Chapter 16. Scientific Ethics[1]

By Patricia A. Bolton

Scientific ethics, defined as the standards of conduct for scientists in their professional endeavors, covers a broad swath of activities from issues handled by White House advisory groups on topics such as the use of human subjects in research or the appropriateness of patenting genetically modified organisms to peer review, to one-on-one mentoring in individual laboratories. Ethical issues in the news recently have spanned a range of issues – from whether or not to use fetal tissue in research to the appropriate role of private sector sponsorship of academic research. Many professional associations, such as the American Association for the Advancement of Science, Sigma Xi, and the American Physical Society, have established codes of ethical conduct for scientists. However, relatively little of the literature on scientific ethics reflects an organizational effectiveness and management perspective – that is, describing how ethical behavior is encouraged and misconduct is sanctioned by an organization. This review focuses on that portion of the literature that addresses organizational structures and processes related to scientific ethics.

Excellent Science, Excellent Ethics

Ethics is part of the "warrant" for science; that is, science can be excellent only if its practitioners conduct their research in accordance with the accepted practices in their fields. For all scientific fields, ethical behavior includes adherence to the principles and practices of valid experimentation (the scientific method, accurate and sufficient sampling of data, accurate record keeping and reporting, etc.), education and mentoring, unbiased peer and expert review, and communication of results to the scientific community. Thus, over and above the results themselves, excellent science has to pass the ethics test.

Science can be said to be ethical in two different ways:

- *Ethics of the topics and findings (morality):* Ethicists ponder the question of whether science is good or bad, especially in specific arenas of science such as biomedical and other research where human or animal subjects are involved. Also, groups with strong beliefs raise ethical questions when possible uses of the findings or the process for doing the science are in opposition to their tenets. Scientists themselves may raise moral or ethical issues, understanding the potential for harm related to the research process or outcome.
- *Ethics of method and process (integrity):* The process of doing and reporting science has a strong ethical component. It addresses the nature of the design, the experimental procedures, and the reporting of the research effort. The assumption of scientific integrity in carrying out the processes of science is basic to trust among scientists, between society and scientists, and to the credibility of scientific results. The research record is important because it is by examining the inputs to a piece of scientific research that scientists with similar expertise can judge the competence of the research design and the credibility of the findings.

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[1] Related chapters include: Science Policy; Performance Assessment; Organizational Culture; Leadership.

The topic of this review is scientific ethics and the management function of ensuring that scientific research is being conducted carefully and honestly.[2] Scientific integrity, ethical science, and high-value science are entwined, particularly for government-funded science. The literature focuses on the definition of scientific misconduct, the factors contributing to misconduct or enhancing scientific integrity, and the ways the science funding and research community can create or sustain environments in which scientific integrity can thrive.

Fostering Scientific Integrity and Responsible Science

Specific aspects of scientific integrity are determined largely by the scientific community, and vary over time. Persons entering science must learn what is appropriate behavior and what is not. In many settings neophyte scientists learn about practices and behaviors appropriate to their disciplines and research settings by observing more senior scientists on a day-to-day basis. In attempting to achieve high levels of scientific integrity and responsible science, strategies that foster learning and work settings that reinforce desired values and behaviors are powerful complements to strategies that focus on detecting and punishing misconduct. Figure 1 outlines the sources of learning and reinforcement for scientific integrity on the part of individual scientists. These measures provide opportunities for science organizations, as well as those that train scientists, to strengthen the elements of learning and work settings that foster and reinforce scientific integrity. This provides a basis for designing a balanced strategy for promoting

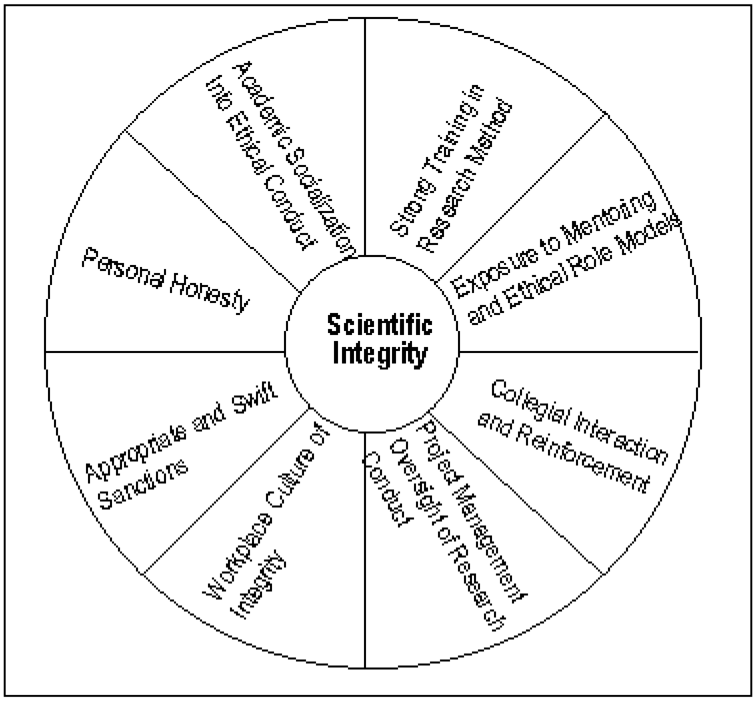

Figure 1. Intervention Points: Forces that Contribute to Scientific Integrity

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[2] This literature is generally quite distinct and focused, with few linkages to the broader organizational effectiveness literature. Related topics in the organizational effectiveness and management literature are business ethics and control functions. Discussion of oversight as an activity is located primarily in the literature on public policy and public administration.

integrity and appropriate conduct, and applying sanctions to discourage misbehavior (e.g., IOM 1989; NAS, NAE, and IOM 1992, 1993, 1995).

The forces behind scientific integrity are social. That is, they are defined and applied through social interaction. The eight forces proposed in Figure 1 can be seen as representing the following categories of influence:

- *Childhood Socialization*. Children acquire their moral sense of what is right and wrong at home and in school. If they learn that it is wrong to lie, cheat, and steal, they can understand and accept professional standards about data falsification, fabrication, and plagiarism.
- *Scientific Socialization*. Scientific education has the responsibility to provide opportunities for student scientists to learn sound research practices and to impart standards of ethical conduct, if not through specific courses, at least through exposure to role models (professors, other students) in the educational setting.
- *Collegial and Professional Norms and Values*. Mentoring is a traditional approach for imparting norms to junior scientists—an "on-the-job" opportunity for observing and practicing good science. As with all professions and occupations, the sub-specialties of science form associations through which scientists with similar training and similar research interests share norms, values, and information. These external professional reference groups may well exert a stronger influence than workplace standards or rules.
- *Workplace Norms, Values, and Incentives*. Most scientists have workplace standards and rules that define responsibilities and accountabilities, including maintenance of the research record and punishments for violations. The attitude toward these workplace standards and rules and the way in which they are managed depend on and are reflected in the workplace culture. By their own behavior and attitudes, the scientific leadership of an organization sets the tone (culture) and signals the importance scientists should place on scientific integrity. Workplaces can provide incentives or rewards for maintaining high levels of scientific integrity, as well applying appropriate and swift sanctions where misconduct has occurred.

These social forces have been examined extensively in the literature on the sociology of occupations and professions and on organizational effectiveness. This literature indicates that the extent to which each of these forces plays a role in fostering scientific integrity will be variable, depending upon the setting. This suggests that these influences on behavior can be designed and applied in a variety of ways and with varying levels of success to reinforce scientific integrity.

Stakeholders in the Scientific Community

Those who have the ability to promote scientific integrity and roles to play in oversight of scientific research and in controlling scientific misconduct include:

- Scientists themselves, who serve not only as practitioners but also as reviewers, colleagues, consumers of other scientists' work, and members of professional associations (Frankel 1993)
- Editors and publishers of scientific articles, who have an interest in being the first to publish ground-breaking science (and who therefore contribute to the pressure on scientists), but also have an interest in enhancing and maintaining the reputation of their publications and institutions

- Research project managers, who both conduct science and oversee the work of other scientists
- Institutional research program officials, who employ the scientists and therefore have direct line responsibility for ensuring compliance with regulatory and contractual requirements and a need to maintain a volume of research that supports those employees and the institutional infrastructure
- Officials in federal and other research funding agencies who commission the research and have responsibility for ensuring that the funds are used effectively and provide benefit.

These stakeholders have both competing and complementary interests. Effective oversight of science requires awareness of the dynamic created by these various interests and the roles they can play in promoting scientific integrity and a commitment to high standards of scientific conduct.

Self-Regulation

Self-regulation plays a major role in identifying and controlling errors and misconduct in science. Professions have traditionally been granted relative autonomy to oversee and correct the behavior of their members; that is, to self-regulate. Science has been of particular interest to scholars of the history and sociology of professions (e.g., Merton 1973; Ziman 1984). Societies are willing to grant autonomy only so long as the members of the profession demonstrate themselves to be trustworthy in regulating themselves, rather than merely furthering the self-interests of group members. According to Guston (2000), the federal government, at least prior to the 1970s, generally trusted the science community to have integrity.

Self-regulation is also seen as possible because the social nature of science creates a self-correcting process that maintains scientific integrity. If science is seen as cumulative and consensual, most typically moving forward in small increments that build progressively on earlier work, other scientists can influence what becomes accepted as valid knowledge and incorporated into the foundation of subsequent work (Bauer 1992; Grinnell 1992). The process assumes that scientific peers will examine the evidence presented by other scientists, and, if they find it not credible, will say so and make the corrected information available to the scientific community as part of the normal course of scientific inquiry.

An important feature of self-regulation is the ability of other investigators to adequately judge the credibility and influence the acceptance of those findings. This feature is important since science comprises a multitude of sub-specialties, each with its own questions, evidence, and settings for establishing evidence, so that no single method can be used to judge all types of science – although the notion of a scientific method as an ideal hovers in the background (Bauer 1992:19-41). Grinnell (1992:47) redefines the notion of scientific method as more of a "scientific attitude" that lies in the thought collective of scientists as a group. The scientific attitude means that "…most scientists do science in ways that they assume will be believable (e.g., publishable, fundable) by other investigators. Even the most basic features of what counts for scientific evidence can change depending upon what kinds of evidence investigators think will be convincing to each other."

The literature on scientific oversight discusses three principal mechanisms that provide this self-correction and serve as the basis of most self-regulation in science (Bell 1992:xiv):

- Peer review (review by specialists of individual proposals submitted for funding, research designs submitted for approval, or research results)
- Refereed publication (review by qualified reviewers of publications, who recommend revision, rejection, or publication of an article)
- Replication of experiments (i.e., other scientists attempting to duplicate the same experiment to see if the same outcome can be achieved).

Types of Problematic Behavior: Mistakes, Unethical Behavior, Noncompliance, and Misconduct

As systems for dealing with scientific misconduct have become more formalized, increasing attention has been given to the definition of misconduct. A brief review of the resulting categories of possible errors scientists can make and unethical behaviors in which they can engage illustrates that many gray areas exist. This increases the difficulty of teaching scientists or overseers the difference between innocent mistakes, dubious professional behavior, and misconduct. As a result of this definitional effort, four categories of problematic behavior have emerged:

- Honest mistakes
- Unethical behavior
- Noncompliance with legal or contractual requirements
- Deliberate deceit (scientific misconduct).[3]

Sources of these behaviors vary from carelessness to deliberate attempts to mislead. Theoretically, many are correctable by self-regulation.

Honest Mistakes

Scientists and their assistants, being only human, can make inadvertent mistakes of various kinds during design, calibration, logging, data entry, and so forth. Errors in interpretation might also fall into the category of honest mistakes. Honest errors and errors resulting from the sloppy execution of research can be corrected by the scientists themselves – if they discover their own mistakes – as well as by those who review or try to replicate the research. Since the stakes are high – mistakes can affect future funding and careers—scientists are likely to take pains to avoid mistakes.

Unethical Behavior or "Scientific Misdemeanors"

Norms in the scientific community define acceptable and unacceptable practices. Teich and Frankel (1992:4) provide examples of behaviors that are not condoned but are in "gray areas:"

- Improprieties of authorship, such as duplicate publication of a single set of research results or fractional publication
- "Gift" or "honorary" authorship

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[3] Similarly, the National Academy of Sciences (NAS, NAE and IOM 1992) broke misconduct into three broad categories, Professional Misconduct (e.g., bad mentoring, authorship disputes), General Misconduct (e.g., embezzlement, sexual harassment), and Research Misconduct.

- Incomplete citation of previously published work
- Bias in peer review of proposals or manuscripts
- Skewed selection of data or results to hide or disguise observations that do not fit the author's conclusions.

Noncompliance

Noncompliance generally refers to failures to follow practices dictated by law. Noncompliance with such requirements may expose a scientist or institution to legal sanctions. The regulatory requirements most commonly associated with scientific research include those governing the ethical treatment of human subjects and laboratory animals. Researchers are accountable to institutional review committees on these topics and generally need approval for their studies that involve human subjects and animals. In addition, the handling of dangerous materials is regulated, including biohazards, hazardous chemicals, the transfer of etiologic agents, and radioactivity. Research in recombinant DNA is also regulated.

In addition, some research contracts may require the research institution to have stringent procedures for protecting data and information. This is particularly true for organizations involved in applied research and technology development or who conduct research in classified areas, such as national security.

Scientific Misconduct

In general, deliberate deceit is the central defining criterion for scientific misconduct, with erroneous information resulting from a deliberate attempt to be dishonest. Dishonesty can occur in the form of forged or fabricated data, falsified or invented results, and plagiarism. Of course, only the outcome of such behavior, and not an individual's motives, can be observed in most instances, so a scientist being accused of such behavior may claim it was an innocent mistake rather than intentional dishonesty. Careful investigation of the record of research often provides the basis for distinguishing between deliberate deceit and other, less serious errors.

Concern that scientific misconduct might be on the rise, or that its impacts might be more deleterious than in the past, has led research funding agencies to establish their own requirements for the institutions they support. Noncompliance with these requirements can result in the loss of research funds. For example, the Health Research Extension Act of 1985 (P.L. 99-158) requires each research institution receiving Public Health Service (PHS) funding to establish an administrative process to review allegations of "scientific fraud" and report substantial allegations to the Department. The 1989 Whistleblower Protection Act (P.L. 102-12) proscribes retaliation against whistleblowers, including those who raise allegations of scientific misconduct (see Pascal 1999a; Teich and Frankel 1992).

Federal Definition of Research Misconduct

In 2000, the Office of Science and Technology Policy (OSTP) published the final federal policy on research misconduct to be used by all federal agencies in the United States. The policy was the product of a panel established in 1996 by the Committee on Fundamental Science (CFS) of the National Science and Technology Council. The panel comprised participants from the National

Science Foundation; National Institutes of Health; National Aeronautics and Space Administration; and the Departments of Energy, Agriculture, and Defense.

The policy (65 FR 235) defines research misconduct as "…fabrication, falsification, or plagiarism in proposing, performing, or reviewing research, or in reporting research results." The policy statement defines each of the terms and states that "research misconduct does not include honest error or honest differences of opinion." The policy states that a finding of research misconduct requires that "there be a significant departure from accepted practices of the scientific community; and the misconduct be committed intentionally, or knowingly, or recklessly; and the allegation be proven by a preponderance of evidence." It confirms that a researcher's home institution has principal responsibility to respond to allegations of research misconduct, while pointing out that federal agencies have ultimate oversight authority for federally funded research. It also provides safeguards for the subjects of allegations as well as for informants.

Previous definitions have for the most part incorporated fabrication, falsification, and plagiarism, but have differed with respect to various types of activities usually believed to be typical of some specific research funding program or research arena. Bird and Dustira (2000) provide a brief description of the concerns about the policy and its implementation that have been expressed by the stakeholders, including federal agencies, scientists, research institutions, and the scientific publishing community.

Prevalence and Significance of Scientific Misconduct

The major federal science-funding agencies have historically not kept statistics on scientific misconduct. A recent regulation now requires science-implementing organizations to report such cases to the agency providing the funding and provide some data on allegations and confirmed cases of misconduct. In fiscal year 1996, nearly 170 scientists were under suspicion by the federal government for possibly committing scientific misconduct and at least 20 scientists were found to have committed scientific misconduct (Dooley and Kerch 2000). The National Institutes of Health (NIH) had close to 100 "active cases" of scientific misconduct and found 17 individuals to have committed scientific misconduct while using NIH research funds. The NSF had approximately 70 active cases and found approximately six individuals guilty of scientific misconduct. Although such figures document the incidence of formally reported cases, they do little to reveal the prevalence of misconduct among scientists practicing in the mainstream of federally funded research, much of which will not be quickly, if ever, detected and reported.

An alternative approach to estimating the prevalence of scientific misconduct is to survey scientists themselves. In 1991 the American Association for the Advancement of Science (AAAS) conducted a survey of 1500 scientists. A quarter of those who responded reported that they had witnessed faking, falsifying, or outright theft of research in the past decade (Marsa 1992:40).[4] Nevertheless, the perspective of the research community is that given the large numbers of projects funded each year, the rate of scientific misconduct is low. This does not mean, however, that scientists, science-implementing organizations, and science-funding organizations do not need to be concerned about scientific misconduct.

In 1995, a Panel on Scientific Responsibility and the Conduct of Research stated that:

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[4] Some concerns have been raised about this particular study's methodology, yet it remains useful as the only broad-based survey that is focused on research misconduct.

> …the number of confirmed cases of misconduct in science is low compared to the level of research activity in the United States. However, as with all forms of misconduct, underreporting may be significant; federal agencies have only recently imposed procedural and reporting requirements that may yield larger numbers of reported cases. Any misconduct comes at a price to scientists, their research institutions, and society. Thus every case of misconduct in science is serious and requires attention (NAS, NAE, and IOM 1995:9).

The seriousness of the problem has been debated. For example, in 1992, an article titled "Scientific Fraud" in the lay-oriented magazine *Omni* (Marsa 1992:38) began with the boldfaced lead: "As mounting scandals shake the public trust, researchers struggle to reconstruct science's shattered reputation." Three years later, an article in the journal *Science and Engineering Ethics* (Shore 1995:383) put a more measured spin on the situation: "In response to a series of allegations of scientific misconduct in the 1980's, a number of scientific societies, national agencies, and academic institutions…devised guidelines to increase awareness of optimal scientific practices and to attempt to prevent as many episodes of misconduct as possible."[5]

Despite the historical confidence in self-regulation, in the early 1990s the literature reflects growing concern, at least in Western societies, that scientific misconduct may be a greater problem than previously recognized and that scientific integrity and self-regulation mechanisms are not as robust as previously thought. This concern was reinforced by indications that the public's trust in science to be self-regulating was crumbling. At this point, the literature began to focus on how the social structure of science, the unfair advantages held by the scientific elite, and the intense competition for financial gain or prestige served to compromise self-regulation in science (e.g., Bell 1992; Chubin and Hackett 1990; Martin 1992). The principal self-regulating mechanisms upon which science traditionally relied (listed above) were judged to be inadequate in the face of these pressures.

The examination of alternatives to self-regulation that followed this growing concern provides a most useful discussion of the issues and approaches to scientific oversight. During the 1990s, major scientific collectives have addressed ways to promote responsible research practice (e.g., NAS, NAE, and IOM 1992, 1993, 1995; Schwartz, 1997). During the same time period, sometimes at the insistence of Congress, the major research funding bureaucracies have extended their capabilities and guidance for handling misconduct (e.g., Frankel 1993, 1995; Ryan 1996; Pascal 1999a, 1999b; ORI 1999). Scientific and professional associations have also stepped forward to develop standards and foster the reconstruction of scientific integrity in the face of the increasing complexity and competing pressures on the scientific enterprise (e.g., AAAS and ORI 2000). As discussed below, this literature focuses on measures that promote "responsibility" in science or in the conduct of research.

Striking the Right Balance: The Responsibilities of Science Funding Agencies

As described earlier, scientists desire autonomy in the conduct of their work and claim that only they have the unique capabilities to evaluate the work of their colleagues. Academic and research

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[5] This multi-disciplinary quarterly, launched in 1995, comprises a useful compendium of articles on the ethical issues and solutions that are emerging cross-nationally in both basic research and practical applications of science and engineering. See tables of contents and abstracts at http://www.opragen.co.uk/SEE/index.html.

institutions prefer not to impose centralized rules of conduct on individual scientists and have battled to protect their ability to create work settings that balance the competing needs for scientific integrity, independence, collegiality, and self-correction of misconduct without excessive outside oversight and regulation.

Nonetheless, the new federal policy requires that federal agencies take more responsibility for protecting society's investment in scientific research. The policies and procedures developed by governmental agencies have involved members of the scientific community, and that the scientist-policy makers themselves are also tied into the scientific organizations and professional associations to which they belong, many of which are making a serious and on-going effort to clarify professional standards and ethical values of the scientific communities they represent (Bird and Dustira 1999:132; see also AAAS and OIR 2000).

A variety of executive and congressional committees and federal funding agencies have played a role in this process. The Department of Health and Human Services (DHHS) was the first to develop policies on the conduct of research because it had the biggest and most visible problem (Schwartz 1997). Several of these initiatives were undertaken during the 1990s (Pascal 1999a). The National Institutes of Health created the Office of Scientific Integrity (OSI) in 1989 in response to increasing congressional concern about allegations of misconduct in science. Its stated purpose was to conduct investigations of scientific misconduct. When this office did not prove to be as aggressive as desired in carrying out its objectives, the Office of Research Integrity (ORI) was created as its successor. The ORI's initial focus was on improving the process for handling scientific misconduct cases and fostering these processes within universities themselves. The ORI prepared a model policy and procedures (see PHS regulation 42 CFR. Part 50, Subpart A) to assist institutions in developing policies and procedures or institutions that conduct inquiries or investigations.

Also in the 1990s several initiatives were undertaken to promote responsible research practices. In addition to the Committee on Fundamental Science (CFS) of the National Science and Technology Council discussed above, other examples include the NIH, which in 1995 established a Committee on Scientific Conduct and Ethics consisting of 32 members representing the various Institutes and scientific professions within the Intramural Research Program at NIH. The guiding principle of this Committee was that "institutions bear the responsibility to define, encourage, and reward good conduct among their scientists" (Frankel 1995).

At the same time, in the broader scientific and engineering community, the topic of how to reinforce the conduct of responsible science was being addressed. Committees were convened and many workshops held to discuss approaches to the conduct of responsible science, which included the maintenance of research integrity (NAS, NAE, and IOM 1992, 1995; Ryan 1996; AAAS and ORI 2000).

The new federal policy emphasizes that applicant and awardee institutions have the primary responsibility for preventing, detecting, investigating, reporting, and resolving possible or alleged scientific misconduct involving those institutions. Concerns that these institutions will not fulfill this responsibility have been the subject of considerable discussion. The DHHS's Office of Research Integrity concluded that "while there will always be fears that some institutions will be reluctant to investigate themselves due to concerns involving reputation and funding issues, ORI's experience has shown that most institutions, and their scientific and administrative staff, are able to navigate those concerns and successfully carry out their responsibility to forthrightly assess allegations received and report their results to ORI" (Pascal 1999a: 195). Currently, approximately 95 percent of all investigations involving PHS extramural support are conducted by the institution that had the grant. However, the point is also made that the funding organizations need to be involved. Pascal, as Acting Director of the Office of Research Integrity emphasized that the Department of Health and Human Services has a critical role in providing oversight of institutional investigations because over 50 percent of all misconduct findings result in debarment from federal funds for a given period, usually three years. “Imposition of this sanction requires assessment of the federal interest at stake and assertion of federal authority that is beyond the scope of any individual institution” (Pascal 1999a: 195).

The central approach by the primary research funding agencies is to emphasize mechanisms for fostering scientific integrity in both their intramural and extramural programs. Agreements between federal agencies and funding recipients can explicitly state expectations for the implementation of such mechanisms, including those that foster and reinforce integrity. Awareness of the ethical problems scientists face and examples of how they can be managed can be incorporated into such approaches as scientist mentoring programs in the basic research programs and into the graduate education programs under the auspices of the funding agencies. Federal program managers should be familiar with these mechanisms and how they can be incorporated into their interactions with those receiving federal funds.

Federal agencies can examine the way in which the pressures of highly competitive science are manifested in the laboratories and other funding recipients, and consider ways of alleviating some of these pressures through adjustment of expectations and reward structures. Agencies can also make it clear to their research laboratories and principal investigators where it stands with respect to the handling of allegations of misconduct, investigation, and sanctions and take measures to support effective implementation of the mechanisms that provide self-correction in science, including active mentoring, a supportive work environment, peer review, refereed publication, and replication of experiments.

Federal agencies can encourage their institutions to develop and implement meaningful and interactive approaches for bringing ethical issues and expectations to the attention of scientists. The key word here is “interactive,” since scientists are more receptive to practical forums for meaningful discussion that are directly related to their work. Required training videos or classes are ineffective at best, especially since they are so often used to transmit compliance training.

Federal agencies that support scientific research could also support important research on the relationship of the elements of research environments to scientific integrity and on the way in which certain types of guidance and oversight enhance or inhibit creativity and innovation in research and development organizations.

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