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Scientific Integrity: Maintaining the Legitimacy of the Research Enterprise

Melissa S. Anderson
Associate Professor of Higher Education
University of Minnesota
USA

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Abstract
Worldwide, most scientific research is conducted in higher education institutions. Funding for science is dependent on the ability of these institutions to support and maintain the legitimacy of the scientific enterprise. As long as the public sees scientific research as beneficial to the common good, support will be forthcoming from government and other sources. In other words, the financial underpinnings of science are derived from public perceptions that scientists act in the public interest.

The fundamental social contract between the public and science is derived from the very nature of scientific knowledge, specifically, that it is the province of scientific experts and beyond the understanding of most non-scientists. The public therefore is called upon to trust the work of scientists in several ways: that scientists choose important problems to work on, that they carry out their work according to accepted and appropriate means, that they used financial resources responsibly, that they present their findings fully and without deceit, and that their work genuinely improves the lives of others. Without the means or expertise to monitor or verify that scientists are conducting their work appropriately, the public relies on the scientific community to maintain high standards through self-regulation. The social contract is thus upheld by legitimacy conferred on science through public trust and confidence.

Science is, however, a human enterprise, and scientists are not perfectly and at all times worthy of the public trust. When scientists reach wrong conclusions through honest error, the mechanisms of review and replication will generally reveal problems, provided that the research is important enough to attract the attention of other scientists. When scientists produce fraudulent research, however, through

deliberate and intentional misbehavior, the damage cannot be repaired simply by good science. It becomes a matter of grave concern to the higher education system that depends on public trust and goodwill. Damage to the legitimacy of science due to a single instance of scientific misconduct can be far-reaching.

It is not surprising, then, that institutions and governmental bodies wish to avoid any association with misconduct in science. Worldwide, there are very few well-developed national systems for the oversight of scientific integrity, and there are no international bodies charged with reviewing and adjudicating misconduct that crosses national boundaries.

Recently, however, there has been increased attention to misconduct on the international level. In February, 2007, the Global Science Forum of the Organisation for Economic Co-operation and Development (OECD) sponsored a workshop in Tokyo at which it presented a policy document on scientific misconduct. The report called for harmonization of policy and oversight of science internationally, to facilitate cross-national approaches to dealing with research integrity. In September, 2007, the European Science Foundation and the U.S. Office of Research Integrity, among others, sponsored the first world conference on research integrity in Lisbon. The conference provided the first international opportunity for scientists, government officials, journal editors and policy makers to exchange information and views on how integrity in research is to be promoted and misconduct to be averted. Again, it is not surprising that some participants at each of these forums saw little reason to be concerned about misconduct, given that it is 1) perceived to be very rare, 2) generally considered an internal matter for scientists to address, and 3) so potentially damaging that formal attention to misconduct might send alarming signals to the public.

What, then, is actually known about the prevalence of misconduct? Under what circumstances does misconduct tend to arise? How effective are training and mentoring in obviating misconduct?

The research that my colleagues and I have done over the past seven years provides answers to these questions. Our work represents the only national, cross-disciplinary study of scientific misconduct ever done. It is based on a 2002 national survey of 3,600 mid-career and 4,160 early-career scientists in the U.S. The first group had a response rate of 52% and the second, 43%. All of the scientists surveyed were supported by federal funding through the U.S. National Institutes of Health, either through basic research grants (for the mid-career group) or through training grants (for the early-career group).

The survey asked respondents if, during the previous three years, they had or had not engaged in each of 33 specific behaviors that could be categorized as misconduct or as questionable research behavior. By the U.S. federal definition, only fabrication, falsification and plagiarism are considered misconduct, but many other

questionable behaviors can compromise the integrity of research. We also collected data on scientists' perceptions of their disciplines as competitive or collaborative, on their subscription to traditional norms of science and alternative counter-norms, on their perceptions of their organizations as distributing rewards fairly or not, and their previous mentoring and training in the responsible conduct of research.

We found substantial misbehaviour among scientists. As reported in Nature, 33% of the respondents reported that they had engaged in one or more of the top ten misbehaviours identified in our study. The proportion of those who had engaged in actual misconduct, by the U.S. federal definition, was much lower (1.7%), but even this percentage is troubling, given that each instance has the potential for serious damage to the scientists' institutions, if revealed.

Moreover, we were able to identify conditions under which misconduct and questionable behaviour are more likely. Those who see their fields as highly competitive are more likely to misbehave, even by the strict standard of actual misconduct. Those who see their colleagues' behaviour as reflecting the traditional norms of science are less likely to misbehave, but those who see the counter-norms enacted exhibit more misbehaviour. Those who see injustice in their own institutions' procedures are more likely to engage in questionable research practices. Unfortunately, mentoring and training do not show strong effects in preventing misbehaviour; in fact, in some cases, they are paradoxically associated with higher levels of inappropriate behaviour.

Our analyses provide some of the only evidence available at the national level about the extent of the misconduct problem and its potential to damage the legitimacy of the scientific enterprise. We call for greater international attention to the problem of scientific misconduct and open discussion of how to address ethical problems that arise, particularly in cross-national research collaborations. We offer specific recommendations on how training and mentoring can be improved to lessen the likelihood of later misconduct, and we suggest ways in which research integrity can be promoted at the international level.

Worldwide, much of the innovation fostered in higher education institutions springs from scientific research. Support for science depends significantly on the public's perception of the legitimacy of the scientific enterprise. Financial and political support is grounded in the public's view of scientific research as beneficial to the common good and scientists as acting in the public interest. Most scientific research worldwide is conducted in universities and affiliated academic institutions, and they therefore play a critical role in supporting and maintaining the public's view of the legitimacy of science.

One of higher education's essential responsibilities is ensuring the integrity of scientific research.

The fundamental social contract between the public and science is derived from the specialized character of scientific knowledge: that it is the province of scientific experts and beyond the understanding of most non-scientists. Without the expertise or means to monitor or verify that scientists are conducting their work appropriately, the public relies on the scientific community to maintain high standards through self-regulation. The social contract is thus upheld by legitimacy conferred on science through public trust and confidence. The public is called upon to trust the work of scientists in several ways: that scientists choose important problems on which to work, that they carry out their work according to accepted and appropriate means, that they used financial resources responsibly, that they present their findings fully and without deceit, and that their work genuinely improves the lives of others.

Science is, however, a human enterprise, and scientists are not perfectly and at all times worthy of the public trust. When scientists make honest errors, mechanisms built into the scientific enterprise are supposed to correct the mistakes. Peer review of proposals and manuscripts is a way for granting agencies and journals to rely on experts to find mistakes or problems in research, so that errors will not waste funds or taint the research record. Unfortunately, pressures on the peer review system compromise its effectiveness, as competition for funds increases the numbers of grants and manuscripts that require reviews.

When mistakes escape detection and incorrect results are published, replication is supposed to safeguard the research record. Replication will generally reveal problems, provided that the research is important enough to attract the attention of other scientists. If findings are not particularly important or in an area of science that is currently seen as "hot," they are not likely to be replicated. Scientists prefer to work on extending previous results, they may have trouble getting replicated findings published, and they do not get much recognition for doing what others have already done.

When scientists produce fraudulent research, however, through deliberate and intentional misbehaviour, peer review and replication become even less reliable mechanisms for correction. Intentional fraud usually involves efforts to mask altered or invented data or inappropriate aspects of the work. Reviewers and other scientists who assume that work is done without deliberate wrongdoing are not going to look specifically for its tell-tale signs. Indeed, scientists who cannot replicate previous findings tend to assume that there is something wrong with their own methods or that the original authors have not provided complete descriptions of the methods they used (Anderson, Ronning, De Vries and Martinson, 2007).

The extent of damage done by fraudulent research depends on its exposure. Fraudulent research that never attracts much attention and never serves as a

foundation for further work may never be uncovered. In this case, fraud still affects the scientific enterprise by falsely inflating the scholarly records of the authors, thereby giving them unfair competitive advantages. Research that is exposed as fraudulent is quite another matter. It becomes a matter of grave concern to the higher-education system that depends on public trust and goodwill. Damage to the legitimacy of science due to a single instance of scientific misconduct can be far-reaching, as recent well-publicized cases have shown (for example, Eric Poehlman in the U.S., Hwang Woo-Suk in South Korea, Pattium Chiranjeevi in India, Jon Sudbø in Norway, Li Guibao in China, Reiner Protsch von Zieten in Germany, Shinichi Fugimura in Japan, and so on).

Responses at the Institutional and National Levels

It is instructive but perhaps counterproductive to focus on cases of egregious misconduct. They do, of course, make institutions and national policy-makers aware of the scope of potential damage that can result from a single instance of exposed misconduct. They also, however, may prompt officials to disassociate themselves and their offices from the whole issue of misconduct, which may actually exacerbate problems in the long run.

Responses at the institutional or national level tend to reflect one of the following perspectives on misconduct: 1) scientific misconduct is extremely rare, and self-regulation by the scientific community is adequate for handling the very few cases that may arise; 2) scientific misconduct is rare, but oversight offices at the institutional and national levels adequately handle the few cases that may arise; 3) scientific misconduct occurs from time to time, and oversight offices at the institutional and national levels respond appropriately through investigation and adjudication; 4) scientific misconduct occurs from time to time, and oversight offices at the institutional and national levels respond appropriately through investigation and adjudication and also oversee a well-developed system of training and assurances to avert potential misconduct. Options 1 and 2 above tend to minimize attention to potential misconduct. They may represent unfounded assurances to the public that adequate steps have been taken to address problems that may arise. Option 3 represents a real capacity to deal with misconduct, whereas option 4 represents additional, proactive steps to obviate misconduct.

There are reasons why institutions or national systems would choose option 1 or 2 instead of option 3 or 4. The latter options require acknowledging that misbehavior in science not only exists but is frequent enough to be problematic. Some regard this acknowledgement itself as damaging to the perceived legitimacy of the research enterprise. It raises alarm and calls into question scientists' ability to regulate their own affairs. Though the substance of cutting-edge science is beyond the understanding of the lay public, the ethical uprightness of scientists is not: this is a part of science that

the public can readily understand. When ethical problems are acknowledged, external critics and detractors of science are given yet another point of attack.

A theory from the field of organizational studies explains some of the dynamics at work in this situation. Institutional theory (Meyer and Rowan, 1977) applies to professional organizations for which the public has highly developed expectations of appropriate behavior. Hospitals, legislative bodies, schools and universities are examples of such institutions. The mechanisms of the work done in these institutions are often beyond the public's specific knowledge, yet the public has general expectations for these institutions that must be met in order for the institutions to maintain their legitimacy, which is the cornerstone of continued public support. According to the theory, to maintain the public's perceptions of legitimacy, an institution maintains a façade that both matches public expectations and protects the institution's core activities from inspection and intrusion by non-professionals. The façade may include structural features, such as committees or policies or offices that address matters of public concern (such as research integrity, in the present instance), but that are structurally or functionally disconnected from core activities (such as actual research activities). The façade represents both responsiveness to the public's concerns and a defense of highly technical and professional work from inappropriate lay interference.

This theory suggests that institutions develop policies, initiate instructional programs, appoint committees and issue statements about research integrity in a largely *pro forma* manner, to deflect potential public criticism of science. Institutions thereby acknowledge public concerns about misbehavior in science, but focus on these concerns instead of on the actual or potential misbehavior. Again, doing so bolsters the perceived legitimacy of science, without involving institutions in exhaustive reform efforts.

Recent Initiatives to Address Research Integrity Internationally

Worldwide, there are diverse national systems for the oversight of scientific integrity. In the U.S. at the national level, responsibility for integrity oversight resides primarily in the Office of Research Integrity (ori.dhhs.gov) within the Department of Health and Human Service (which includes the National Institutes of Health), and in the Office of the Inspector General of the National Science Foundation (www.nsf.gov/oig). The NIH and NSF require institutions to have systems in place for investigating alleged misconduct and providing training in the responsible conduct of research. In other countries, integrity oversight may be handled through an ombudsperson (Germany) or through a multi-institutional collaboration (the U.K.), or through a national office (Japan). Many countries have no national system for addressing scientific misconduct. In India, for example, the national science advisory committee has just announced its

support for the creation of a national scientific-integrity office. There are no international bodies charged with reviewing and adjudicating misconduct that crosses national boundaries.

Recently, however, there has been increased attention to misconduct on the international level. In February, 2007, the Global Science Forum of the Organisation for Economic Co-operation and Development [OECD] sponsored a workshop in Tokyo at which it presented a policy document on scientific misconduct (OECD Global Science Forum, 2007). The report called for international harmonisation of policies and oversight of science to facilitate cross-national action on research integrity. An OECD international research-integrity committee has been appointed to consider how to enact this kind of harmonization.

In September, 2007, the European Science Foundation and the U.S. Office of Research Integrity, among others, sponsored the First World Conference on Research Integrity in Lisbon, Portugal (Mayer and Steneck, 2007). The conference provided the first international opportunity for scientists, government officials, journal editors and policy makers to exchange information and views on how integrity in research is to be promoted and misconduct to be averted. The conference rapporteur's summary identified four topical clusters for further attention: misconduct, bioethics, conflicting interests and institutional integrity (Tindemans, 2007).

In August, 2007, the U.S. Office of Research Integrity agreed to sponsor a conference at the University of Minnesota, USA, on challenges and tensions in international research collaborations, to be held in October, 2008 (http://www.international.umn.edu/oriconf/index.html). The premise of the conference is that ethical issues and more general problems in collaborations are often attributed to miscommunication or misunderstanding, but in fact they are more likely due to fundamental, cross-national differences in the way science is done. Of particular interest are the effects on scientific integrity of differences in the organization and funding of science, in relevant legal and regulatory systems, in cultural expectations, and in the training of graduate students and postdoctoral fellows.

Again, it is not surprising that some participants at the first two of these forums saw little reason to be concerned about misconduct, given that it is considered to be 1) very rare, 2) an internal matter for scientists to address, and 3) potentially very damaging. Even addressing misconduct prospectively and formally appears to some to invite unwelcome scrutiny.

The Prevalence of Misconduct and Other Misbehaviours

Attention to scientific misconduct is therefore neither consistent nor persistent. It tends to be driven by major cases that erupt in the media. If, in fact, misconduct is very rare,

this approach is probably justified. If it is not rare, then this approach poses troubling risks. What is actually known about the prevalence of misconduct?

The research that my colleagues and I have done over the past seven years provides relevant empirical evidence. Our work represents the only national, cross-disciplinary study of scientific misconduct done to date. It is based on a 2002 national survey of 7,760 U.S. scientists in two samples. The first sample of 3,600 scientists was drawn from the set of all scientists who received an initial basic research grant from the U.S. National Institutes of Health [NIH] during 1999-2001. This is the sample of mid-career scientists, which had a response rate of 52% for a response-group size of 1,768. The second sample of 4,160 scientists was drawn from the set of scientists who received NIH funding as postdoctoral fellows during 2000 or 2001. This group of early-career scientists had a response rate of 43% and a response-group size of 1,479.

The survey was designed to yield estimates of the prevalence of behaviors that are recognized as misconduct, as well as "questionable research practices" or what we have termed "misbehaviors" (De Vries, Anderson, Martinson, 2006). The U.S.common definition of misconduct (ori.dhhs.gov/policies/fed_research_misconduct.shtml), which has been officially adopted by the major federal agencies that fund research (except for a few agencies that have taken the definition under consideration), recognizes only three behaviours as misconduct: fabrication, falsification and plagiarism [FFP]. There are other misbehaviours, however, that can compromise the integrity of science, such as ignoring human-subjects requirements, not disclosing conflicts of interest, carelessness, inappropriate authorship assignments, inadequate record keeping, and so on. Such behaviours are matters of concern because they may involve violations of policy, distortion of the research record, avoidable errors, misrepresentation, waste of resources, and other negative effects.

In our survey, we asked respondents if, during the previous three years, they had or had not engaged in each of 33 specific behaviours that could be categorized as misconduct or as questionable research practices. In our analyses, we assigned 27 of these behaviours to 8 categories, as noted below. It is important to note that our analyses are based on self-reported behaviours. Respondents may have been reluctant to disclose misbehaviour, despite anonymity ensured by the data-collection process; we therefore view our results as conservative estimates.

We found substantial levels of misbehaviour among scientists. Misconduct (FFP) within the previous 3 years was admitted by 1.7% of the respondents (Martinson, Anderson, De Vries, 2005). This percentage is low but nonetheless troubling, given that each instance has the potential for serious damage to the scientists' institutions, if revealed. The following percentages of mid-career and early-career scientists, respectively, reported having engaged in at least one misbehaviour in the given

category during the previous 3 years[1]: data, 27%, 28%; methods, 40%, 37%; policy, 45%, 43%; use of funds, 72%, 39%; outside influence, 53%, 27%; peer review, 31%, 15%; credit, 19%, 13%; cutting corners, 66%, 50% (Anderson, Horn, Risbey, Ronning, De Vries, Martinson, 2007). Questionable research practices are thus not rare by any standard. What makes these practices even more worrisome is that respondents who engaged in them are significantly more likely also to have engaged in misconduct (FFP).

These findings show that, at least in the U.S., there is cause for concern about the extent to which scientists do things that may compromise the integrity of science. The extent to which scientists in other countries engage in such behaviours is unknown.

Factors Associated with Misconduct and Other Misbehaviours

We were also able to identify conditions under which misconduct and questionable behaviour are more likely. Findings from previous research and focus-group discussions that we held with scientists prior to the administration of the survey (De Vries, Anderson and Martinson, 2006; Anderson, Ronning, De Vries and Martinson, 2007) led us to investigate four related sets of factors: 1) scientists' perceptions of their disciplines as competitive or cooperative, 2) their perceptions of their colleagues' behaviour as corresponding to traditional norms of science or alternative counternorms, 3) their perceptions of their organizations as distributing rewards fairly or not, and 4) their previous mentoring and training in the responsible conduct of research.

Perceptions of disciplines as competitive or cooperative. We asked about the extent to which respondents view their disciplinary fields as competitive or cooperative. Those who see their fields as highly cooperative are less likely to engage in misbehavior of several kinds. By contrast, those who think their fields are highly competitive are more likely to engage in misbehaviors, including federally identified misconduct.

Perceptions of colleagues' behavior as normative or counternormative. The norms of science, as originally identified by Robert Merton over 50 years ago (Merton, 1942) are principles that represent collective expectations for and understandings of appropriate and desired behavior. The Mertonian norms are communality, universalism, disinterestedness and organized skepticism. These norms were subsequently matched with alternative counternorms that represent contrary behavior: secrecy, particularism, self-interestedness and organized dogmatism, respectively (Mitroff,

[1] Fabrication/falsification are included in the data category, and plagiarism is included in the credit category.

1974). We have expanded both of these lists by adding two norms and two associated counternorms: governance/administration and quality/quantity (Anderson, De Vries and Martinson, 2007). Our survey results show that scientists who see their peers' behavior as corresponding to the traditional norms (in their expanded version) are less likely to engage in misbehavior. Those who see colleagues enacting the counternorms instead are more likely to misbehave.

Perceptions of organizational injustice. We also investigated the extent to which scientists view the process of decision-making in their institutions as fair. In the literature on organizations, procedural justice is identified as the perception that decisions about the distribution of resources in an organization are made in a fair way. We measured scientists' sense of procedural injustice, or sense of unfairness in decision-making, and found that it is associated with higher levels of misbehavior. This finding suggests that scientists who are not convinced that they are working in a context that promotes fairness in the distribution of resources may find ways to adjust the imbalance by stretching the rules or otherwise engaging in behaviors that compromise integrity (Martinson, Anderson, and De Vries, 2006).

Training and mentoring. Given the substantial investment that the U.S. government and institutions have put into training in the responsible conduct of research, it would seem that training should be associated with lower levels of misbehavior. Mentoring also, as a more traditional means of transmitting the mores of scholarly work, should lower misbehavior. We asked respondents about the extent and forms of mentoring that they had received, as well as their exposure to training in responsible conduct of research through formal courses and more informal means. We found disappointingly few effects of either on mid-career scientists' subsequent behavior. Among the early-career scientists, training was negatively associated with FFP, but positively associated with misbehavior in the data category. The early-career respondents who had mentoring in ethical behavior, research and personal issues were less likely to misbehave; however, those with higher levels of mentoring in the art of survival in science (a kind of strategic mentoring) were more likely to engage in misconduct and in misbehaviors in the method, use-of-funds and peer-review categories. It appears that students might learn from their mentors that survival and success in science sometimes involve bending the rules (Anderson, Horn, Risbey, Ronning, De Vries and Martinson, 2007).

Recommendations for Maintaining the Legitimacy of the Scientific Enterprise

Scientific integrity is absolutely essential to successful and sustained innovation in higher education. It includes, but extends beyond, the absence of scientific misconduct. It is accuracy, honesty and transparency in the conduct of research; it is an enactment of the responsible conduct of research.

By contrast, misconduct and other compromises to scientific integrity inflict damage on the legitimacy of the scientific enterprise, thereby threatening future financial and political support for science. *The problem that our research has demonstrated is that some of the characteristics of fast-track, high-pressure development environments are the very factors that are associated with higher levels of misconduct and misbehaviour*: competition, dominance of non-traditional norms of science, and shifts in organizational reward structures that some may see as unfair. It is critical for institutional and national systems to ensure that innovation proceeds in ways that maintain integrity and legitimacy: that they take proactive steps to ensure that scientists -- individually and collectively -- conduct their research in accordance with the highest standards of professional integrity. Innovation environments must also be integrity environments, if innovations are to be successful and sustained.

Our analyses provide some of the only evidence available at the national level about the extent of the misconduct problem and its potential to damage the legitimacy of the scientific enterprise. That levels of misconduct and questionable research practices are unknown in many other countries does not provide assurance that such practices do not exist. To the contrary, not knowing about behaviour that may compromise research integrity or the prevalence of such behaviour leaves institutions and funding agencies vulnerable to unfortunate surprises, should misconduct be uncovered and exposed by the media.

We therefore call for:

1) Greater attention to scientific misconduct. Assuming that scientists never do things that might compromise the integrity of science is a risky strategy. Avoiding the issue may make institutional and national leaders less likely to identify problematic behaviors as such. If instances of misconduct are exposed in the media, leaders and institutions may not be well prepared to deal with the misconduct or with the resulting media attention. Avoidance also wastes an opportunity to avert misconduct through policy development, open discussion and instruction about appropriate and inappropriate conduct, the risks and costs of misconduct, and the sanctions to be imposed.

2) Development and articulation of national and institutional policies on research misconduct and research integrity. National and institutional policies vary widely in terms of what is considered misconduct and how it is to be handled. The OECD international research-integrity committee's work toward harmonization of policies and procedures is a promising step toward this goal.

3) International cooperation in inquiries, investigations and adjudication of cross-national misconduct. Science is an increasingly global enterprise, involving dense webs of international scientific collaboration. These collaborations are not immune to behaviors that compromise research integrity, and the lack of international mechanisms for addressing ethical problems is a substantial concern. A formal means must be developed for enacting both fair reviews of alleged misconduct and binding sanctions on guilty parties.

4) Alignment of institutional and national policies and training on research integrity. National efforts to ensure research integrity must be supported by institution-level efforts. The U.S. model of placing primary responsibility for research integrity on research institutions may not be appropriate in other countries. In any case, however, institutions are the sites where research is done and where appropriate conduct needs to be assured. Persistent and insistent efforts to promote integrity and avert misconduct must be seen as the collective responsibility of the scientific community, supported by institutional policy, administration and resources.

5) Intensified and improved training in the responsible conduct of research. Our research has shown that training and mentoring do not always have the salutary effects that one might expect. Scientists must adopt effective methods of instruction in the responsible conduct of research, not relying on cursory or didactic instruction to meet formal instructional expectations. We encourage the development of group mentoring to counter the effects of private mentor-student conversations that might promote inappropriate behaviour for the sake of career success. We also call for enactment of the principle of collective openness (Anderson, 2008) in laboratories and other research settings. This principle requires all scientists and other personnel working on scientific projects to raise questions about any aspect of the work that seems questionable, in either its correctness or its ethicality. Scientists who wish to promote collective openness as a defense against potential misconduct must be explicitly supportive of questions about the design, methods, conclusions and interpretations of the work done by everyone in the laboratory. This kind of persistent, everyday attention to the ethical aspects of science holds great potential for averting misconduct and maintaining the legitimacy of the scientific enterprise.

Institutional and national systems that do not take proactive steps to ensure the integrity of science are putting their research-based innovations at risk. When the media expose high-profile cases of misconduct, it is rare that an individual scientist takes all the blame. To the contrary, reports nearly always reference the high-pressure environments in which the scientists worked. These environments must be the targets of interventions that will secure the integrity of scientific research while promoting innovation.

Bibliography

- ANDERSON, M.S. (2007) "Collective openness and other recommendations for the promotion of research integrity", Science and Engineering Ethics, 13(4), pp. 387-394.
- ANDERSON, M.S., A.S. HORN, K.R. RISBEY, E.A. RONNING, R. DE VRIES, and B.C. MARTINSON (2007) "What do mentoring and training in the responsible conduct of research have to do with scientists' misbehavior?: Findings from a national survey of NIH-funded scientists", Academic Medicine, 82, pp. 853-860.
- ANDERSON, M.S., B.C. MARTINSON, R. DE VRIES (2007) "Normative dissonance in science: Results from a national survey of U.S. scientists", Journal of Empirical Research in Human Research Ethics, 2(4), pp. 3-14.
- ANDERSON, M.S., E.A. RONNING, R. DE VRIES, and B.C. MARTINSON (2007), "The perverse effects of competition on scientists' work and relationships" Science and Engineering Ethics, 13(4), pp. 437-461.
- DE VRIES, R., M.S. ANDERSON, and B.C. MARTINSON (2006) "Normal misbehavior: Scientists talk about the ethics of research", Journal of Empirical Research on Human Research Ethics, 1 (1), pp. 43-50.
- MARTINSON, B.C., M.S. ANDERSON and R. DE VRIES (2005) "Scientists behaving badly", Nature, 435, pp. 737-738.
- MARTINSON, B.C., M.S. ANDERSON, and R. DE VRIES (2006) "Scientists' perceptions of organizational justice and self-reported misbehaviors", Journal of Empirical Research on Human Research Ethics, 1(1), pp. 51-66.
- MAYER, T. and N. STENECK (2007), Final Report to ESF and ORI, First World Conference on Research Integrity: Fostering Responsible Research, Lisbon Portugal, 16-19 September, 2007. (Retrieved at www.esf.org/conferences/researchintegrity on March 16, 2007).
- MERTON, R. (1942) "Science and technology in a democratic order", Journal of Legal and Political Sociology, 1 (1-2), pp. 115-126.
- MEYER, J. and B. ROWAN (1977) "Institutionalized organizations: Formal structure as myth and ceremony". American Journal of Sociology, 83 (2), pp. 340-363.

- MITROFF, I. (1974) "Norms and counter-norms in a select group of Apollo moon scientists: A case study of the ambivalence of scientists", American Sociological Review, 39, pp. 579-595.
- ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT [OECD], GLOBAL SCIENCE FORUM (2007), Best practices for ensuring scientific integrity and preventing misconduct. (Retrieved at http://www.oecd.org/dataoecd/37/17/40188303.pdf on March 16, 2007).
- TINDEMANS, Peter (2007). An action-oriented summary of the First International Conference on Research Integrity, Lisbon 16-19 September 2007. (Retrieved at www.esf.org/conferences/researchintegrity on March 16, 2007).