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Research Misconduct and the Physical Sciences

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ABSTRACT: Research misconduct includes the fabrication, falsification, and plagiarism (FFP) of concepts or ideas; some institutions have expanded this concept to include "other serious deviations (OSD) from accepted research practice." An action can be evaluated as research misconduct if it involves activities unique to the practice of science and could negatively affect the scientific record. Although the number of cases of research misconduct is uncertain (formal records are kept only by the NIH and the NSF), the costs are high in integrity of the scientific record, diversions from research to investigate allegations, ruined careers of those eventually exonerated, and erosion of public confidence in science. Currently, research misconduct policies vary from institution to institution and from government agency to government agency; some have highly developed guidelines that include OSD, others have no guidelines at all. One result has been that the federal False Claims Act has been used to pursue allegations of research misconduct and have them adjudicated in the federal court, rather than being judged by scientific peers. The federal government will soon establish a first-ever research misconduct policy that would apply to all research funded by the federal government regardless of what agency funded the research or whether the research was carried out in a government, industrial or university laboratory. Physical scientists, who up to now have only infrequently been the subject or research misconduct allegations, must none-the-less become active in the debate over research misconduct policies and how they are implemented since they will now be explicitly covered by this new federal wide policy.

KEY WORDS: Scientific misconduct, physical sciences, and public policy.

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Science plays a key role in providing economic prosperity and improved quality of life. The validity of the scientific knowledge-base is essential to both the researchers whose work builds on its foundation and the society which supports and benefits from the accumulated knowledge. The scientific enterprise is currently being challenged by growing public concerns over the ability of the science community to maintain the integrity of the research record. High profile cases of scientific misconduct (also known as research misconduct) played out in the mainstream press have promulgated the notion that the science community's self-policing system is seriously flawed. These cases can lead to a serious deterioration of the public's trust and could result in a fundamental change in how scientific research is monitored and its contributions measured. Also, as the current case involving the validity of a well-utilized carbon dating method has shown, a single case of research misconduct could potentially undermine the results of an entire discipline.

Reported cases of research misconduct are scarce in the physical sciences and therefore many scientists in the field are either unaware of or uninterested in the issues surrounding the research misconduct debate. While most researchers in the physical sciences are already likely subject to their institution's policy on research misconduct, few are aware of the policies and procedures involved in handling an accusation of research misconduct. Processes for the inquiry and investigation of an allegation of research misconduct can include the confiscation of data, equipment, and notebooks, essentially halting the progress of the accused's research. Research funds may be frozen and colleagues and collaborators may be interviewed. Though rarely invoked, sanctions for research misconduct include the retraction of archival research papers, the public reporting of the researcher's name along with case details, and debarment from obtaining federal funds for a specific time period.

Adding to the complexity of this scenario is the fact that currently there is neither a federal-wide definition of research misconduct nor principles that would underlie the implementation of a federal misconduct policy. The result is federally-sponsored investigators are in the precarious situation of not knowing exactly what constitutes research misconduct and how such an allegation would be handled. As a substantial supporter of research, the federal government has a clear role in developing policies that insure both the integrity of the research record and the fair and uniform treatment of investigators supported from all government agencies. The concern over the current lack of a federal-wide misconduct policy was recently addressed by the President's National Science and Technology Council (NSTC) which charged an inter-agency panel to formulate a common definition and principles for

assurance and oversight. Their recommendations will soon be released to the scientific community and will form the basis for a new federal regulation on the conduct of science.

Physical scientists should remember that scientific misconduct allegations of various types have been leveled at some of the great scientists of the past, such as Galileo, Newton, Dalton, Mendel, Milkan, and Einstein, who have been charged with fabricating data, falsifying data and plagiarism (Broad and Wade 1982, Corry et. al. 1997). The potential will soon exist for any federally funded scientist to be called before a panel of peers who have been asked to look into an allegation of scientific misconduct that has been leveled against him or her. Physical scientists must become more knowledgeable about how scientific misconduct policies and procedures are put into practice. The purpose of this paper is relate the key issues in the research misconduct debate and to discuss the ramifications of a federal-wide policy on the physical sciences community.

What is research misconduct?

Research misconduct usually refers to "FFP" or fabrication, falsification, and plagiarism. Fabrication is the making up of data or concepts, falsification is the manipulation or altering of data and concepts such that the reported results do not accurately reflect the research that was conducted, and plagiarism is falsely representing the ideas or words of another as one's own. Significantly, most definitions of research misconduct also explicitly state that research misconduct does not include "honest error or honest differences in interpretations or judgments of data" (42 CFR Part 50). By excluding "honest mistakes" from definitions of research misconduct, the federal government and research institutions are correctly acknowledging that there is a fundamental distinction between error (a healthy and natural part of the research process) and deliberate acts intended to mislead others.

We propose the following standard be used by scientists, federal and institutional research misconduct officials and others to determine whether an act is research misconduct or not. The standard is it to query whether the misbehavior is a) unique to the practice of science and b) could directly and negatively impact the integrity of the scientific record. [1] The importance of this standard can be seen by examining a hypothetical case in which a scientist is accused of tampering with or destroying another scientist's ongoing research. Evaluated by the above standard, we would conclude that "tampering" is not

[1] We define the "scientific record" as the research outcomes that embody the known facts of a scientific inquiry, and includes, for example, journal articles, research proposals, theses, and scientific presentations.

scientific misconduct because people in many walks of life have been known to commit acts of vandalism. It is also not scientific misconduct because vandalism does not directly impact the scientific record, rather the impact here is likely to be a secondary order impact relating to the opportunity cost of having to repeat experiments or rebuild damaged apparatus. This second point is important. Vandalism and tampering are likely to result in wasted time, wasted resources, and a delay in the dissemination of research results. While reprehensible, this is not as direct an assault on the integrity of the scientific record as injecting falsehoods would be. The exclusive focus of institutional and federal scientific misconduct policies should be to protect the integrity of the scientific record. As we will explain shortly, there are other mechanisms that should be relied upon to deal with all other misbehaviors that occur in research settings.

Federal Definitions of Scientific Misconduct

The Public Health Service defines Misconduct in Science as "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." (42 CFR Part 50)

The National Science Foundation defines Misconduct in Science and Engineering as "fabrication, falsification, plagiarism or other serious deviations from accepted practices in proposing, carrying out, or reporting results from activities funded by NSF, or 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." (NSF 1997b)

The core definition of FFP has been adopted by many research institutions because it is seen as encompassing the most serious and the most prevalent acts of research misconduct. Currently there is no uniform, federal-wide policy on research misconduct, and the specific language on the definition of research misconduct varies across agencies and research institutions. While the core of most definitions includes FFP, the Public Health Service (PHS) and the National Science Foundation (NSF), the two agencies which collectively have the most experience in carrying out a research misconduct policy, have extended their definitions to include "other serious deviations from accepted practices" as an additional form of research misconduct. Those that favor this additional clause explain that the "other serious deviations" (OSD) clause sets the community standard by which behavior can be deemed true research misconduct (NSF 1997a). Moreover, it has been argued that this OSD cause is needed "because it is impossible to predict and list all the unethical actions that might warrant (federal) agency action" (Goldman and Fisher 1997).

The National Academy of Sciences (NAS) contends that the OSD clause is ambiguous and may

allow the misinterpretation of actions that are legitimate and more in the realm of creative but slightly unorthodox research practices, rather than dishonest scientific practices (NAS 1992, Schachman 1993). Many in the scientific community have argued that scientists might forego planned research for fear of running afoul of this extremely vague OSD clause (Goldman and Fisher 1997). While the OSD clause has never been invoked at PHS, it was used by the NSF in a case involving recurrent sexual harassment by an NSF grantee (NSF 1991). Although this is an isolated case, it demonstrates the concern that actions punishable by existing law will be treated under the OSD clause as research misconduct cases rather than being handled through the appropriate channels with the appropriate sanctions. Furthermore, as this case amply demonstrates, focus on safeguarding the scientific record can be lost using the OSD clause, thus diverging from the fundamental purpose of scientific misconduct policies.

Defining research misconduct as FFP does not obviate the possibility that other regrettable behaviors cannot happen in a research setting. Scientists can also engage in what can be termed professional misconduct, which can include authorship disputes, conflicts over laboratory space, sloppy recordkeeping, etc. Scientists can also engage in general misconduct, which encompasses activities covered by existing law and includes theft, embezzlement, and sexual harassment. What differentiates research misconduct from professional misconduct and general misconduct is that only acts of research misconduct are likely to cause damage to the scientific record. And it is because of possible damage to the scientific record that scientific expertise will need to be brought to bear to assess the allegation of research misconduct. As noted by Woodward and Goodstein (1996), "Only a panel of scientists can deal with matters such as data fabrication that require a detailed understanding of the nature of the experiments, the instruments used, accepted norms for presenting data and so on to say nothing of the unique importance of experimental data in science."

Another characteristic that differentiates professional misconduct, general misconduct, and research misconduct is the organization responsible for dealing with the actions. Acts of professional misconduct do not *directly* affect the integrity of the research record and are therefore best handled at the institutional level with one-on-one interventions between the parties involved. General misconduct such as sexual harassment clearly falls under the jurisdiction of existing state and federal laws, statutes and regulations and should be handled through the court system. Research misconduct, on the other hand, represents a shared responsibility between various sectors, including the federal government that funds the research, the research institution that creates an atmosphere where integrity is fostered, and

professional societies that have the responsibility of promoting proper research practices. But, most importantly the responsibility for preventing research misconduct from taking place and dealing with allegations of research misconduct when they do arise rests with each and every scientist and engineer.

The evolution of the handling of research misconduct allegations

While descriptions of scientific misconduct can be found stretching back at least as far as Charles Babbage's 1830 *Reflections on the Decline of Science in England* in which the inventor of the forerunner of modern computer's described "trimming, cooking, and forgery" as forms of scientific misconduct prevalent at the time, modern concern over this issue and the drafting of federal policies and procedures to deal with the problem stem from the early 1980s (Broad and Wade 1982). Scientific misconduct first came to the public's and Congress' attention in 1981 with the public disclosure of four major acts of scientific misconduct at large US research centers the year before. Before that time, allegations of scientific misconduct were typically handled very quietly and informally by research institutions (ORI 1997a).

After the public disclosure of these acts and subsequent congressional hearings, the federal government and many research institutions began to draft policies on scientific misconduct. Research misconduct guidelines at US research institutions (i.e., university, federal, not-for-profit and industrial research laboratories) were developed in large part in response to two forces: (1) the institution had recently been caught up in the *ad hoc* handling of an allegation of scientific misconduct and understood that well defined policies and procedures would be in the best interest of all involved and (2) the institution desired to be in compliance with the PHS and/or NSF research misconduct policies that were adopted in the late 1980s (Shore 1995). With respect to the second point, these federal agency policies require that research institutions adopt the agencies' definition of scientific misconduct and have their own misconduct policies and procedures in order to remain qualified for funding. (See for example, 42 CFR Part 50.)

Given the pervasiveness of NSF and NIH research funding, most large research institutions in the US may be assumed have some type of research misconduct policy in place, with an accompanying definition of misconduct and principles for implementation. The research misconduct policy would typically cover all of the institution's research staff regardless of the source of any individual's research funding. However, many smaller research organizations, and, as noted earlier, some federal agencies

currently have no policies, and hence no experience, in dealing with accusations of misconduct (ORI 1997b). This lack of uniformity in the coverage of these policies and the differing institutional definitions employed has led to much concern and confusion in the scientific community with recurring debates about what constitutes research misconduct, who is covered by these policies, what specifically will occur during a misconduct investigation, and what will be the resulting sanctions.

Prompted by concerns over the way these policies were being implemented at local research institutions, and specifically, the publicity brought about by several high profile cases of misconduct in the biomedical field, reported cases of "whistleblower retaliation," and widespread displeasure with the way in which the Department of Health and Human Services (DHHS) Office of Research Integrity was handling investigations of alleged research misconduct, Congress, through the NIH Revitalization Act of 1993, charged the Commission on Research Integrity (CRI) to formulate new research misconduct policies for the DHHS. In its November 1995 final report, CRI rejected the FFP definition and greatly expanded the role the federal government would play in handling allegations of research misconduct. CRI endorsed what it claimed to be a more legally enforceable definition of research misconduct which it defined as "misappropriation, interference and misrepresentation." The terms were made intentionally broad and were meant to be tested over time using a case law approach. That is, under the proposed policy, allegations of research misconduct would be tried in reference to previous precedent rather than judged solely on merit of the case's technical considerations, which is a system for assessing the truth that is more in line with the nation's legal system than with the practice of science. The report also called for a proactive federal role, including on-site visits to research institutions even in cases where there has been no allegation of misconduct made (CRI 1995).

The report's ambiguous definition of research misconduct coupled with an expansive government role raised concerns that the implementation of the Ryan report recommendations would hinder rather than promote the process of scientific inquiry. For example, Dr. Ralph Bradshaw, President of the Federation of American Societies for Experimental Biology, noted that CRI's assertion that "interference" with another's career is misconduct would "turn journal reviewing and grant reviewing into chaos." Bradshaw notes that under this definition a reviewer could be open to lawsuits and federal research misconduct proceedings merely for giving "a bad review or not citing a researcher's work in my journal." (Burd, 1995) Because of concerns like this, the CRI report received a great deal of criticism from many sectors of the scientific community when it was released in late 1995 and it has yet to be

formally adopted or rejected by DHHS. However, this does not mean that this report and its recommendations are moot and therefore are not something to be concerned with. One of the major recommendations in the CRI report was the Commissions' belief that their report could (and perhaps should) serve as the basis for a federal-wide scientific misconduct policy. Physical scientists should ask themselves if they are willing to live under this policy.

Another recent and troubling development in the handling of allegations of research misconduct has been the use of the federal False Claims Act as a vehicle for bringing acts of research misconduct before the nation's federal court system. The Act's *qui tam* provision allows any person with the knowledge of false claims or fraud against the government to bring a lawsuit in his or her name (the US government can join the suit if it believes the claim of fraud to be meritorious). The Act allows for the collection of trebled damages with up to 30 percent of these damages going to the person who originally brought the suit. Since 1986, the *qui tam* provision has been used to recover $1.13 billion for the US Treasury, with most of these cases involving fraud carried out by defense contractors and health care fraud (Budeiri 1996). However, allegations of scientific misconduct are increasingly being pursued via the Act.

The first application of the False Claims Act to a case of scientific misconduct was in 1994 and involved allegations of data falsification on NIH-supported research into the immune system's response to burns. In this case two universities, the University of California at San Diego and the University of Utah, paid $1.5 million in damages with 15 percent of the damages going to the whistleblower (Hoke 1995). A more recent application of this law to a research misconduct case occurred in the summer of 1997 when the University of Michigan was ordered to pay $1.67 million in damages to a research psychologist formerly employed at the university. This case, which centered on allegations that coworkers plagiarized the whistleblower's work to win a federal grant, resulted in the largest False Claims settlement to date for an act of research misconduct (Hilts 1997).

In these False Claims Act research misconduct cases, the primary goal of the proceedings is to determine if the government has been defrauded and if it has to recover funds that were fraudulently obtained. In hearing these cases, the courts have not been interested in protecting or restoring "the integrity of the scientific record," which is purportedly the aim of federal and institutional research misconduct policies. Moreover and of particular concern to the scientific community is that the lure of recovering a significant fraction of the trebled damages might induce whistleblowers to bypass their

institution's mechanisms for resolving scientific disputes (including research misconduct) in favor of filing a case in civil court. As Burk noted, "By substituting a financial incentive for the self-policing norms of the scientific community, this statute promises to have a negative impact on the way scientific research is conducted." (Burk 1996). Others have noted that the financial penalties associated with these *qui tam* suits will act as a "perverse incentive" for research institutions to not conduct thorough and in-depth investigations under their institutional scientific misconduct policies for fear of having any information of wrongdoing uncovered being used as the basis for a *qui tam* suit. In this sense, many feel that the Act's *qui tam* provisions will "undermine rather than strengthen science's capacity to police itself" (Hoke 1995).

How common is research misconduct?

It is difficult to know with any precision what the actual occurrence of research misconduct is within the large body of science conducted annually in the United States. However, we can consult data on federal misconduct cases published by the NSF and the DHHS National Institutes of Health (NIH), the two federal agencies that have the most experience and the most developed infrastructures for dealing with scientific misconduct. In FY1996, the NIH had close to 100 "active cases" looking into alleged acts of research misconduct. Seventeen individuals were found to have committed scientific misconduct, while using NIH research funds in 1996 (ORI 1997b). In that same year, the NSF had approximately 70 active cases and found approximately six individuals guilty of scientific misconduct (authors' tabulation from data in NSF 1996a,b,c). Therefore in 1996, nearly 200 scientists were under suspicion by the federal government for possibly committing scientific misconduct and at least 20 scientists were found to have committed research misconduct and were assessed penalties by the federal government that most likely ended their carriers as researchers. How many of these scientists were physical scientists and how prevalent are these allegations in the physical sciences?

Unfortunately at present, it is simply impossible to estimate what the prevalence of research misconduct within the physical sciences. This is due to the fact that the agencies that fund the majority of physical science research (e.g., the Department of Energy, the Department of Defense) do not have functioning scientific misconduct policies. That is, acts of research misconduct are not being reported to the federal agencies that fund the majority of physical science research, and these agencies are not investigating these allegations and reporting them to the public.

While we can not quantify the prevalence of scientific misconduct in the physical sciences, we note that many of the circumstances and drivers that seem to foster research misconduct in NSF and NIH funded research are also present in the physical sciences. Researchers who commit research misconduct tend to be experiencing career pressure, are overconfident about the scientific conclusions their yet-to-be completed research will yield, and or work in fields where individual experiments are not expected to be precisely reproducible (Goodstein 1996). We note that to a greater or lesser extent these pressures are felt by all scientists regardless of what type of institution they work for or what type of research they conduct, and therefore, we conclude that no one knows the true magnitude research misconduct in the physical sciences. It is certainly higher than zero. How much higher is unknown. Moreover, exactly how high the incidence is we believe largely unimportant and beside the point; research misconduct is a problem that affects all of science and it is therefore a problem that impacts the physical sciences.

The Costs of Scientific Misconduct

The costs of allegations and acts of research misconduct can be tabulated in ruined careers, lost reputations of accused but exonerated individuals, and a loss of public trust in science. For example, in a 1996 study of the consequences of *erroneously* being charged with scientific misconduct, 60 percent of the accused reported some form of negative consequence on their careers with 17 percent reporting "severe consequences" including termination of employment. Only 25 percent of those interviewed were satisfied with steps the research institution took in an attempt to restore their damaged reputations, e.g., doing something as simple as notifying coworkers that the charges were unfounded (Laubin et. al. 1996).

Perhaps the most famous instance of a scientific misconduct case gone awry involves Nobel Laureate David Baltimore and his colleague Thereza Imanishi-Kari. It took Imanishi-Kari a full decade to finally clear her name of charges of data falsification that were zealously investigated by the DHHS Office of Research Integrity. The investigation of the charges against Imanishi-Kari involved 10 separate investigations, including investigations at the research institutions where she worked, Congressional hearings, two investigations by the Secret Service, multiple investigations by the PHS Office of Research Integrity and a preliminary investigation by the US Attorney's Office (Kevles 1996). Only after 10 years and 10 investigations was Imanishi-Kari finally able to present her evidence and question her accusers in a hearing that overturned and laid to rest the earlier findings of research misconduct. Imanishi-Kari believes that a fundamental lack of due process in the procedures that were used to investigate these

charges is a primary reason why it took so long to resolve these allegations and therefore why the costs to her research career were so high (Beardsley 1996). Imanishi-Kari's case might be one of the best known, but others have suffered through decade-long investigations only to be later exonerated of all charges of scientific misconduct.

The guilty also pay a high price for acts of scientific misconduct. The most common punishment that the federal government levies against those who have been found guilty of scientific misconduct is to debar the individual from receiving further federal research funding. This debarment period typically last for three years though debarment periods of less than three years and up to ten years have also been meted out depending on the seriousness of the transgression (ORI 1996a). The federal government can also prohibit those found guilty from serving on federal peer review panels and advisory boards and can also seek the retraction of tainted articles in addition to other measures. It is important to note that these punishments are federal wide in scope (i.e., a person found guilty by one agency cannot seek funding from other federal science agencies for the duration of the debarment period). These punishments are also made public by posting the guilty party's name in the Federal Register, and, in the case of the PHS, the guilty party's name and details of the case are posted on an easily accessible world wide web site.[2]

"Science" also pays a high price for the occasional act of scientific misconduct. We believe quite fervently that even one high profile case can cause significant damage to a whole field of inquiry and that is why all scientists must take this issue seriously. For example, recently, there have been serious allegations that have been brought forward and played out in some of the most prestigious scientific journals relating to the validity of a particular carbon dating technique and more than a decade's worth of published research results that were in part based upon using this technique to establish the age of particular formations and artifacts (Beck, et. al. 1998 and Dalton 1998). These allegations whether they are substantiated or not have most likely permanently discredited what was an important experimental technique and have likely discredited the work of many in this field. It is for this reason that we maintain that regardless of the incidence (whether it be 1 case/year or 100 cases/year), research misconduct must be seen as something that affects all aspects of science and that therefore affects all scientists.

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[2] The Public Health Services Administrative Actions Listing world wide web page can be found at http://silk.nih.gov/public/cbz1bje.@www.orilist.html

Conclusion: Research Misconduct and the Physical Scientist (i.e., You)

Since the first scientific misconduct procedures were issued by NIH and NSF more than a decade ago, there has been widespread and nearly continuous disapproval of how research misconduct is defined and how these policies have been implemented. Prestigious panels have examined the situation and recommended improvements. Yet problems still persist and perhaps things are actually getting worse with the advent of *qui tam* research misconduct cases. In response to this situation, the White House Office of Science and Technology Policy has announced that it will soon finalize a first-ever federal-wide research misconduct policy (Francis 1998). This policy would apply to every single research project funded by the federal government and to every scientist and engineer that is supported – even in part – by federal research funds. This policy will most likely affect you.

We have shown that research misconduct cases and allegations of research misconduct are extremely damaging to all involved. Research misconduct is in fact damaging to all researchers even if we are not directly involved in a case, because each case reduces the public's trust in science and erodes the integrity of the scientific record upon which our economic health, national security and personal and environmental wellbeing are built upon. With the advent of this coming federal-wide research misconduct policy, the potential will soon exist for any federally funded scientist to be called before a panel of peers who have been asked to look into an allegation of scientific misconduct that has been leveled against him or her.

We believe much can be learned from the past decade's experience in handling allegations of research misconduct and that this knowledge should be applied to the proposed federal-wide policy. For example, it is clear that well thought out misconduct policies and systems for handling and assessing allegations of research misconduct can work to strengthen science. On the other hand, the costs paid by scientists from allegations or acts of scientific misconduct are often magnified by the misapplication of vague institutional research misconduct policies. As CK Gunsalus, associate vice chancellor for academic affairs at the University of Illinois, observes, individuals with concerns or suspicions about possible acts of scientific misconduct will utilize institutional research misconduct policies only to the extent that the individual believes that the policy and those charged with implementing them will give their concerns a fair hearing. If these concerned individuals do not trust their institution's in-house mechanisms, they will turn to external mechanisms. Increasingly, the external mechanism of choice is the False Claims Act's *qui tam* provisions, a law never intended to cover scientific misconduct (Hoke 1995).

Before this situation deteriorates further, scientists must step forward and take ownership of this issue and their responsibility to police themselves. The present situation -- characterized by competing definitions of research misconduct, differing or lacking policies, and administrative and legal procedures that do not focus on the integrity of the scientific record -- needs to be remedied through scientific leadership. That these polices are needed is perhaps a necessary evil, but that does not mean that scientists can be complacent about this situation.

The longer the scientific community fails to take care of this problem the larger the role played by non-scientists will be in handling and assessing allegations of research misconduct. Time is rapidly running out for the scientific community to assert any control over the shape of these polices. If scientists take a passive stance towards research misconduct, they can be assured that Congress or federal Inspector Generals will step in to fill the void.

The physical science community has so far been fortunate to be relatively untouched by these polices. It would be foolish to assume this will always be the case. The physical science community must become engaged in the dialog about what type of federal research misconduct policy is capable of striking an appropriate balance or be prepared to live with the consequences of inaction. We urge you to become personally involved in shaping the proposed federal-wide research misconduct policy and your institution's policies for dealing with research misconduct.

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