises and you are unlikely to be caught, then is when your character is tested. The ethical researcher will not succumb. The undergraduate with a sense of self-worth and values will not succumb.

But if you succumb to temptation, fail to stick to standards of ethical behavior, does that mean a life-long stigma so that you might as well continue to cheat? No. Realize the mistake, put that behind you, understand what led you to fail, and work to prevent it from happening again. As an undergraduate, treat it as a learning experience. (So long as you do not accumulate a string of such learning experiences.) By the time you graduate, ensure that you do have a set of values that preclude cheating.

Easy? No.

Possible? Yes.

3
Graduate Students

Much of the literature on ethical advice for researchers focuses on this category, the researcher of the future. Today's graduate student is tomorrow's professor, industry scientist, Congressional staff person, or Congressional Representative. The student has gotten into a graduate school and, hopefully, arranged finances so that the path to a degree, while cloudy, is possible.[18] Pressures increase. It does not take the graduate student long to realize that competition is intense. The better (more renowned, working on the more interesting problems) professors want the brightest graduate students, and grades may be a criterion for selection. Fellowships for financial support that can make thesis work much easier seem to be awarded to those who already have some publications. And as thesis completion is in sight, it becomes clear that postdoctoral positions are hard to get, particularly with the same prestigious professors or at prestigious institutions. Tenure track assistant professorship positions at research universities, the holy grail for many graduate students (and their mentors), may seem to be worth a Faustian bargain.

In these graduate student years, the young researcher really learns what are and are not good practices. These are much more than the floor below which lies scientific misconduct. These good practices are what should be the research guidelines that will enable the researcher to do productive work, to attack the unknown-which is what much research is-to collect, analyze, organize, and interpret the data that will become the next step for the community of scholars, to produce the publishable papers, and provide the inner satisfaction of work well done.

> "In the cases of scientific fraud that I have looked at, three motives, or risk factors have always been present. In all cases, the perpetrators:
> 1. were under career pressure;
> 2. knew, or thought they knew what the answer would turn out to be if they went to all the trouble of doing the work properly, and
> 3. were working in a field where individual experiments are not expected to be precisely reproducible."

"Conduct and Misconduct in Science," David Goodstein, Vice-Provost and Professor of Physics and Applied Physics, California Institute of Technology in The Flight from Science and Reason, *Paul R. Gross, et al., eds., New York Academy of Sciences, 1996, p. 31*

These practices can be self-taught. However, it is better to have colleagues who know the practices: faculty, postdoctoral fellows, more senior graduate students.

There are some basic ethical standards included in good research practices:

- You do not fabricate data. Experimental work can be grueling, requiring long periods of preparation (months, even years). Extreme care is required to ensure the experiment tests what is desired. There may come a great temptation to short-cut all of this "work in the trenches" and make up data. Besides violating the trust upon which scientific progress is based,[19] and introducing a corrosive process inside yourself, fabricating data is incontrovertibly scientific misconduct. If caught, you can be dismissed from graduate school and barred from participating in funded research for a period of years.

> "The coin of the realm is scientific truth. If you fake the data, you're counterfeiting the coin. That's a serious crime."

Caltech scientist, quoted by David Goodstein in book review of Travails of Publishing, Science, *258, 27 November 1992, pp. 1503-4.*

-You do not falsify results. As an undergraduate, if your lab data did not mesh with theory, you may have been tempted to drop some points. And you may have done so. Or you may have used someone else's data to complete your report since your data looked so poor. In the real world, you must use all your data. Dropping points you do not like or slightly modifying data should not be done. This does not mean that you cannot exclude data which you have a sound reason to exclude. (This is the heart of a mischaracterization of Robert Millikan's oil drop experiments.)[20] It does mean that if the data look poor and that is your only reason to exclude the data, you must include them. You also should be clear, accurate, and thorough in describing the experimental procedures.

Yes, after rigorously examining all sources of error in the experimental equipment, if the results still cannot be explained, this means you may have to redo the experiment.[21]

> "...experimentation, the ultimate arbiter of truth. Sir Arthur Eddington, a formidable experimenter in the early 20th century, called experimentation 'an incorruptible watch-dog.' Max Planck, one of the founders of quantum theory, said 'An experiment is a question which science poses to Nature, and a measurement is the recording of Nature's answer.'"

"*The Proof is in the Neutrino,*" *Simon Singh,* The New York Times, *16 June 1998.*

Scientific progress can be based only on solid research. Other researchers will count on your results to be accurate as they go on with their research. (Of course, if the results are astounding, many others will attempt to repeat them-cold fusion is a classic example. To avoid great embarrassment or worse, be sure your data are correct.) Although not the usual case, anomalous data may indicate the presence of unexpected but important phenomena. The discoveries of superfluidity in helium-3 and of C-60 (buckeyball) are such examples, and each led to the Nobel prize.[22]

-You do not steal ideas. Whereas the previous two standards pertain primarily, if not exclusively, to experimental research, idea theft occurs in both experimental and theoretical work. Idea theft takes many forms-all are wrong. The basic point is that if you use an idea that you obtained from someone else, you must give them credit for the idea. In some cases, you should not even use the idea without their permission.

Ideas for what experiment to do, what theoretical work to begin, how to solve an experimental problem, how to solve a theoretical problem-if provided by someone else and significant for your research-must be attributed. Sometimes these ideas come in formal discussions, sometimes from casual conversation, and sometimes from reading the literature. All must be attributed.

> "...researchers should properly assign credit to others for the work they have done; present original material in only one publication, include in publications only the names of those who have contributed to the research; and include the names of coauthors in publications only after seeking permission to do so."

"Fostering Responsible Conduct in Science and Engineering Research: Current University Policies and Actions," Nicholas H. Steneck, in Responsible Science: Ensuring the Integrity of the Research Process, Vol. II, *National Academy Press, 1993, p. 6.*

The ideas that may not be used are those to which you are exposed by reading drafts of articles given to you in confidence, such as when you serve as a peer reviewer. (See Section 10 on peer review.)

"Needless to say," but needing to be said, is that you cannot plagiarize-use the words or data of another as your own. This can be burdensome if you are writing a thesis, but you should keep careful records of where you got particular words or data.

Is it plagiarism to use your own words? No-but it is wrong to publish essentially the same article in two journals by changing the title and perhaps some of the wording.

> "The prevailing rule is that all material borrowed from another source, even when it is one's own previous publication, must be put in quotation marks and referenced. This reinforces the important distinction between an idea and the expression of an idea."

Kennedy, op cit., *p. 214.*

As a graduate student, in addition to the pressure to finish your thesis (often a self-imposed pressure), you may face several other difficult ethical issues. As a teaching assistant, you may be confronted with undergraduate cheating. Students may conclude that, since you are only a graduate student, they can get away with more blatant forms of cheating. Unfortunately, the rules for good practice described earlier may not be applied by the department or the particular professor for whom you are working. Before the term begins, you should discuss with the professor what are his or her rules, and how he or she would want you to treat cheating. Sadly, you may find this is a subject they wish to avoid. Your professor may argue there is no cheating, or it is so rare as not to be a concern, or that dealing with cheating is not worth the trouble.

As Carl Sagan used to say, quoting a pop song, "denial is more than a river in Egypt."

What then do you do? Several possibilities:

Try to get the professor to take a stand against cheating, using the arguments presented earlier. This may not work, particularly in a school where cheating essentially has been tolerated.

Try to get a meeting of teaching assistants (TAs) to discuss how to handle cheating in the classroom. A consensus effort may be able to pressure the department, the school or college, or the university to take action. This discussion can include noting that tolerating cheating is not helpful to the offending students, who not only do not learn the material, but also develop a practice which later may get them into more serious trouble and may harm others.

Take the situation to the university ombudsperson, if there is one.

Bring the problem to the attention of the department chair or the dean.

You may have to become a martyr for truth and honesty.

Although it is to be hoped this is not necessary, accept the situation and vow not to become jaded.

4
Postdoctoral Fellows

Being a postdoc-this sounds to an undergraduate science major as an exalted position, and the progress of many great scientists included a stint as a postdoctoral fellow for another prestigious scientist. And some students do go on for postdoc work to continue with a well-established scientist to hone the student's skills and deepen the learner's understanding. However, many go on to a postdoctoral position because they are unable to get a tenure-track, or even non-tenure-track, faculty position or find a job in industry. Today, having several postdoc positions is not unusual.

Is being a postdoctoral fellow rewarding? It can be. Working in a productive lab or with a highly productive theoretician can be inspiring and intellectually expanding. Furthermore, some such individuals are true mentors and take upon themselves the responsibility for making connections that can enable the postdoc to move on successfully.

Unfortunately, there is a dark side to the postdoc position-it can be "an apprenticeship, indentured servitude, or slavery." [23] The picture presented by some postdocs is bleak.[24] Some of the difficulties that postdocs encounter include being called on to do far more than scientific research, such as baby-sitting, house cleaning, secretarial tasks, etc. Sometimes these are not polite requests, but stated requirements. And the postdoc must realize that he or she has only one supervisor and may have no recourse to any administrative unit. Therefore, there may be little choice but to accept the unpleasantness, unless he or she wishes to leave, thereby probably scuttling the chances of the coveted academic position.

One of the most common concerns expressed (in private) by postdoctoral fellows is that of authorship. It would be useful for the new postdoc to find out what are the policies of the professor for whom the postdoc is working and those of the department regarding authorship. For example, if the postdoc does much of the work, is he or she guaranteed to be listed as an author? If the postdoc is the main researcher (as opposed to worker), will the postdoc be given first author position? Is there a requirement that the lab director always be included as an author, independent of contribution? The time to get these issues discussed is before work is under way or a paper gets started, not when the paper is in draft.

> "Criteria for authorship of a manuscript should be determined and announced by each department or research unit. The committee considers the only reasonable criterion to be that the coauthor has made a significant intellectual or practical contribution. The concept of 'honorary authorship' is deplorable."

Guidelines for Investigators in Scientific Research, Harvard University Faculty of Medicine, 1988, quoted in Responsible Science: Ensuring the Integrity of the Research Process, Vol. II, *National Academy Press, 1993, p. 128.*

"I already wrote the paper. That's why it's so hard to get the right data."

The Chronicle of Higher Education, January 10, 1997, Benita Epstein. Used by permission.

Before signing on to a research group, a postdoc also should determine whether copying data the postdoc gathered, intending to use it after departure, is acceptable.

Given that the postdoc is in a vulnerable position, what are the ethical issues that may pose the greatest problems? Clearly, they are (1) when a postdoc witnesses misconduct by another researcher in the lab or group, especially if it involves a senior person, and (2) temptations that could seem to help get that next coveted position. The first has been written up by Carl Djerassi in the novel, *Cantor's Dilemma*.[25] Djerassi offers no solutions but does describe the problem vividly.

At a Sigma Xi forum on ethics and values in research, a postdoc said that when a conflict develops in a lab based upon a charge by a postdoc, the postdoc has few choices, none of them good.[26] Having a private discussion with the mentor or the lab head is best, even if that person is the one suspected of misconduct. If there is not a successful resolution, the postdoc may have several unpalatable choices:

- say nothing and go on to complete your fellowship, hoping that raising the issue will not lead to an unfavorable recommendation;
- become a "whistle blower" by raising the issue to a higher level in the university or to the funding agency or foundation[27]; or
- ending your fellowship and seeking employment without a recommendation from your supervisor.

Pursuing the last may mean leaving your field, which is not necessarily life-ending and may be best for you anyway in that you may find a more rewarding career outside of science or engineering research.[28]

The second large challenge comes when you are faced with the temptation to commit one of the ffp trio. This may come when you are at a dead-end in your research but find out about an idea that could lead to a successful project. Unfortunately, the idea is either overheard, casually mentioned by a colleague, or found in a confidential draft of an article or of a research proposal. The challenge may come when you are getting close to the end of your fellowship and need a published paper. You find that your data do not support your hypothesis and either are poor data or seem to leave you with an unproved concept. However, moving some of the data, or adding some data, could lead to a published paper. Or you need to get another grant, and you find the right words in a draft from another researcher and conclude that if you use those ideas you will likely get funded, but without them your proposal is too weak.

If you have read this far, you know that this guide will advise **not** committing the ffp misconduct. But what if that means you cannot get a research job, and you have a family to support? The small steps that you could take to gain what may appear to be the needed next rung on a research career ladder could well be the steps that take you to dishonor, banishment, and true economic hardship-as well as corroding your integrity and spirit.

5
Junior Faculty

Many Ph.D. recipients will not go into an academic research situation. Some will go into industry or government—these areas will be covered in a later section. In United States institutions of higher education, faculty have a combination of duties involving teaching, research, and public service. This advice is aimed at those whose activities are primarily in research. Those graduates who go to non-research institutions, but still do research—and this is a growing number—are covered here.

You have finished your degree or your postdoc and have landed a junior faculty position. Have you now gotten through the shoals and are in calm water? Hardly. The tenure test awaits you. You will have a period of perhaps seven years to prove that you are worthy of joining the tenured faculty at your university. To achieve that stature you may be told you have to be a good teacher, a cooperative member of the department, working on departmental tasks, and, of course, do productive research-i.e., publish in the appropriate journals. Do not be misled. Most universities, while espousing the above criteria, will end up judging you almost entirely on the last. 'Publish or perish' is alive and well in tenure decision-making.

"Publication is the hard currency of science-it is the primary yardstick for establishing priority, the chief source of recognition from one's peers, and the standard on which advancement of science is based."

"Professional Societies and Responsible Research Conduct," Mark S. Frankel, in Responsible Science: Ensuring the Integrity of the Research Process, Vol. II, *National Academy Press, 1993, p. 31.*

As a junior faculty member, you will be required to carry what may be a heavy teaching load. You will be asked to handle departmental tasks. And you may be asked to be a ‘good member’ and be willing to develop a new course every year. Beware. Such activities may lead to warmth from the department chair and thanks from colleagues who are thereby relieved of taking on those burdens. *But do your research and get it published. The Chronicle of Higher Education’s* files have many articles on student protests when the junior faculty member voted best teacher for several years does not make tenure -because he or she did not publish enough. (A typical tenure review will solicit comments from other researchers in the field, who are likely to comment on the quality of the research of that person, not on their teaching ability. Although such solicitations usually ask for comments on the nominee’s teaching, the results are not always taken seriously.)

> “...it is important to remember that all university faculty are teachers...Many will argue about the relative importance of teaching and research at research universities, comprehensive universities and baccalaureate institutions, but it is clear that both are major responsibilities of the faculty....[T]he rules for tenure are not the same at every place. Furthermore, they are currently changing as more pressure is placed on institutions to improve science education for all students.
> ....[I would] advise them to find out up front what the real criteria are. This would involve talking to the administration responsible for this decision, their department chair, and wise colleagues of all ages who know the story.”

Cathryn A. Manduca, Keck Geology Consortium Coordinator, Carleton College

The emphasis on research should not be surprising, although many of those turned down for tenure appear to be surprised. If you work hard to get into a research university, it is because research is being done there, good research, well known research, i.e., published research. To use a baseball analogy, when a pitcher gets called up to the major leagues, he does not expect to stay there by being a pleasant person in the clubhouse, by doing odd jobs for the manager, or by being active in the community. He knows that to stay there he must perform well on the mound. Similarly, if you accept a junior faculty position in a research university, you should realize from the beginning that you will be judged primarily on your research.

> "In the world of scholarship, we are what we write. Publication is the fundamental currency; except for the creative arts and a few disciplines in the applied sciences, research quality is judged by the printed word."

Kennedy, op cit.*, p. 186.*

The ethical challenges can be large. Some practices are not in the category of scientific misconduct. These can include being cruel to students or being cavalier with regard to university and even government regulations concerning funding, reporting, use of money and supplies, such as double billing of travel expenses or falsifying expense reports. They include neglecting your duties to your students, both undergraduate and graduate.

But the most difficult challenges are similar to those for the postdoc: what to do if you uncover misconduct and how to handle the pressures of the need to publish from destroying your integrity.

Although you have a more secure position than the graduate TA, undergraduate student cheating can be a major problem for you.[29] Discuss the issue with your department chair and with senior faculty. Decide what is your policy on cheating. Explain your position to your TAs and discuss potential problems with them. If you are going to be firm and not tolerate cheating, you must tell the students that in the first class. However, if you decide not to come down hard, it may be best not to tell that to the students.

What should you do?

Continuing the theme of the need to maintain the integrity for the research process, it would be best if you decide not to countenance cheating. This may have an additional salutary effect by convincing some students that scientists really do believe in the necessity of integrity.

The need to publish can become all-consuming as your tenure decision time is seen approaching-even if several years away. (This pressure varies by university. A senior faculty member at a leading research university said that the physics department there expects that, for tenure, a junior member will have one article a year published in *Physics Review Letters*-probably the hardest journal in which to get published in the field of physics.) All the temptations of ffp can descend upon you-like the visitor Goethe described appearing to Dr. Faust.

To avoid a build-up of pressure, start early with focusing your research. Do not attempt to spread yourself across many projects. Be realistic about what you can accomplish. Get advice from someone you trust. However, the mid-point of your pre-tenure period may be reached without any success or even strong possibility of success. (Some departments have mid-point reviews.) It is then that the temptations to cut corners may become strong. It is also then that you might consider leaving that university and go to an institution which would better match your temperament and skills, rather than risk losing everything by compromising your integrity.

6
Senior Faculty

This group is both the most important and often the hardest to convince of the need for explicitly addressing ethical practices. Most important because they have the greatest influence-in word and action-over the young researcher, grad student, postdoc, and even junior faculty. Hardest to convince because many senior faculty do not believe there are real ethical problems in science and, if there are, it is not their responsibility to do anything about them.

> "I am less concerned with the aberrations of the junior perpetrators than with the attitudes and behavior of the senior scientists in whose laboratories these events occurred.... Incidents of dishonesty in science will continue to occur until senior scientists understand that if there is unethical behavior in their laboratories, it is they who are personally responsible, they who share the guilt, and they who cannot evade the point."

Nobel laureate Rosalyn S. Yalow, 1993 Sigma Xi Forum Proceedings, pp. 26-27.

The problem is most likely small, in the sense of misconduct by researchers as a proportion of all researchers. But what that proportion is we do not know.[30] We do know that the press and some in Congress have been concerned about some cases. And there have been a few bad cases.[31]

If the senior faculty member is willing to accept the possibility that teaching ethical practices is important, even if not always required (U.S. Department of Health and Human Services training grants do so require), what is the proper approach?

> "This review of congressional activities concerning misconduct in science is characterized by the divergence in perspective between the Congress and the science community regarding the prevalence of misconduct, the competency of the science community versus Congress to judge instances of misconduct, the effectiveness of the institutions of science to implement oversight and investigative mechanisms (i.e., the ability to be self-policing), and the legitimacy of questions concerning the use and misuse of public funds. Representatives of the research community have indicated that cases of research misconduct are extremely rare and that they usually involve isolated acts by psychologically disturbed individuals.... Several members of Congress have expressed views that challenge these findings."

"Congressional Activities Regarding Misconduct and Integrity in Science," Barry T. Gold, in Responsible Science: Ensuring the Integrity of the Research Process, *Vol. II, National Academy Press, 1993, p. 111.*

First, and most obvious, is to practice ethical behavior. In addition to the minimum, avoiding ffp, the senior faculty member should be a good advisor.[32] This means spending time with your graduate students and postdocs. If you cannot, then you should not accept them as your students or fellows. Just as young children learn more by what their parents do than by what they say, so the graduate student learns more about ethics in research by what the advisor does than by what he or she may say.

> "It's very important that young scientists be inculcated with the right values from the start. From my own experience, that is usually done by example, of the research advisor, rather than through lectures or written policies. Perhaps it's something we should pay more attention to."

Alan Campion, Chair, Chemistry Department, University of Texas at Austin, quoted in C&EN, *22 November 1993, p. 24.*

Second, establish channels for regular communication and clear guidelines for cooperative work, for giving of credit, and, most important, for authorship.

> "[S]cholars who take part in a collaborative project should explain forthrightly-to disciplinary peers as well as academic colleagues and such members of the public as may have occasion to inquire-the respective contributions of those who put their name to the finished work. This clarification might be accomplished in a preface, an extensive footnote, or an appendix: no one format can serve every scholarly combination. But a candid statement would do much to establish degrees of responsibility and authority, to ensure fair credit to junior or student colleagues, and to avoid unseemly later disputes about priority, real or alleged errors, and plagiarism. Purely formal association with the enterprise (such as the headship of a laboratory where no direct research involvement was present) would be noted for what it is, to the benefit of the participants as much as of those outside the field."

American Association of University Professors Committee B on Professional Ethics "Multiple Authorship," Jonathan Knight, Science*, 275, 24 January 1997.*

> "Of considerable importance in the issue of authorship is the embedded problem of 'complimentary authorship,' whereby a person not really meriting a place in the list of authors is given one anyhow....For the scientific community as a whole, complimentary authorship amplifies confusion about who is responsible for what work. Misinformation always has costs. The most common abuse in authorship is the addition of the name of academic supervisors to largely independent work done by students. The fact that this has become a custom in a number of fields does not make it less pernicious."

Kennedy, op cit.*, pp. 196-7.*

Third, if you have accepted students and fellows, recognize you also have a responsibility for advising them on their future careers and, to the extent you can, assisting them in finding positions.

> "[R]esearchers who serve as mentors to students assume obligations to those students and should not compromise these obligations for personal gain or career advancement."

Steneck, op cit.*, p. 7.*

> "[T]he mentor [of a postdoctoral trainee]... must carefully evaluate whether the scientific capabilities, directions, and goals of the laboratory are appropriate for the trainee in light of his own aspirations. Secondly, the mentor must have sufficient resources, including salary funding, instrumentation, and space, with which to support the trainee and his work. Finally, the mentor must have a well-considered plan for the overall education of the trainee, including a general outline for a research project."

"Guidelines for the Responsible Conduct of Research," University of Michigan Medical School, quoted in Responsible Science: Ensuring the Integrity of the Research Process, Vol. II, *National Academy Press, 1993, p. 141.*

Fourth, be a willing listener and counselor if your students or fellows come to you with concerns about someone's misconduct, whether it is undergraduate cheating, fellow student misconduct, or questions about the practices of a faculty member.

> "Unless science students are thoroughly inculcated with the discipline of correct scientific process, they are in serious danger of being damaged by the temptation to take the easy road to apparent success."

Branscomb, op cit.

Finally, recognize that you are a role model for the junior faculty. For example, your attitude on student cheating and how you instruct your TAs will influence the junior faculty on what should be their attitude.

"Well, then, how about an endowed chair, a Nobel Prize, and a major research institute named for you?"

Used by permission.

> "In 1987, as a member of the National Academy of Sciences' Institute of Medicine's Committee for the Study on the Responsible Conduct of Research, I chaired the panel on education and training for research.... During the twelve months of our deliberations, I could not help but reflect on my past performance as a mentor....I was particularly struck by the ad hoc manner in which many senior professors (including me) in the top chemistry research departments deal with the mentoring issue. Young faculty members get absolutely no formal guidance.... More important, I was struck by the total absence (at least in those elite institutions with which I am familiar) of any formal mechanism for evaluating the mentor's performance. In many respects, the mentor plays the role of intellectual parent in the development of a new researcher."

"*Mentoring: a Cure for Science Bashing?,*" *Carl Djerassi, Stanford University professor of chemistry and member of the National Academy of Sciences,* C&EN, *25 November 1991, pp. 30-33.*

These are all mentoring issues.

Two cases four years apart illustrate the need for extreme vigilance if misconduct is to be prevented. In 1992, a paper in *Cell* was withdrawn because of fabricated data by a researcher at the National Cancer Institute. In describing the case,[33] *Nature* quoted Michael Green of the University of Massachusetts Medical Center, saying that "Confronting such deliberate fabrication ... 'is frightening, but...it's virtually impossible to stop a person who is willing to act in a determined and malicious fashion.'" An NCI division director, Alan Rabson, is quoted: "This case points out that a truly determined person can deceive even a full-time, conscientious scientist." The NCI lab director, Louis Stadt, who uncovered the fabrication by being unable to replicate the results, is described as concluding "that extra precautions, no matter how inconvenient, are needed to avoid another case of misconduct."

> "In the sciences frequency of publication can vary widely; some researchers publish a paper only every few years, whereas those who run large laboratories may produce dozens or, in a few unusual instances, a hundred or more. How any semblance of quality control can be maintained under such circumstances is a mystery, and it is perhaps no accident that these over-producing enterprises, most of which are in the biomedical sciences, are responsible for a disproportionate share of academic misconduct cases."

Kennedy, op cit.*, p. 187.*

In 1996, Francis Collins, the head of the U.S. human genome project, withdrew five papers because a junior staff member fabricated data. In this case, the fabrication was finally detected by a reviewer of another proposed publication. Collins is described[34] as rejecting the idea that closer supervision would have prevented the deception: "My bottom-line answer is very unsatisfying, but there is no fail-safe way to prevent this kind of occurrence if a capable, bright, motivated trainee is determined to fabricate data in a deceptive and intentional way, short of setting up a police state in your laboratory." In a remark similar to Green's comment in *Nature*, Collins said "It rocks you down to your foundation to realize that an activity that you value so much and people who you develop this scientific and intense personal relationship in which you spend twelve hours a day together could be contaminated in this way." *Science* had a different reaction: "...The incident has led some to question whether Collins and other top scientists who run huge enterprises can pay enough attention to the details of the research they co-author to ensure that the work is valid in the first place." [35]

> "[W]hen our students and colleagues inquire about integrity in science, let us tell them....that integrity is not achieved merely through fear of sanctions against dishonor, but must be earned through positive acts: acts motivated by some understanding of the grand history of our science, and of our privileged place in it; motivated by the scope and beauty and seriousness of our quest as scientists, motivated by the growing hope that science will lead to a coherent world picture; and not least motivated by our responsibilities, as scientist-citizens, to the larger society that has nourished us, the society which we must help to live, or with which we shall perish."

Holton, op cit.

Of course, the pressures of grant writing and publication are not removed from the senior faculty member. They even may be greater if the senior member has run into a string of dead ends in his or her research and is having trouble getting grants. It may be that collaboration with a previously spurned colleague will be necessary, or switching to primarily or solely teaching, or, if available, retirement. If the choice is between one of these and losing integrity, the former is the best choice.

Amidst the many concerns about misconduct, senior faculty must not lose sight of the motivations which led them to go into science and to pursue a research career. The young people who look to the senior faculty as role models need to see the positive side of science.

7
Deans and Chairs

The higher you rise in administrative positions, the more difficult are the people problems brought to you. (The easier ones are handled below you.) A chair in a department with rotation the practice may not want to take a position unpopular with those colleagues the chair will rejoin. A dean may see taking a controversial stance as an impediment to future advancement to higher positions. The upper levels of administration have a major responsibility to establish the environment in which faculty and students work, study, and teach.

"The relationship between the formal academic curriculum and the informal curriculum that students absorb in the hallways, laboratories, and hospitals bears careful examination. What does the informal curriculum teach students in your laboratory or university? What messages do students pick up about authorship and publication practices? How do they see mentors reconcile a desire for a hefty publication record with admonitions not to engage in 'salami science' or divide work into 'least publishable units'? Do students observe professors maintaining confidentiality in reviewing grant applications? What sort of example do you set? Most important, do the rules apply to everyone in your environment or only to the students? ...The goal should be to provide guidance to the well-intentioned-those who may want to do the right thing but who genuinely do not know what is right in a complex situation or how to determine it."

C.K. Gunsalus, Associate Provost, University of Illinois at Urbana-Champaign, "Ethics: Sending Out the Message," Science, *276, 18 April 1997, p. 335.*

Faculty do have a role here, fiercely guard their independence, and do not respond well to attempts by school administrations, whether president, provost, dean, or chair, to impose requirements.[36] Administrators may have to stress the faculty's responsibilities.

> "A graduate student who hasn't already decided to avoid fraud or plagiarism isn't going to be persuaded to do so by a one-hour lecture on ethics."

Glenn McGee, director of the Responsible Training Program, University of Pennsylvania, The Chronicle of Higher Education, *2 August 1996, p. B3.*

> "Articulating, explaining, and implementing standards is an important task for scientific research groups, especially critical for orienting graduate students and postdocs and preparing them to be professionals.... [G]raduate students, postdocs, young and seasoned investigators all need to have pointed out what in the model behavior is to be imitated and why. And that effort requires articulation and explanation of standards."

Vivian Weil, Director, Center for the Study of Ethics in the Professions, Illinois Institute of Technology, personal communication.

Deans and chairs do have responsibilities to undergraduate students, to graduate students, to postdocs, and to both junior and senior faculty. These administrators should ensure that rules and guidelines are clear-regarding cheating, use of property, conditions for progress toward degrees, authorship, and for intellectual property rights.

> "Especially under an honor code, the most important requirement for preserving academic honesty is clear rules....[T]he most common problems under honor codes often involve a failure, on the part of students or faculty, to know and understand the rules."

Kennedy, op cit.*, pp. 86-87.*

Administrators also have the responsibility that all affected groups are informed of the rules and procedures and that institutional rules and procedures are effective, appropriate, and fair. If they are not, the administrators have the responsibility to work to change these rules and procedures. The administrators are responsible for ensuring that rules for work with industry are clear. Granted, some of these issues must be decided at a higher level in the university. However, the dean or chair has the responsibility for making clear the university's rules to people in the school or department. If these rules are absent or unclear, the dean or chair has the responsibility to bring this to the attention of the administration. This should not have to be done by the faculty and certainly not by the students or fellows.

> "The scientific community can show it is serious about maintaining high standards in research by establishing better procedures at the institutional level, said Kenneth Shine, president of the Institute for [sic] Medicine.... 'Everyone should know who's in charge and who to go to,' he said."

"Scientific misconduct at issue," Anthony Flint, The Boston Globe, *27 June 1994.*

The administration also has a responsibility for the future of the students.

> "Good graduate programs produce people who are prepared to become faculty members or industrial researchers or practicing professionals in a host of fields. They have acquired knowledge and skills that make them well-suited for a variety of different positions, but they may need to be assisted in adapting to them. Regardless of the type of employment, the challenge [for graduate schools] is to make the transition smoother and more productive."

"Doctoral Education: Preparing for the Future," Jules B. LaPidas, President of the Council of Graduate Schools, APS News, *December 1997, p. 8.*

> "[D]epartments should be required to tell their incoming graduate students several important facts about the history of their training programs before the students make their decisions. The first critical item of information is the percentage of students entering the program in the past decade who have earned their degrees....The second is an accounting of the average time taken to obtain the degrees. Finally, the department should report, for each member of some substantial recent cohort of doctoral degree recipients, his or her employment history."

Kennedy, op cit.*, p. 58.*

Probably the most difficult time for the dean or chair is when a charge of misconduct is raised. At this time, and often in association with the higher administrative levels of the university, the dean or chair has two major duties: (1) that the charge is handled following all the rules and (2) that both the person who alleges that research misconduct has occurred and the person against whom the allegation is made are treated fairly and impartially.

> "[C]ollegiality among scientists has been lost, especially among those in fast-paced fields where scientific breakthroughs produce not only moments of glory but also the potential for commercially viable products. Collaboration and communication among peers often have been replaced by competition and mistrust.... Academic institutions might well consider developing programs for dispute resolution in their scientific departments so that they can deal with interpersonal conflicts before they escalate into allegations of scientific misconduct. Such allegations are too easy to file, and the effects are too costly, to miss opportunities for mediation."

"The Needless Agony and Expense of Conflict Among Scientists," Barbara Mishkin, partner in the law firm of Hogan & Hartson, The Chronicle of Higher Education*, 23 February 1994, pp. B1-B2.*

As potential commercial rewards increased, conflict-of-interest issues have grown larger in institutional, industry, and government funding discussions.

Chauncey Starr, former Dean of Engineering, University of Southern California, President Emeritus of EPRI (Electric Power Research Institute), member, National Academy of Engineering, personal communication.

"Research as a career was supposed to have a societal mission and psychic rewards, not monetary. If one earned enough to avoid penury, the intellectual adventure would be the compensation....Of course, we all know what has changed. So research and cash flow have now joined. Ethics here are the same as in any business."

Universities have set up offices to commercialize research and, as industry has down-sized and closed research laboratories, more industrial research funding is being targeted at universities. These trends have highlighted issues of academic freedom to publish, proprietary rights, and patent rights.

[Academic] "Institutions need to reach some common understanding about definitions and management of conflicts of interest to protect their primary missions-the acquisition and dissemination of new knowledge, along with education-without arbitrarily squelching collaboration that might benefit the public, universities, and industry. To do this, they need answers to some important questions: To what extent should faculty members be allowed to make commitments to parties other than the university that might damage the credibility and integrity of university research? How much is "too much" of an interest for a faculty member to hold in a company? Should employees of universities be allowed to hold managerial or other fiduciary roles in a company that supports their research? How much information with commercial value should universities be willing to allow researchers to withhold in their publications?"

"Secrecy and Financial Conflicts in University-Industry Research Must Get Closer Scrutiny," Mildred K. Cho, Center for Bioethics, University of Pennsylvania, The Chronicle of Higher Education, *1 August 1997, pp. B4-B5.*

Finally, senior university administrators also have important roles in establishing and maintaining a climate in which ethical practices are taught and supported.

> "University administrators have ultimate responsibility to ensure that university policies and procedures are respected... Administrators might understandably be concerned about the embarrassment caused to their institution if an allegation of research misconduct is brought to light....They should guard against the temptation to take heroic measures to protect the institution. Ultimately, such behavior would hurt the institution as well as put the rest of the university community in jeopardy....Universities must avoid even the appearance of a conflict of interest and deal forthrightly with allegations of research misconduct involving Federal funds...."

Sybil Francis, White House Office of Science and Technology Policy, personal communication.

8
Researchers in Government, Industry and NGOs

Most researchers are not in academia but, based on where research dollars are spent,[37] are in industry and government. A much smaller number work for non-governmental organizations (NGOs), such as the National Resources Defense Council (NRDC), the Environmental Defense Fund (EDF), the World Resources Institute (WRI), and Resources for the Future (RFF). Research universities are not under threat of closing, nor are most university departments. However, many industry research units are under such threat, and some have been closed. NGOs live primarily on soft money,[38] so NGO researchers seldom have the equivalent of tenure. In recent years, the federal national laboratories have been subject to reviews which have recommended reduction in size, narrowing in scope, and, in some cases, closing. These pressures, not common in academia, lead to implicit and sometimes explicit demands of loyalty to the organization. One pressure can be to be less-than-objective regarding results which might go against the desires of the leaders or funders of the organization.

Government

Under this category are both those who are government employees, such as researchers at the Navy Research Laboratory (NRL) or the NIH laboratories, and those who are contractor employees working at government-owned laboratories, such as researchers at the Los Alamos National Laboratory, who are employees of the contractor, the University of California.

Government researchers perform the spectrum of research from pure basic research to applied technology development. Many compete for grants just as do their academic colleagues and are rewarded (including promotions) for their productivity. Therefore, the ethical challenges they face are not different from those faced by academic researchers, except for student cheating. Also, senior researchers at government facilities are mentors to both postdocs and to junior employees, and have similar advisor responsibilities as senior academic faculty.

However, some government researchers will face a different ethical challenge: "to speak truth to power." "The users of our results, the decision-makers who need our advice, will always press us to be more sure of ourselves than our data permit, for it would make their jobs easier." [39] This is one challenge the government researcher faces: to insist on an accurate description of what is known and what is not, to include uncertainty in the estimates, and to be clear just how far the science can take you. A more difficult challenge comes when the scientist's position, based on his or her research, contradicts a strongly held position of senior political appointees. These situations, while perhaps rare, can place the government researcher in a dilemma: acquiesce or leave.

These are not necessarily instances of immediate danger to public health or national security-in such cases the scientist most likely will receive some strong support. More likely they involve questions of long-term effects, whose significance will not be known for many years. Examples include the nature and severity of global warming, the health effects of low levels of exposure to radiation, the toxicity or carcinoginity of anthropogenic chemicals, or the cost-benefit analyses of environmental regulations.

In such cases, does the researcher have a responsibility to 'go public'? There is no simple answer. It depends on how certain the researcher is of his or her scientific position and how sure he or she is that all the relevant factors are known. In most major governmental decisions, many factors must be weighed, and the researcher may not know most of them. It is always the researcher's responsibility to give the decision-maker a frank, understandable description of the science.[40] Often science alone is not enough to determine the course of action. The government researcher may disagree with the decision, but that disagreement may be more a policy issue than a scientific issue. The researcher should not confuse the two and particularly should avoid confusing the public.

Industry

Similar to government, industry research can be very basic or applied, although the trend in the `90s has been to reduce the amount of pure basic or opportunity-driven research in favor of mission-oriented research. In this environment, productivity is necessary for promotion and retention. The ffp trio remains a potential set of challenges, particularly for those researchers in organizations which do contract work. Since often the peer-review system is not as strong (or even absent) in the industrial setting, the temptations to meet deadlines by ffp can be large. Senior members of the research staff bear a large responsibility for teaching the new, junior staff that missed deadlines are undesirable, but unethical practices are unacceptable.

Industry researchers also face the challenge of bringing forward results which differ from the company's desires and, if necessary, must be willing to disagree in public. Perhaps the most publicized example in recent years in the United States has been the silence of researchers employed by the tobacco industry, as the industry publicly claimed that the evidence was inconclusive linking smoking to lung cancer. Anopther example, with failure lessons for both government and industry, is the series of actions (and inaction) leading to the destruction of the Challenger space shuttle.[41]

NGO

Researchers in NGOs have been extremely valuable in identifying weaknesses, errors, and neglect in industry and government analyses. However, the NGO researcher often has the challenge of remaining objective. NGOs are held to a different standard of objectivity than is the government[42] and often are far more interested in making a case in the media than in the court of science.[43] An example is the Alar controversy,[44] which one observer described as "an instructive study in the social construction of science." [45] NGOs usually have a set of societal goals and often serve as advocacy groups. The NGO researcher may find it difficult to present the uncertainties inherent in some of the results and still produce material supportive of the NGO's goals. However, the researcher should first try to explain the science and the uncertainty. Eventually, however, the researcher will have to accept that to remain with the NGO may require compromising, just as remaining with industry or with government may require compromising. The researcher should examine his or her conscience and decide with how much compromising he or she can live.

9
Government and Industry Managers

In some ways, the responsibilities of these managers are similar to those of deans, chairs, and senior professors: to establish a climate in which good research can flourish, to ensure policies are clear and followed, to serve when called upon to advise junior members on questions of ethical conflicts, and either to be the person making the decision or to participate in the decision process when ethical charges arise.

However, there are several additional duties and also complications. The industry or government manager usually has responsibilities to those above him or her that involve ensuring the industry or the agency policies are followed. These may involve limiting the areas of research. They also may involve using funding as an incentive for research direction, and usually involve a much greater influence on promotion than does a single individual in the academic setting. All these are powerful responsibilities and are open to serious misuse.

There probably is no better guide to follow than the Golden Rule: do unto others as you would have others do unto you. That provides a reasonably clear guide to just treatment.

Conflict of interest issues can be complex in government and the manager must ensure that the rules are applied, but not without logic and realism. It is too easy to become a captive of literal, unthinking application of regulations, to the detriment of your research and, most likely, to departure of your best researchers.

> "Conflict of interest (COI) is a complex and important issue because uncompromised judgment is at stake. People in science need a fuller understanding of what COI is, what is wrong with it, how to avoid it, and, when it is not possible to avoid (happens often), what are the things to do about it: 1) disclose or 2) divest or 3) recuse oneself from making a judgment."

Personal communication from Vivian Weil, Director, Center for the Study of Ethics in the Profession, Illinois Institute of Technology

Industry research managers also can be exposed to pressure from within or outside the company to modify or suppress results.

Two examples provided by a senior industry manager:

"1. On two occasions we evaluated politically popular government programs and concluded they were ineffective.... We were pressured to change our conclusion for one and, for the other, the agency wrote its own conclusion until we protested strongly. When you depend on government sponsors for support, standing your ground is vital but carries obvious risks.

2. We are sometimes asked to collect data with a sample size too small to produce valid conclusions. The sample size, of course, drives cost and quality. We have to decide if the study, with the practical funding limits, meets our own minimum standards. Saying no when you need the funding can be painful."

It is wise to think through these possible events before they occur. The examples quoted above provide a good model to follow.

10
Peer Review

Funding agencies and scientific journals use "peer review" to help determine which grants to fund and which articles to publish. As a member of the research community, you may be called upon to serve on review panels for funding agencies or as a reviewer for journal manuscripts. To do so has been considered a responsibility for a member of the research community.

But to do so may pose ethical problems, since the process of selecting peer reviewers tries to find people quite familiar with the subject matter-usually fellow researchers. Grant proposals or manuscripts may be from friends or close colleagues. Your review may be instrumental in acceptance or rejection. Perhaps a greater challenge comes when reviewing a submission from an archrival. In all these cases, you should do your best to be objective.

> [For] "investigators who may find themselves asked to participate in peer review decisions at a relatively early stage in their careers...there are a host of issues that need to be thought through-how one deals with friends or rivals whose applications may be in the pile, how one deals with approaches and methodologies that may be legitimate but with which one is not sympathetic, how much one can legitimately 'borrow' from research proposals one reviews, etc."

W.R. Connor, Director, National Humanities Center, personal communication.

Another temptation may come when a grant proposal or manuscript contains the answer to a problem that has been stymying your own research. You must not steal ideas.[46] It also is wrong to block someone so that you can use their idea or gain time to complete your own research. In the unlikely case that use of what you have read truly would solve a problem that has blocked your progress, realistically you cannot avoid using it. But you first should contact the originator and get permission and be prepared to give that person appropriate credit in any of your publications.

David Goodstein has noted[47] that when their own proposals or manuscripts receive what they see as unfair review, prospective reviewers have their standards eroded. Seldom (if ever) are reviewers held accountable for what they write. This permits a reviewer to delay or deny funding or publication to a rival. This facet of peer review problems should be addressed by journal editors and grant managers, even if it would entail substantial effort and might lead to a reduction in available reviewers. The alternative, to not do anything, threatens to substantially reduce the value of "peer review."

> "Well-chosen peer reviewers can be highly knowledgeable about the subject matter and the characters of the authors involved. Most of the time they offer excellent advice. However, for a variety of reasons, including self-interest, sometimes they don't. Safeguarding against such events is the responsibility of editors and their associate editors. It is also the responsibility of staffs of granting agencies. Their duty is to review the reviewers and to maintain records on their backgrounds and performance. With modern computer systems, this is quite feasible."

"Integrity of the Research Process," Philip H. Abelson, editor emeritus of Science, Science*, 256, 29 May 1992, p. 1257*

11
Other Topics

A senior scientist at an off-the-record Sigma Xi Forum planning conference, Wingspread, WI, August, 1992.

> "We are guilty of selling our souls in order to finance our research. We do make claims about the promise of science, about what's going to come out of our work, that we know we can't support-or at least if we are honest with ourselves. So there are genuine moral issues involved."

The pressure to get grants has increased as researchers are asked to fund more of their own time, as the cost to run experimental facilities has increased (along with the size of the facilities), and the need to get funds to cover an increased number of graduate students has grown. As success rates decline in the granting agencies, pressures increase that may lead to being less than honest in grant proposals.

Steneck, op cit., *p. 9.*

> "There seems little doubt that most researchers do not, and know that they should not, manufacture data or forge experimental results. It may be less clear, however, how results should be presented in grant applications, when 'enough data' are needed to give confidence that a project will succeed but 'enough work' remains to be done to justify getting the grant. How 'preliminary' should 'preliminary research' be?"

As researchers seek and receive multiple grants, time pressures can become extreme and make resource allocation difficult. Multiple grants also raise the issue of what work belongs to which grantee. Funding constraints also are different for commercial, foundation, and government funding, increasing the administrative pressures on researchers.

> "Dr. Kenneth Shine, president of the Institute of Medicine...described the trends forcing science into a 'dog eat dog' world. The success rate of grant applications has declined, and openness and sharing have given ground to competition and secrecy. Scientific journals compete with one another to solicit papers from scientific authors, negotiating with them for future publishing rights. The increasing presence of corporate money in the academic laboratory, however neutral its effects on the research conducted, seems to alter colleagues' perceptions of an investigator's motives and willingness to disclose data."

Summary of a Planning Workshop for a Guide for Education in Responsible Science, *National Academy of Sciences, 26-27 February, 1997, p. 1.*

The increasing involvement of industry, through grants and other support, has been encouraged by universities. While financially advantageous, and bringing faculty into contact with practical problems, these industrial links also have brought restrictions on publication and other challenges to academic freedom. An early proponent has cautioned that "the price of corporate support is eternal vigilance." [48]

Science misconduct issues are associated with the research enterprise and are not unique to the United States, although there are cultural differences in some basic concepts. Examples of the types of ethical issues discussed in this booklet can be found in other countries, for example, in China,[49] Germany,[50] and Hong Kong.[51]

"Allegations Prompt Debate in Germany," Robert Koenig, Science, *277, 11 July 1997, p. 172.*

"'The complexity and the growing international competitive pressure in many scientific fields may be increasing the temptation to use deception and fabrication' in research, said the DFG's [Deutsche Forschungsgemeinshaft] president, Wolfgang Fruhwald."

Other ethical pressures arise in court cases, where scientists are asked to testify on behalf of one or the other side. The public often perceives scientists as "hired guns," particularly when the media present the views of two opposing scientists as being determined by whom they represent. Unfortunately, this conclusion often is valid.

"Credibility in Science and the Press," Daniel E. Koshland, Jr., editor of Science, Science, *254, 1 November 1991, p. 629.*

"The credibility of scientists varies from those with records of objectivity to others who only travel from press conference to press conference and law court to law court saying what their clients want to hear."

Another challenge to science has come from the instances when government agencies advocate a position that is unpopular with a local community or with organized groups, both industry and public. Frequently, the government agency asks an advisory group to address the issue. One such issue was the question of radiation doses on residents near the Hanford, Washington, atomic weapons material site. John Till led the advisory group examining that issue. Some of the lessons he learned provide valuable advice for other scientists who may get involved in such public issues.

> "[U]nless we communicated openly with people, involved them in our work and earned their trust, all our efforts would be for naught- a waste of our time and the government's money. No matter how well we conducted our science or how valid the results, we were doomed to fail in our responsibility to conduct a public study if we failed to convince the public to believe us.
>
> ....
>
> A public study is scientific research created through public interest, concern or fear. By its very nature, a public study must be conducted with careful attention to structure, source of funding, and public involvement. Scientific and public credibility of the research are of equal importance.
>
> ...
>
> The most important aspect of any public study must be heavy reliance on social science, state-of-the-art methods and intense scientific peer review. In the end, the technical quality of the research and its contribution to science will be the most important criteria by which the work will be judged- by the public, by the scientific community and, in all likelihood, by a court of law."

"Building Credibility in Public Studies," John E. Till, American Scientist, *83, September-October 1995, pp. 468-473.*

Perhaps the most contentious area of debate between scientists and some of their critics and among scientists themselves is the social responsibility of scientists for their science. This debate has covered many topics, including development of the atomic bomb, military research, gene technology, the use of animals, and funding of the space program.

Science has great power and engineering has demonstrated feats once thought impossible (e.g., walking on the moon). Nobel laureate Peter Medawar wrote "[I]t is the great glory as it is also the great threat of science that everything which is in principle possible can be done if the intention to do it is sufficiently resolute." [52] Medawar believed that scientists should become concerned about issues in which they have special knowledge: "The scientist certainly has a social responsibility and it is a special responsibility where he has, or thinks he has, special knowledge which he thinks ought to influence others in possession of authority....I do not think any scientist can or ought to repudiate his unit responsibility in a democracy...." [53]

This responsibility leads scientists and engineers to serve on government advisory committees and to enter government service, at the local, state, federal, and international level. In these positions, scientists must be careful to distinguish between the advice they offer based on their technical knowledge, in which they are experts, and that in other areas, where their prestige should not give their advice extra weight over that from non-technical people.

The medical community has unique opportunities to go beyond appropriate boundaries because patients are vulnerable. This has been captured by Dr. Leon Kass.

> "There are many clinical situations that already permit, if not invite, the manipulative or arbitrary use of power provided by biomedical technology....Physicians are sometimes troubled by their increasing power, yet they feel they cannot avoid its exercise. 'Reluctantly,' one commented to me, 'we shall have to play God.' With what guidance and to what ends...By whose authority?"

Toward a More Natural Science: Biology and Human Affairs, *Leon R. Kass, M.D., The Free Press, 1985, pp.30-31.*

There also is the question as to whether the scientist has a social responsibility to examine the effects of the scientist's research. A segment of the science community believes that the search for truth is their goal and that others must worry about applications. An ethicist has noted that, in reading some writings on ethics for scientists, "the impression is left that scientists are primarily concerned with their honor not with their service." [54] The science community is not unanimous on this issue and it deserves more debate and attention in the scientific community.

"I object strenuously to the concept of the social responsibility of science. I think that is an incongruous idea. I think science ought to be value free. People should be concerned about how the science is used in pursuit of societal goals, but I don't want the scientist to be responsible for worrying about the outcome of his science for the public at large."

A senior scientist, in an off-the-record Sigma Xi Forum planning conference, Wingspread, WI, August, 1992.

A response to this position was given by another senior scientist in reviewing an early draft of this booklet:

"The statement concerning social responsibility of science is pure rot. We all have a responsibility to act according to our beliefs, and to avoid actions we feel to be evil. We cannot enforce the proper behavior of others, but we can certainly do so for ourselves."

Ira B. Bernstein, op cit., *personal communication.*

These issues are ones the researcher should address. Situations differ. There are no absolutes other than that, as a responsible researcher, you should think through these issues and decide your positions based on reasons you would not mind telling your colleagues, students, friends, and family.

12
Conclusions

This booklet begins with the view of Nobel laureate Michael Bishop that the success of science "is driven by human values," such as honesty, commitment, courage, and imagination. Each subsequent section describes some of the ethics issues that may be faced by students, faculties, researchers, and mangers. These issues are many and can be extremely difficult.

> "Pressures on researchers are real. Data must be interpreted, written up, and published. Names must be included or not included on journal articles. Experimental results are property that someone owns. The ownership of ideas is important; it has a bearing on promotion, and ideas sometimes can be sold for profit. Conflicts of interest exist. Future scientists and engineers must be trained. Public and private interests do compete. Researchers have responsibilities to more than one constituency. Superiors do not always make responsible decisions. The modern practice of science is complex. It is unlikely that anyone can intuitively know how to act or will instinctively want to act responsibly in every situation. Therefore, even if it is true that basic moral character is what determines whether scientists, engineers, and other researchers act responsibly in research settings, there is still much that universities can do to remind and clarify for researchers what it means to be 'responsible.'"

Steneck, op cit., *pp. 21-22.*

But the responsibilities of the researcher go beyond meeting the constraints of law or regulations. Science is a noble calling. It has many rewards, including the satisfaction of working on interesting problems in conditions often quite pleasant. It also brings with it obligations to the society in which the researcher is supported.

> "[T]he most demanding of the principles of integrity: the obligation scientists have to exercise sound citizenship....There are many reasons why the obligation is special. The most obvious one is simply this: Having been helped to become scientists and to live as scientists in this suffering world, we are the beneficiaries of unusual privilege, of scarce resources, and of the painful labors of our scientific parents. The mechanics we learned in school came to birth in the anguish of Galileo, dictating his book in his old age, blind and under house arrest. Kepler died on a highway like a dog, on one of his futile journeys to find money to pay for printing the books from which we later learned about his laws. Indeed, many of the formulas we rely on every day were distilled from the blood and sweat of our distant forebears, most of them now forgotten. We stand not only on the shoulders of a few giants, but also on the graves of thousands."

Holton, op cit.

This booklet is not in any way intended to dissuade you from entering the exciting world of research-it is intended as a guide for the journey.

Other Sources

Examples

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Notes

[1] *Honor in Science*, Sigma Xi, The Scientific Research Society, 1986.

[2] J. Michael Bishop: "Science and Human Values," commencement address, Redwood High School, Larkspur CA, 15 June 1990.

[3] *Lying: Moral Choice in Public and Private Life*, Sissela Bok, Harvard University, Pantheon Books, 1978; "Hidden Costs," Sissela Bok, *World Link*, **4,** Nov. / Dec. 1991, pp. 70-71; "Lies: They Come With Consequences," Sissela Bok, *The Washington Post*, 23 August, 1998, pp. C1-2; "Is It Ever Right to Lie? The Philosophy of Deception," Robert C. Solomon, University of Texas-Austin professor of philosophy, *The Chronicle of Higher Education*, 27 February 1998, p. A60.

[4] *All I Really Need to Know I Learned in Kindergarten: Uncommon Thoughts on Common Things,* Robert Fulghum, Villard Books, NY, 1988.

[5] The first research misconduct hearing was conducted in 1981 by Representative Al Gore.

[6] *The Responsible Conduct of Research in the Health Sciences,* Committee on the Responsible Conduct of Research, Institute of Medicine, National Academy Press, 1989; *Responsible Science: Ensuring the Integrity of the Research Process,* two volumes, report of the Panel on Scientific Responsibility and the Conduct of Research, National Academy Press, 1992. Usually referred to as the David Report.

[7] *Integrity and Misconduct in Research,* Report of the Commission on Research Integrity, Kenneth J. Ryan, M.D., Chair, U.S. Department of Health and Human Services, 1995.

[8] See pp. 180-181, David Report, *op cit.*

[9] The reliance on ffp to assess research misconduct has become common. However, some object to its use as being elitist, or simplistic, or insufficient.

[10] "What is Misconduct in Science?," Howard K. Schachman, *Science*, **261**, 9 July 1993, pp. 148-149, 183., and personal communication from Howard Schachman.

[11] Richard A. McCormick, John A. O'Brien Professor of Christian Ethics, University of Notre Dame, personal communication.

[12] *Integrity and Misconduct in Research, op cit.*, p. 1; 42CFR Part 50, Subpart A.

[13] "Some Considerations in Defining Misconduct in Science," Donald E. Buzzelli, NSF Inspector General's Office, Sigma Xi Forum: *Ethics, Values, and the Promise of Science,* Forum Proceedings, Sigma Xi, the Scientific Research Society, Inc., 1993, hereafter Sigma Xi Forum, p.220; Federal Register 56 (14 May 1991): 22286-90.

[14] *Responsible Science, op cit.*, p. 27.

[15] *Integrity and Misconduct in Research, op cit.*, p. 13.

[16] ORI Newsletter, Vol. 6, No. 4, September 1998, p.7.

[17] "Ethical Problems in Academic Research," Judith P. Swazey, *et al.***,** *American Scientist,* **81**, November-December 1993, pp. 542-553; "Universities Finding a Sharp Rise in Computer-Aided Cheating," Ian Zack, *The New York Times,* 23 September 1998.

[18] "For the graduate student, it too often comes down to a painful choice: work on the professor's project so I can get supported, or work on my thesis so I can get out." *Academic Duty,* Donald Kennedy, President Emeritus of Stanford University, Harvard University Press, 1997, p. 49.

[19] "Once published, forged data can be nearly impossible to remove from the literature because of repeated citations." Bill Howard, Motorola. Quoted in personal communication from F. Thomas Wooten, President, Research Triangle Institute.

[20] "Scientific Fraud," David Goodstein, *American Scholar,* **60**, Autumn 1991, p. 505; "Scientific Fraud," David Goodstein, *Engineering & Science,* Winter 1991, pp. 11-19.

[21] "Integrity in Science," Lewis M. Branscomb, member of the National Academies of Science and Engineering, former Director of the National Bureau of Standards and former Chief Scientist for the IBM Corporation, *American Scientist,* **73**, September-October 1985, pp. 421-423.

[22] These examples were pointed out by Beverly Hartline, White Office of Science and Technology Policy in a personal communication.

[23] "Postdoctoral Researchers: A Panel," Sigma Xi Forum, p. 52.

[24] *Ibid.,* pp.47-59; "Postdocs: Tales of Woe From the 'Invisible University,'" *Science*, **257**, 18 September 1992, pp. 1738-1740.

[25] *Cantor's Dilemma*, Carl Djerassi, Doubleday, 1989.

[26] Sigma Xi Forum, *op cit.*, p. 52

[27] The National Science Foundation and the Department of Health and Human Services (in which is located the National Institutes of Health) have offices which investigate allegations of misconduct in science.

[28] *Reshaping the Graduate Education of Scientists and Engineers*, Committee on Science, Engineering, and Public Policy, National Academy Press, 1995.

[29] "Why Professors Don't Do More to Stop Students Who Cheat," Alison Schneider, *The Chronicle of Higher Education*, 22 January 1999, pp. A8-A10.

[30] "Rethinking Unscientific Attitudes About Scientific Misconduct," C.K. Gunsalus, associate provost, University of Illinois at Urbana-Champaign, *The Chronicle of Higher Education*, 28 March 1997, pp. B4-B5. Of course, even if the number is quite small, the results can be extremely harmful to science, both in spreading false information and in corroding the trust on which the science community relies.

[31] "Fraud in Science: the Case for Tough Enforcement Standards," Barbara Mishkin, *Cosmos*, **3**, 1993, pp. 47-51.

[32] "Advisor is a role that can be structured and specified; it carries certain duties and privileges. Mentor is an open-ended relationship involving a personal commitment that cannot be mandated." Personal communication from Vivian Weil, Director, Center for the Study of Ethics in the Profession, Illinois Institute of Technology

[33] "NIH laboratory admits to fabricated embryo research, retracts paper," *Nature*, Christopher Anderson. Vol. 357, 11 June 1992, p. 427.

[34] "Falsified Data Found in Gene Studies," Lawrence K. Altman, *The New York Times*, 30 October 1996, p. A8.

[35] "Fraud Strikes Top Genome Lab," *Science*, Vol. 274, 8 November 1996, p. 908.

[36] However, faculty also want the administration to stand between the faculty and the onerous tasks of handling federal bureaucracy, state and federal regulations, and, if possible, fund-raising (other than research grants).

[37] *Science and Engineering Indicators: 1998*, NSB 98-1, National Science Foundation, 1998, p. 4-10. Most applied research funding is in industry; most basic research funding, in academia.

[38] "Soft money" refers to funding from grants or contracts that has a specific duration, so that when that time ends, the money stops. Researchers on soft money regularly must seek new funding.

[39] Branscomb, *op cit.*

[40] Government reports have a greater responsibility for objectivity than do those from industry or NGOs: *Improving Risk Communication*, National Research Council, National Academy Press, 1989, pp. 129, 169.

[41] For example: "From Quagadougou to Cape Canaveral: Why the Bad News Doesn't Travel Up," Charles Peters, *The Washington Monthly*, April 1986, pp. 27-31; *Report of the Presidential Commission on the Space Shuttle Challenger Accident*, NASA, Washington, DC, 1986.

[42] For example, see *Improving Risk Communication*, National Research Council, National Academy Press, 1989, p. 120.

[43] "Charges Fly Over Advocacy Research," Jock Friedly, *Science*, **275**, 7 March 1997, pp. 1411-1412.

[44] Alar (trade name for daminozide) was sprayed on apples to delay ripening and increase shelf life as well as appearance of harvested fruit. A major public campaign against use of Alar was mounted by an NGO in cooperation with a major television network. See *The Fifth Branch: Science Advisors as Policy Makers*, Sheila Jasanoff, Cornell University, Harvard University Press, 1990, pp.141-149.

[45] *Ibid.*, p. 141.

[46] Problems with peer review led to a court case in which a research team claims that a manuscript reviewer used information from the manuscript for a patent application: "Suit Alleges Misuse of Peer Review," Eliot Marshall, *Science*, **270**, 22 December 1995, pp. 1912-1914.

[47] "Peer Review after the Big Crunch," David Goodstein, *American Scientist*, **83**, September-October 1995, pp. 401-2. See also "Fraud in science: causes and remedies," Arnold S. Relman, editor-in-chief of the *New England Journal of Medicine*, *Scientific American*, April 1989, p. 126.

[48] Former Harvard president Derek Bok, quoted in "A Cautionary Tale," Dorothy S. Zinberg, *Science*, **273**, 26 July 1996, p. 411.

[49] "Chinese Researchers Debate Rash of Plagiarism Cases," Li Xiguang and Lei Xing, *Science*, **274**, 18 October 1996, pp. 337-8.

[50] "Panel Proposes Ways to Combat Fraud," describing the work of a panel created by Germany's main granting agency for basic research, the Deutsche Forschungsgemeinshaft, Robert Koenig, *Science*, **278**, 19 December 1997, pp. 2049-2050; "German Investigators Seek to Unravel a Mammoth Case of Scientific Fraud," Burton Bollag, *The Chronicle of Higher Education*, 20 February 1998, pp. A57-A60.

[51] "Survey battle leads to plagiarism verdict," David Swinbanks, *Nature*, **366**, 23/30 December 1993, p. 715.

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[53] *Ibid.*, p. 11.

[54] Richard A. McCormick, *op cit.*, personal communication.