FILO-037

Volume 110 Number 1

SURGERY

JULY 1991

Original communications

Misconduct and fraud in research: Social and legislative issues symposium of the Society of University Surgeons

Panelists: Richard L. Simmons, MD, Hiram C. Polk, Jr., MD, *and* **Barbara Williams, PhD, Moderator: Constantine Mavroudis, MD,** *Pittsburgh, Pa., Louisville, Ky., Bethesda, Md., and Chicago, Ill.*

Misconduct and fraud in scientific research has recently attracted wide attention from researchers, government officials, and institutional administrators and has resulted in national guidelines for definition, investigation, and sanctions. This report summarizes the results of a questionnaire sent to the active members of the Society of University Surgeons in 1989 concerning misconduct and fraud in research. The report also gives the opinions of the participants, who included Richard L. Simmons, MD, professor and chairman, Department of Surgery, University of Pittsburgh, "Quality assurance in laboratory research"; Hiram C. Polk, Jr., MD, chief editor, American Journal of Surgery, *professor and chairman, Department of Surgery, University of Louisville, "Peer review—Success or failure"; and Barbara Williams, PhD, senior scientist, Office of Scientific Integrity, National Institutes of Health, "Office of scientific integrity—National approach to quality assurance." (SURGERY 1991;110:1-7.)*

From the Social and Legislative Issues Symposium, Society of University Surgeons Meeting, Los Angeles, Calif. February 8-10, 1990

MISCONDUCT AND FRAUD in scientific research is not a new phenomenon. The theories and practices of such notable scientists as Ptolemy, Galileo, Newton, Dalton, and Mendel have been called into question for irregularities concerning studies that were allegedly never performed, data that were too good to be true (fudging), and experiments that could never be confirmed or repeated by other scientists.[1, 2]

During the last two decades, many scientists[1-3] were found to have faked data, falsified records, and plagiarized scientific papers. These notable scientists included John Darsee, a Harvard cardiologist, who faked experiments and submitted abstracts and scientific papers for publication[4]; William T. Summerlin, a Sloan-Kettering physician-researcher, who painted white mice black to fake intraspecies immunocompatibility when skin grafts were placed in a nutrient solution before trans-

Committee members: Constantine Mavroudis, MD, Chairman, Paul Addonizio, MD, R. Morton Bolman, MD, David L. Dunn, MD, John B. Hanks, MD, Ronald C. Merrell, MD, *and* Bruce G. Sommer, MD.

Accepted for publication September 19, 1990.

Reprint requests: Constantine Mavroudis, MD, Division of Cardiovascular-Thoracic Surgery, Box 22, Children's Memorial Hospital, 2300 Children's Plaza, Chicago, IL 60614.

11/56/26170

plantation[2]; and Robert A. Slutsky, a University of California-San Diego radiologist, who fabricated data to support papers that in turn were the focus of subsequent double publication in separate journals.[5]

What makes talented and seemingly accomplished researchers resort to misconduct and fraud has been the focus of much concern. Enger et al.[5] proposed the "rotten-apple" versus the "rotten-system" theories, which have also been discussed by Relman[6] and Koshland.[7] The first theory states that human frailty is ever present and that some researchers with moral standards that are suspect will resort to immoral practices. The other theory faults the academic "publish or perish" environment, which pressures scientists to out perform their peers to achieve national and international acclaim. No doubt, the reasons for these kinds of activities are multifactorial, and consequently their solutions are similarly complex.

Landmark discoveries of great potential use to society must ultimately pass the test of reproducibility and time, which eventually will confirm quality assurance. What about the rest of scientific research? Must all experiments be duplicated? How can we detect plagiarism? Who should we believe? Just what is fraud and misconduct? Who will blow the whistle? These and other compelling questions have had a resounding effect in the scientific, political,[8] and institutional communities over the last few years and have resulted in editorial discourse and governmental action. The *Final Rule* for "Dealing With and Reporting Possible Misconduct in Science"[9] was issued by the Public Health Service on August 8, 1989. In conjunction with this document, newly developed Offices of Scientific Integrity and Scientific Integrity Review will oversee and investigate allegations of misconduct with full due process and enforce actions that may eventually include loss of National Institutes of Health (NIH) funding.

To address these and other concerns, we conducted a survey through a questionnaire of the active members of the Society of University Surgeons in 1989. The data were analyzed by the Committee on Social and Legislative Issues of the Society in preparation for the "Misconduct and Fraud in Research" symposium. The symposium was organized in three parts that included presentation of the questionnaire data; individual presentations by Richard L. Simmons, MD, professor and chairman, Department of Surgery, University of Pittsburgh, on "Quality Assurance in Laboratory Research"; Hiram C. Polk, Jr., MD, chief editor, *American Journal of Surgery*, professor and chairman, Department of Surgery, University of Louisville, on "Peer Review—Success or Failure"; and Barbara Williams, PhD, senior scientist, Office of Scientific Integrity, National Institutes of Health, on "Office of Scientific Integrity—National Approach to Quality Assurance"; and a question and answer period. The purposes of this article are to document and analyze the results of the questionnaire and to chronicle the highlights of the symposium.

MATERIAL, METHODS, AND RESULTS

The questionnaire was developed to assess attitudes of the membership concerning the definition, perception, and correction of fraud. The questions were selected to focus on areas in which the respondents might be expected to disagree and on areas in which subsequent agreement was anticipated. Responses were returned by 204 (82%) of the members.

Seven questions dealt with definitions of fraud. The responses showed a strong condemnation of behaviors such as discarding experiments, eliminating study patients, and duplicative publication, although casual attention to accuracy of bibliography was treated more generously. However, even for those questions, agreement was far from uniform. Failure to completely read a coauthored manuscript, lack of meticulus review of raw data, and submission of data not completely confirmed in abstracts were considered questionable in the main, without any clear condemnation as fraud or endorsement as unethical behavior.

In answers to the eight questions concerning the perception or recognition of fraud, the membership expressed a distrust of specific investigators and were not entirely secure in the accuracy of papers published, even in "good" journals. Confidence in the ability of peer reviewers to detect fraud was far from complete, and most members disagreed with the contention that fraud was a new phenomenon in science.

Forty percent of the members were aware of at least one incidence of fraud that had been openly investigated in their institutions; 43% of the members were aware of at least one quiet inquiry. Twenty-seven percent of the members had directly refuted data published by a colleague, and 15% of the members had strongly suspected fraud, which had not been investigated, in their universities. These data contrast with the response that 75% of the universities in our membership have ethics policies that are related to science and that are widely communicated to the faculty. Seventy percent of the members believe research fraud publicity penalized honest researchers.

Six questions related to correction or reduction of fraud in our environment; the strongest endorsement (89%) was for severe academic penalties for scientists

who were found guilty of fraud. However, no general consensus was reached about the value of institutional quality assurance programs or open access to data.

Members of the Society seem to have a great interest and concern related to scientific fraud. The members express some ambivalence in the definition of fraud. This is appropriate for any area of ethics and calls for on-going dialogue among scientists to define acceptable and unacceptable behavior. The membership reports a strong perception that fraudulent behavior is an element of our academic lives that is not new and is not precluded by ambient safeguards in our universities or journals. Publicity surrounding academic fraud is hurtful to honest scientists, and general agreement occurs only on academic punitive measures. There is great interest regarding ethical scientific behavior and better mechanisms to prevent, recognize, and respond to unacceptable activities.

DISCUSSION

The gathering interest from scientists, ethicists, legislators, and the media concerning misconduct and fraud in research has resulted in intense global study. Political interest, public opinion, and scientific community consultation has resulted in the *Final Rule*,[9] put forth by the Office of Scientific Integrity to provide definitions and guidelines for misconduct prevention, preliminary investigations, and due process. The participants of this symposium have addressed these very important issues from the viewpoint of a chairman of a department of surgery, a chief editor of a well-recognized surgical journal, and a senior scientist of the Office of Scientific Integrity.

"Quality Assurance in Laboratory Research," Richard L. Simmons, MD, professor and chairman, Department of Surgery, University of Pittsburgh. The point of my communication is that all crime—including a "crime" that simply violates norms rather than laws—takes place in a social context. That social context of scientific fraud is the laboratory subculture in which norms may or may not strictly conform to the accepted tenet that "science is the search for the truth" and "honesty is the best policy."

Evidence that fraud in science has a social context in the laboratory subculture comes from many sources, which include laboratory humor. I mention here common phrases like "publish or perish," "fudge factor," and "a rat is an animal which, given a drug, generates a report," all of which suggest that careerism is more important than scientific truth.

Blatant fraud is usually the product of a single individual who, although working alone, gains veracity by sharing credit with colleagues who are not involved in the data generation. Such people are frequently described as brilliant loners whose future careers are thought to be assured by virtue of their close association with distinguished mentors who have given them what turns out to be excessive independence. Conspiracy to commit scientific fraud is rare. To detect fraud in laboratory operations, one must (1) be suspicious of the brilliant loner who seems to be uncooperative with his peers; (2) be suspicious when one's own hypotheses are constantly being proved right by the data; (3) be suspicious if experiments always seem to "work"—it is difficult to so control the experimental conditions that reproducible results can be reliably obtained without many trials; (4) insist on seeing the raw data for every repeat experiments to be sure that there is not excessive internal consistency; (5) if results are suspicious, have the experiment repeated by another investigator; and finally, (6) listen to the substance of internal dissensions and trivial fights between technicians and students. If one is deaf to complaint, conflicts that could unduly influence the proper collection or analysis of data will be missed.

Detecting fraud after the fact is difficult. How can one prevent fraud from being committed under one's nose? Recognition that fraud takes place in a social context, which permits sloppy science, is essential; then one can provide a role model for scientific integrity. Equally important, techniques can be taught for data gathering, analysis, and storage that permit the advancement of career goals while being faithful to scientific truth.

The laboratory director must never take credit that is not due. This establishes the principle that undeserved rewards are not desired. The laboratory director must "be there" to see and comment on the raw data day after day. There is no useful role for the director who edits abstracts on the day of submission.

The laboratory director must minimize competition for precedence—both within the lab and with other laboratories. Working together and sharing credit for the contribution acclerates progress and almost totally eliminates the opportunity for duplicity because replication and verification become part of the process.

We must all recognize that "fudging" is a natural consequence of the common scientific idea that the beautiful hypothesis is more important than the data. Every day, we are confronted with unexpected and uninterpretable results. Every day, investigators select experiments that "work" from those that do not. In fact, the good scientist can be defined as one who can tell the "forest" from the "trees." Every published report contains distortions of the raw data that make the data con-

form to some reasonable hypothesis. No journal will publish data in isolation from a hypothesis. Minimizing bias in the normal process of data analysis is the best way to create an environment inconsistent with the possibility of fraud.

Several guidelines may help in this process. First, never accept the first experiment that works. Second, after many repetitions, which permit one to predict reproducibility, one must mentally discard that evidence—but preserve the raw data. Third, a set of "perfectly controlled experiments" must then be performed to test the hypothesis that was deduced from the pilot data. None of the data from these critical experiments, which challenge the paradigm, can be subject to data selection bias.

The Harvard Medical School Guidelines,[10] from Investigators in Scientific Research, provide a brief and clearly-stated set of useful laboratory practices. Brief, formal courses in proper scientific method need to be established in each institution to address proper scientific data management. Both new and more seasoned investigators should be required to take these courses at intervals in their careers.

"Peer Review—Success or Failure," Hiram C. Polk, Jr., MD, chief editor, *American Journal of Surgery*, professor and chairman, Department of Surgery, University of Louisville. Misrepresentation in science is a long-standing issue that troubled Huxley, among others, nearly 150 years ago. How prevalent such misrepresentation is depends on its definition. If you include certain areas that I personally think are somewhat grey, as opposed to black, misrepresentation is very prevalent. If you look at the issues that are out-and-out fraudulent or intended to deliberately mislead, then misrepresentation represents as little as 2% to 3% of research effort and probably a much smaller percentage among surgical scientists.

An assumption exists that much of this misrepresentation is related to a publish or perish atmosphere and is concentrated among young physicians who need to produce to climb an "academic ladder." As a matter of fact, equal numbers of identifiable episodes of scientific fraud occur in the biomedical community among senior, well-established individuals, who are no longer tenure-hungry assistant professors.

The capability of the peer-reviewed medical journal process to identify fraud is most limited, particularly if the data presented are internally consistent. This has been addressed by others, and it would be extraordinarily unlikely for the editorial review process of most surgical journals to identify experiments that were never done or results that were "adjusted."

Some issues regarding coauthorship, however, can be addressed in a more definitive manner. The tendency to include honorary authorship for everyone who has passed through a laboratory or carried a chart in a project is more prevalent in some institutions than others. The recent hue and cry by the popular press over a distinguished scientist who finally had to admit that he had relatively little knowledge of a particular experiment that likely is imperfect and of which he was a coauthor is a case in point. Increasingly many journals are going to adopt the posture being established by the *Journal of the American Medical Association* that requires coauthors to accept written personal responsibility for the conducting of the experiments, interpretation of data, and general reliability of the work. These kinds of public disclaimers are moving forward in a constructive way, and I suspect they will increase paperwork but not become a major handicap to most active laboratories.

The review process for a paper submitted to a journal is typically understood by most of the people in this audience. Some concerns exist about bias toward young versus established investigators and institution A as opposed to institution B. As a matter of fact, a number of trials have been done to see if this is true, and much of the data are somewhat conflicting. No clear trend indicates a bias based on institutional affiliation or seniority of the author. Given the amount of time devoted to the process of peer review, it may be disconcerting to realize that something on the order of 85% to 90% of papers submitted to a very high-quality journal ultimately get published somewhere.

Within recent years importance has been been focused on the entire issue of peer review in monograph form by Stephen Lock,[11] the editor of the *British Medical Journal*, and by the recent International Congress on Peer Review in Biomedical Publication held in May 1989.[12] The congress was a most worthy undertaking, and its proceedings will deserve attention and careful scrutiny.[13] I might summarize some of the concepts presented, as I heard them, in the following comments:

First, peer review, like democracy, is an imperfect process. The real issue is to devise something better. Duplicate publications, in one fashion or another, have been studied in depth by Byron Bailey[12] in the surgical field of otolaryngology, and, again, it is a matter of grey versus black. The tendency to segment work, so-called "salami slicing," is fairly common. On the other hand, fewer than one third of those apparent duplications appeared deliberate efforts to conceal previous work, whereas two thirds of the duplications generally reflected previously published related work, by the same author(s), in a fair and honest fashion in their references. The segmentation issue is a tough one, and tiny

variations on a theme do magnify the doubt of the surgical-editorial community regarding an individual's work. Indeed, the very group that a young surgeon may be most anxious to impress includes those who become most alert to such conduct.

Mundane issues, and I believe they are mundane, related to precise reference accuracy and statistical validity will be refined over the years ahead to increasing levels of reliability. The obligations of coauthorship, even as we speak, are rapidly escalating; one must, as is so often the case in American medicine, only look to the courts to see the remarkable example of product liability in which one publisher of air route maps is being held liable for an erroneous publication that may have led to an airplane crash and a death. I cannot see this happening in the short term to the surgical literature and to our biomedical journals. On the other hand, a single precedent-setting award could overturn that sense of fairness.

To encourage critique, anonymity of reviewers seems wise; the same process applied to authorship does not appear to alter the acceptability of manuscripts; most journals openly provide such information to reviewers. My conviction is that few people try to magnify the surgical world's impression of their work by repeated publications of strikingly similar material. I would suggest that in the broad field of general surgery, those individuals represent about 2% of the academic community and only a slightly larger proportion of submitted work. Most authors are extraordinarily conscientious and bend over backwards to reference their own work, related material, and often, in covering letters, call the editor's attention to such similarities and stress how the currently submitted manuscript may be different.

I would interpret this entire movement toward accurate publication as a substantial step in the right direction and feel that, although peer review will always remain imperfect, it will surely continue to be refined further over the intermediate term.

"Office of Scientific Integrity—National Approach to Quality Assurance," Barbara Williams, PhD, senior scientist, Office of Scientific Integrity, National Institutes of Health, US Public Health Service. The Office of Scientific Integrity was established in 1989 in response to concerns from Congress, the press, and the scientific community that the existing system for investigating allegations of scientific misconduct was not effective. The Office of Scientific Integrity (OSI) was created to monitor, and, if necessary, conduct inquiries and investigations into allegations of scientific misconduct in research and in research training supported by the Public Health Service. Additional missions are to promote the responsible conduct of science by mutual cooperation between the OSI and research institutions, to enhance the quality of research and research training, and to lower the incidence of scientific misconduct. It is our belief that by inculcating the principles of responsible conduct of science and rigor in adhering to these principles, early in research careers, the occasional but extremely unfortunate and expensive instances of scientific misconduct can be lowered. We hope to foster an environment that lessens cutting corners, the "little sins" of research. Our fundamental principle is a commitment to truth: letting data speak for themselves, keeping an empirical mind, and telling it all, as messy as it may seem. Science is a process of discovery. If a researcher's view of data is colored, that researcher will miss what is being revealed and may mislead others. It is essential to plan education and prevention programs and to develop standards in many related areas, including data retention and authorship practices.

The NIH are developing internal policies and procedures. The Assistant Secretary for Health, Dr. James Mason, is personally interested in drafting this document, and our internal policies will be available as a model for other institutions in the near future.

The OSI uses scientists as case workers. This ensures a basic understanding of the scientific model underlying the issues. We are proactive, but we consider ourselves colleagues with the scientific community. We feel that misconduct in science is properly a professional scientific matter. The primary responsibility for conducting inquiries and investigations and for establishing preventive programs lays with the institutions. Several studies and models may be used in developing programs for the responsible conduct of science; some of these are the "Report on Responsible Conduct in Research in Health Sciences,"[14] the Association of American Medical Colleges' "Framework for institutional policies and procedures to deal with misconduct in research,"[15] and a book by Sigma Xi, "Honor in Science,"[16] which we recommend dispersing to junior members as they come in laboratories.

The *Final Rule*,[9] 42 CFR Part 50, was published in the *Federal Register* on August 8, 1989, and was republished in the *NIH Guide for Grants and Contracts* in September 1989. It is the document that sets forth the responsibilities of awardee institutions for dealing with and reporting possible misconduct in science. This document provides that all institutions that apply for Public Health Service research funds submit an assurance to the OSI that adequate procedures and policies are in place for dealing with allegations of misconduct in science.

The definition of scientific misconduct in the *Final Rule* is "fabrication, falsification, plagiarism, and other practices that seriously deviate from those that are com-

monly accepted in the scientific community for the proposing, conducting, and reporting of research." This definition explicitly excludes honest scientific error and differences in interpretation of data. It also excludes animal and human welfare issues, which are covered by the Office for Protection from Research Risks, and financial concerns, which are also handled by another office. Because the OSI is responsible for administrative investigations, the definition does not use the term *fraud*. It is possible, however, that criminal prosecution can follow from a case.

The *Final Rule* provides for a two-step process, which generally begins at the institution. When an allegation of scientific misconduct is received, the institution has a 60-day period in which it must conduct an inquiry to determine whether there is substance to the allegation. If a full investigation is warranted, it must be completed within 120 days. The principles in the *Final Rule* for conducting inquiries and investigations include thoroughness, fairness, timeliness, and objectivity. The standard for thoroughness is extremely rigorous. The principle of fairness is for both the person who has brought forth the allegations and for the subject of the inquiry and investigation. Once allegations of scientific misconduct have been brought to the attention of the institution, certain procedures are initiated to ensure a proper investigation and to protect the involved individuals. These procedures include immediate data acquisition, strict confidentiality, and the promise of a complete investigation.

All potentially relevant primary material must be secured immediately on receipt of an allegation. It is helpful to remember that, if the work was performed with the support of the Public Health Service, the institution has primary responsibility for the data. Thus, the institution has not only the right but the responsibility to secure the data. This ensures the integrity of the data for examination and protects the investigator from any charge of altered data. The investigator has, of course, the right to reasonable supervised access, but the primary data must be held at all times under custody of the institution. Another issue to consider is the role of attorneys in the inquiry and investigation process.

Confidentiality for all involved individuals, both the person who came forth with the allegations and the subject of the inquiry and investigation, is of prime importance during this process. Attention must be paid to their particular vulnerabilities within the institution, especially during the inquiry and investigation. If a finding of misconduct occurs, proper disclosures may be in order. If no misconduct is found, individuals must be properly protected. In the latter case, if, for some reason, confidentiality has been breached, there may be a necessity to take action to clear the names of the people involved.

The OSI adheres closely to the principle that, once an allegation of scientific misconduct is made, the process must be completed; no bargains may be made, no signed agreements may be made to drop the case. It must be pursued to the end, even if the subject of the inquiry or investigation moves to another institution.

The person bringing the allegations, those persons who conducted the research, and those persons who have relevant knowledge of the research or of the suspected misconduct must be interviewed. The proceedings of the investigation must be documented in detail. We recommend that all interviews be taped and that a copy of the transcript or the relevant portion of the transcript be provided to the interviewees for comment. One of the final requirements of the OSI process is that individuals be provided with the portion of the report that describes their involvement and that they have an opportunity to comment. A word-by-word transcript is the best documentation of the proceedings for deliberation; it is very difficult for an interviewee to argue with a transcript.

It may be difficult for the members of the investigational panel to determine misconduct. For instance, improper data selection may not render a clear-cut judgment of misconduct. The administration of the institution may need to take the lead in making the final determination.

Lastly, the report must come to the OSI. The OSI has rigorous standards regarding the report and may need to ask for further information or documentation after the report is received. The staff of the OSI can, in certain ways, assist individuals and institutions faced with an allegation of scientific misconduct: extramural expert consultation, planning assistance for the inquiry or investigative process, and interinstitutional coordination in the event that an investigator has moved to or collaborated with researchers at other institutions.

If the OSI has questions about a case, we will work with the institution toward resolution. When our questions are satisfied, the OSI will forward a report of an investigation, with any recommended Public Health Service sanctions, to the head of the appropriate agency, who then forwards the agency recommendation to the Office of Scientific Integrity Review. Decisions about sanctions are made by the Assistant Secretary for Health, unless the recommendation is for debarment, in which case it is forwarded for a debarment hearing. We wish to work together with research institutions to prevent misconduct and to fairly resolve allegations of misconduct, when they arise.

SUMMARY

The symposium was concluded with a question and answer period, which served to clarify and further emphasize the aforementioned issues. Many concerns of coauthorship responsibilities, due process, and potential sanctions were discussed. Moral and ethical issues reflecting the extent of punishment, reporting of misconduct to hospitals and specialty boards, and the almost assured litigation and counter-litigation were approached with considerable apprehension and concern.

Misconduct in science will clearly be monitored more closely than in the past. Increasing coauthorship responsibility, conscientious senior investigator supervision, and institutional cooperation will provide the framework to discourage dishonesty in science and encourage proper educational development of both young and established investigators in a milieu of scientific integrity.

This summary was prepared by Constantine Mavroudis, MD.

REFERENCES

1. Broad W, Wade N. Betrayers of the truth: fraud and deceit in the halls of science. New York: Simon and Schuster, Inc, 1982.
2. Kohn A. False prophets: fraud and error in science and medicine. Oxford: Basil Blackwell Ltd, 1986.
3. Dworkin G. Fraud and science. In: Berg K, ed. Research ethics. New York: Alan R Liss, Inc, 1983:65-74.
4. Culliton BJ. Emory reports on Darsee's fraud. Science 1983;220:936.
5. Engler RL, Covell JW, Friedman PJ, Kitcher PS, Peters RM. Misrepresentation and responsibility in medical research. N Engl J Med 1987;317:1383-9.
6. Relman AS. Fraud in science: causes and remedies. Scientific American 1989;260:126.
7. Koshland DE Jr. Fraud in science. Science 1987;235:141.
8. Marwick C. Congress puts pressure on scientists to deal with difficult questions of research integrity. JAMA 1989;262: 734-5.
9. Dealing with and reporting possible misconduct in science. Public Health Service, US Department of Health and Human Services. Federal Register 1989;54:32446-51.
10. Harvard Medical School Guidelines. Cambridge, Massachusetts: Investigators in Scientific Research, February 16, 1988.
11. Lock S. A difficult balance: editorial peer review in medicine. Philadelphia: ISI Press, 1986:172.
12. Guarding the guardians: discussion on peer review. The First International Congress on Peer Review in Biomedical Publication [Abstracts]. Chicago: American Medical Association, May 1989.
13. Guarding the guardians: research on editorial peer review. Selected proceedings (30 articles) from The First International Congress on Peer Review in Biomedical Publication. JAMA 1990;263:1317-1441.
14. Report on responsible conduct in research in health sciences. Bethesda: National Institute of Medicine, Public Health Service, US Department of Health and Human Services, 1989.
15. Framework for institutional policies and procedures to deal with misconduct in research. Washington, DC: Association of American Medical Colleges, March 1989.
16. Honor in science. New Haven, Connecticut: Sigma Xi, The Scientific Research Society, 1986.