AVIAN DISEASES 51:1–7, 2007

Invited Commentary—

The Proper Conduct of Research

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Received 13 November 2006; Accepted 12 December 2006

SUMMARY. Scientific misconduct has garnered recent attention by the media over scandals concerning falsification and fabrication of data surrounding potentially promising breakthroughs in stem-cell research, allegations of plagiarism at a U.S. university, and financial conflicts of interest between researchers and drug companies. While this makes for interesting copy, discussion of scientific fraud provides an excellent opportunity to review ethical standards for research and examine the conflicts that confront researchers today. This review specifically focuses on five areas that involve scientific integrity—plagiarism, falsification, fabrication, authorship, and conflict of interest—as well as nuances in each area that even senior investigators may not be aware of (e.g., self-plagiarism). The standards for ethical conductance of research discussed in this review are those set by many scientific, peer-reviewed journals and by federal and private granting agencies, and therefore it highlights the expectations and guidelines surrounding manuscript and grant submissions and review, and the consequences associated with violations. This review is intended to stimulate discussion among readers and assess what is necessary to become a good, competitive, but ethical researcher, especially in an era of shrinking financial resources for research.

RESUMEN. *Comentario por Invitación*—La conducta apropiada en Investigación.

La mala conducta científica ha llamado la atención a los medios publicitarios recientemente sobre los escándalos relacionados con la falsificación y fabricación de datos en áreas con avances potencialmente prometedores como la investigación el campo de las células madre, los supuestos plagios en una Universidad de Estados Unidos y los conflictos de interés financieros entre los investigadores y las empresas fabricantes de fármacos. Aunque esta situación parece interesante, la discusión del fraude científico proporciona una excelente oportunidad para revisar los estándares éticos de la investigación y examinar los conflictos que confrontan los investigadores actualmente. Esta revisión se enfoca específicamente en cinco áreas que involucran la integridad científica: el plagio, la falsificación, la fabricación o creación de datos, los derechos de autor y los conflictos de interés, así como otras situaciones en cada área que aún los investigadores experimentados no las conocen, como la redundancia de publicaciones. Los estándares para la conducta ética de la investigación discutidos en esta revisión son aquellos establecidos por muchas publicaciones científicas e indexadas, y por agencias privadas y federales que otorgan fondos para la investigación y por lo tanto hace énfasis en las expectativas y las pautas relacionadas con el envío de manuscritos o propuestas de investigación, y revisa las consecuencias asociadas con las violaciones. La intención de esta revisión es estimular la discusión entre los lectores y evaluar lo que sea necesario para ser un investigador bueno, competente y ético, especialmente en una época cuando los recursos financieros para la investigación disminuyen considerablemente.

Key words: authorship, scientific misconduct, conflict of interest

Abbreviations: LPU = least publishable unit; ORI = Office of Research Integrity

Why would a research microbiologist want to discuss scientific ethics? As a graduate student in the 1980s, I observed many high-profile cases of scientific misconduct, which brought me to the obvious question: what is the proper conduct of science? I am by no means an expert on scientific integrity, but in my 20 years as a researcher, from student to professor, I have encountered many situations for which no formal graduate course could have ever prepared me. What constitutes authorship? Ownership? More importantly, how do I become a good, competitive, but ethical scientist?

In a recent essay, Dr. Paul Wolpe made a compelling argument why researchers should be engaged in discussions about ethics. Advancements cannot be made without a free and open exchange of ideas and materials. Scientists ''must assume personal responsibilities for the integrity of their research, their relations with colleagues and subordinates, representatives of their home institutions . . . and science as public enterprise'' (57). In the conduct of scientific investigations, it is assumed that research is conducted honestly and ethically. However, there are those few, for various reasons, who feel compelled to violate the sacred tenets governing scientific inquiry. Many readers are probably familiar with recent allegations of scientific misconduct surrounding Dr. Woo-suk Hwang's embryonic stem cell research. Dr. Hwang was accused and found guilty of falsifying and fabricating data published in the prestigious journal *Science* (34,35,56). In 2004 the scientific community was excited about the prospect of creating a cloned, stem cell line by Woo-suk Hwang and colleagues (34), and the follow-up 2005 paper seemed even more promising toward the development of new therapies to repair injured tissue or cure genetic diseases (35). However, these claims quickly unraveled, as a scientific inquiry into allegations of fraud found no cloned stem cell lines existed. The deceptions in both *Science* publications involved manipulated and fabricated photos, fabricated DNA test results, and other data supporting the 2004 *Science* paper, and the falsified source of stem cell lines described in the 2005 publication. Dr. Hwang was personally complicit in the deception when he ordered a subordinate to fabricate data to make it look like they had 11 stem cell lines (56). Like other cases of scientific misconduct such as misrepresenting, falsifying, or fabricating data in a grant application (26,36), this violation was only brought to light by a whistle-blower (23).

Although hopefully not rampant in the scientific community, scientific misconduct has spurred government agencies and journals to take action. China's National Science Foundation has recently

Table 1. Scientific misconduct reported to the ORI for Public Health Service–funded research.[A]

Year	Allegation	No. inquiries/ investigations	No. ruled misconduct	Examples	Punishment associated with examples[B]
2005	Falsification	16	3	(1) Falsified tissue type in report to justify patient enrollment.	PHS exclusion (3 yr); supervision by institution
				(2) Falsified images as human when actually murine; falsely reported on reagents used in online publication.	PHS exclusion including grants and contracts (3 yr)
				(3) Altered colorized image; falsely reported on repetitions; used control bands for experimental group in publication.	Debarment (2 yr); PHS exclusion (3 yr); supervision by institution
	Fabrication	2	2	(1) Fabricated research records for subjects.	Debarment; PHS exclusion (3 yr)
				(2) Fabricated research interviews.	Debarment (individual also guilty of larceny)
	Falsification/fabrication	2	2	(1) Fabricated pedigrees; false reporting of sample size; no controls could be substantiated.	PHS exclusion including grants and contracts (3 yr)
				(2) Numerous examples where data were falsified or fabricated to show trends in grant applications *and* publications.	Permanent PHS exclusion; retraction of 10 papers
	Plagiarism	2	1	(1) Plagiarized 9 pages of a 21-page review.	ORI reporting; supervision, PHS exclusion (3 yr)
2004	Falsification	7	2	(1) Altered images including removing gel band and reusing images or gel bands in submitted manuscript.	PHS exclusion including grants and contracts (3 yr); withdraw manuscript.
				(2) Misrepresented source of data in figure and falsified intensity of gel band in submitted manuscript.	PHS exclusion including grants and contracts (3 yr); withdraw manuscript; supervision
	Fabrication	3	0		
	Falsification/fabrication	8	4	(1) Falsified and fabricated data/records for study participants.	PHS exclusion including grants and contracts (3 yr)
				(2) Fabricated educational background; falsified biographical sketch in claim of authorship.	Debarment; PHS exclusion including grants and contracts (3 yr)
	Plagiarism/falsification	3	1		
	Plagiarism/falsification/ fabrication	1	1	(1) Plagiarized figures from publication; altered these images for grant application; fabricated experimental data.	Debarment; PHS exclusion including grants and contracts (3 yr); retraction of two publications

[A](9,10).
[B]PHS = Public Health Service.

taken action against scientists guilty of fabricating or falsifying data or plagiarism (58). The United States Congress authorized the formation of the current Office of Research Integrity (ORI; http://ori.hhs.gov) following a series of scandals in the 1980s (3) focusing on falsification and fabrication, exemplified in cases against John Darsee, Robert Slutsky, and Stephen E. Breuning (1,21,40).

In 1981 a Harvard-initiated investigation found a young researcher, John Darsee, guilty of falsifying data in a study examining the effect of drugs on the canine myocardium. A more thorough investigation found the researcher had falsified data in at least five animal studies. Dr. Darsee was barred from receiving NIH funding for 10 years. This investigation also resulted in the retraction of nine publications. The senior scientist supervising Dr. Darsee was placed on one-year probation to ''ensure a high standard of supervision'' (1). In a case against Robert Slutsky, an initial investigation by the University of California at San Diego found evidence that data were fabricated in three papers, and the investigator had falsified his qualifications in his curriculum vitae. The investigation was triggered when an outside promotion/tenure reviewer identified statistical discrepancies in several published studies. A second investigative committee identified 10 more fraudulent papers. Toward the end of Dr. Slutsky's tenure at the University of California at San Diego, he was ''producing 1 paper every 10 days.'' Was this even possible? The scandal affected many coauthors at the institution including several senior faculty members given authorship ''for providing facilities without substantial contributions or knowledge of, the validity of the work'' (40). Finally, in 1988 Stephen Breuning pleaded guilty to falsifying results in a $200,000 National Institute of Mental Health grant application. Dr. Breuning came to prominence for his work demonstrating that the stimulants Ritulan and Dexedrine can be more effective than tranquilizers in controlling hyperactivity in retarded children. However, few children treated actually received either drug, the research was not performed as described, and the results had not been obtained as described in the grant application (21).

The ORI investigates allegation of scientific misconduct for any Department of Human Health Services–funded research. Table 1 illustrates recent ORI inquiries and investigations of alleged scientific misconduct, specifics on those cases found guilty, and the actions taken in response to these violations. In 1997 the Committee on Publication Ethics was formed in the United Kingdom to assist editors of medical journals with matters concerning research integrity. The impetus for the formation of this committee and the rules and guidelines adopted by many medical journals was the cases of plagiarism and fabrication discovered by editors and reviewers (51). More importantly, editors were concerned with the consequences of publishing manuscripts implicated in scientific misconduct, and what action should be taken. For example, should the journal inform the author's institute of this violation (51)? One estimate of published fraudulent material was ~0.02%, for 400,000 articles published between 2000 and 2002. This estimate was based on the cases investigated by ORI for that period (24). However, the true incidence may be higher. In a recent anonymous survey of U.S. researchers ($n = 3247$), 0.3% respondents admitted to falsifying data and 1.4% plagiarism (41). Just a few fraudulent papers can have a significant impact on research, as labs waste valuable time and resources trying to replicate experiments and expand the findings described in the tainted paper. Problematic with the publication of fraudulent material is whether the publication retracts the paper once the author(s) have been found guilty of scientific misconduct and the subsequent notification of the scientific community of this retraction (15,27,54). Retracted articles are also not physically removed from a journal's published volumes. While MEDLINE notes the retraction, it does not withdraw the paper from its archives (15). Therefore, even retracted papers are still read and cited by researchers unfamiliar with the field. Most damaging with these few cases of misconduct is the subsequent erosion of the public's trust and support of science.

It seems self-evident that the perpetrators of scientific misconduct know better, and for the most part this is probably true. However, there have been many recent cases involving proper conduct of science where probably most researchers are not aware of any impropriety. This is best illustrated with recent issues concerning conflicts of interest and financial disclosures involving scientists' ties with biotechnology and pharmaceutical companies (13,18,28,47). Recent allegations of plagiarism at Ohio University (53) have also lead me to stop assuming that students and young scientists and engineers are cognizant and familiar with the basic tenets and proper conduct governing research. What was particularly troubling with the allegations was that the faculty missed these egregious violations and the students did not appear to be aware that what they are doing was wrong. Some believe the violations were not offensive because the plagiarism was limited to the theses' literature review. However, if the students found this permissible, what will keep them from continuing this practice when they submit their work for publication? This case best illustrates ignorance concerning proper conduct and the necessity for scientists and students to understand that originality, honesty, and transparency are the basic underpinnings of scientific inquiry and reporting.

This commentary is meant to assist young researchers in their maturation as scientists and in their understanding of the proper conduct of research. For established investigators, this article is meant as an opportunity for self-reflection and a catalyst to stimulate discussions in the laboratory, between mentor and student about the conduct of science. Scientific misconduct should be viewed from a geneticist's perspective; we learn how something is supposed to work often from aberrations or mutations in life. Obviously I cannot cover all the issues or in the depth necessary for the reader to be completely knowledgeable in the proper conductance of research. Therefore, I strongly recommend the following books as a necessary part of any investigator's library: *Scientific Integrity,* 3rd ed. (38); and *At the Bench: A Laboratory Navigator* (17). I also recommend visiting the ORI's website (http://ori.hhs.gov/), which contains several web-based resources concerning data management, collaborations, etc. Most importantly, it is the intention of this commentary to stimulate discussions on the philosophy of science rather than its mechanics.

PLAGIARISM

The academic definition of plagiarism is taking another's work or ideas and passing it off as one's own. Plagiarism has a broader definition, and it is more than the copying verbatim of another's work without citing the original source and placement of quotation marks around the cited phrase, sentence, or paragraph. It is taking credit for another's idea(s) or work. We have seen numerous examples of plagiarism with theses (53), publications (22), and grant applications (9).

The internet has made information quite accessible. In fact, there are no more excuses for a writer's ignorance of the literature since the advent of search engines like PubMed (www.pubmed.gov) and Google Scholar (scholar.google.com). It has also made it easier to plagiarize others' work. However, Google has also made catching plagiarism easier as well. There are internet sites available that promise students term papers written for them, by ghostwriters (monsterpapers.com, www.ez4search.com, www.duenow.com). Use of such term papers is considered plagiarism, and faculty have the tools (e.g., plagiarism.org) to help catch the offenders (49). Many universities have policies in place concerning plagiarism and other issues concerning academic honesty (e.g., "A Culture of Honesty," http://www.uga.edu/ovpi/honesty/ah.pdf). There are circumstances where even paraphrasing and citing another's work may still not be sufficient in avoiding an accusation of plagiarism. An example of this is what I refer to as "a review of a review," where the plagiarist paraphrases and cites large sections, at many times pages in length, of a book chapter or review for their purpose of reviewing the literature. The original author(s) of this work had gone through the trouble of gathering the relevant literature and sifted through and evaluated this information for the reader to understand the topic discussed. Citations, of book chapters or reviews, are meant to refer readers to these references for details that cannot possibly be covered by the author.

Plagiarism may not stem from ill intent but rather poor writing skills, ignorance concerning how to acknowledge or cite sources, and misconceptions concerning intellectual property and ownership, especially for material on the internet (12,49). One could also include the overwhelming volume of information, unfamiliarity with how to read a science article, confusion on how to cite internet sites, and reliability of non-peer-reviewed websites. Although not condoning this behavior, it is easy to see how tempting it is to lift material from a single reference. Investigators should not assume that their institution defines plagiarism with the rules and guidelines for writing theses or dissertations. In reviewing my own institution's guidelines on writing theses and dissertations, there was no mention of plagiarism. What students do not understand is that plagiarism is not just stealing other people's work, but is also a violation of trust. If the writer is willing to steal another's idea or work, then what else would they be capable of doing? A colleague related to me a story concerning a former student. The student had clearly plagiarized sections of the thesis. The advisor explained to them what plagiarism was and told them to go back and correct this. Upon second review and seeing that the plagiarism continued, the advisor made the student repeat all of the thesis research because the act of plagiarism alone brought the student's integrity and their work into question.

Senior scientists may not be aware that they too could also be guilty of plagiarism by reusing text or data, in part or in toto, in more than one publication. This is referred to as self-plagiarism, which manifests itself in duplicate publication, or redundant publication (19). Even seasoned writers may not be cognizant of this violation. Compare two editorials on scientific misconduct published in *Ophthalmic Research* and *Ophthalmologica* (43,44). At the least, as with most cases of plagiarism, the authors are guilty of violating copyright law. Several journals are quite clear in ''that the manuscript, or one with substantially the same content, was not published previously, is not being considered or published elsewhere'' (4,5). There are a few cases where duplicate or redundant publications are permissible (6). For example, ''preliminary disclosures of research findings webcast as meeting presentations or published in abstract form as adjuncts to a meeting are not considered prior publications,'' and they are therefore permissible for consideration (4,5,6). It is often recognized that this information is an incomplete work in progress, and it is understood that it will be published in its entirety once it is complete. Other cases involve government labs that may be required to provide information in government publications for the general public (25). Occasionally there are circumstances where the information was published in another language in a journal with limited distribution (19). Several journals, including this one, recognize language as a barrier in disseminating information and therefore provide the abstracts in two languages to broaden their readership. In the few cases where duplicate publication is permitted, the author must cite the original source (19).

FABRICATION AND FALSIFICATION

Fabrication is ''the recording or presentation of fictitious data'' (19). Falsification, on the other hand, is ''the manipulation of data or procedures to produce a desired outcome or avoid a complications or inexplicable results'' (19). Both are brazen and deliberate attempts at deception. It is often the whistle-blower who alerts authorities to these deceptions (20,23). On rare occasion, a lab's failure to replicate the results of a paper alerts authorities to potential fraud (16,20). Even the withholding of essential information or details is unethical and constitutes falsification (11). This may be done in the belief that it gives the investigator an edge over competitors. However, validity of one's work comes only through its faithful reproduction by other labs. The result is the perpetuation of this work by others who cite it in their own article and its multiple citations by the scientific community at large. Also, omission of a trial or data set to strengthen statistical verification is falsification. For example, leaving out select data points that skew P values constitutes a falsification of data, unless statistical testing confirms their removal. Some journals may request the raw data sets for in-house analysis (42,55). This journal's review process has detected authors' deception (55).

Other examples of scientific misconduct deal with image manipulation, which has been done in many cases to fabricate data or remove or hide an extra band and avoid additional scrutiny and explanations necessary to satisfy reviewers. Many journals have explicit instructions concerning acceptable and unacceptable practices regarding processing of images (8,48). What motivates the scientist to do this varies from fear of rejection of a grant application to avoidance of extra work: the need to repeat experiment(s) to produce publication-quality images or having to perform additional experiments. Authors may believe that manipulation of images that enhance the image, remove background, or make other corrections to remove extraneous or desired gel band(s) is acceptable behavior (48). There are software programs available or being developed to determine if images have been manipulated (45,46). Journals may also ask authors what image software was used to produce or analyze images (48). The *Journal of Cell Biology* published an excellent discussion concerning digital images and what is ethically permissible (48). Obviously image software is necessary to label lanes or molecular weight standards and even analyze data (e.g., densitometry), but was the image manipulated to deliberately deceive reviewers and ultimately the reader?

There are examples where an action taken by an author may not be an attempt to deceive but stems from confusion, inexperience, and misconceptions concerning the review process. There are several journals that set page or word limits for published articles. It is therefore a challenge to determine how much information to include. Which data stay? ''Data not shown'' represents figures, tables, or graphs that were necessary to convince reviewers of the author's argument(s) but not essential or as essential as other data for readers to comprehend the findings. What constitutes ''data not shown'' is often dictated by reviewers and the editor or through discussions between the author and editor on how to reduce the length of a manuscript. As journals have become ''electronic,'' the solution to this dilemma has come in ''online'' supplements, especially for ''complex data sets'' (5).

AUTHORSHIP

Personal stakes are high in research as tenure, promotion, and pay raises are determined by quantifiable measures of research success: grants, grant dollars, and peer-reviewed publications (33). Grant awards and renewals are determined based on relevance, originality, the researcher's expertise, probability for success, and past productivity. Again, what better measure of a researcher's potential for success and productivity than publications? Unfortunately, these are the same pressures that motivate some to publish redundant or duplicate publications, as well as the least publishable unit (LPU). A LPU is the minimum amount of data an author can publish, or try to publish, to have as many papers as possible from a single study. Unfortunately, this practice, also referred to as ''salami-slicing,'' produces a fractured and incomplete story that dilutes and detracts from the body of work. Although the study may be well designed, and the results and interpretation adequate, reviewers and editors may still reject the manuscript if the work is considered incomplete.

Conflicts arise in clashes between junior and senior scientists over quantity *vs.* quality of publications. The measure of success for a senior scientist is in the quality or impact of their work. This can be measured by a journal's impact factor (Journal Citation Reports®, http://scientific.thomson.com/products/jcr/), a score tied to the journal's citations within a field, and the number of times an article is cited in the literature. Authors can track an article's popularity through journals that track this information (American Society for Microbiology; Proceedings of the National Academy of Sciences USA), through PubMed and ''Links'' cited in PubMed, or subscription to a web-based search engine, such as Web of Science (http://scientific.thomson.com/products/wos/). Therefore, while the junior scientist or assistant professor is going to be evaluated by the number of publications, the senior scientist or associate professor needs to demonstrate impact.

Most conflicts that I've experienced or observed between colleagues and students are attributed to credit and authorship. The first obvious question is What constitutes authorship? Authorship is granted to any individual who has made a significant contribution to the study, and this contribution may be through an idea for study or experiments, study and experimental design, data analysis and interpretation, an expertise essential to the proposed study, writing of the manuscript, editing and submission of the work, or any combination of these tasks (39). With authorship comes responsibility. By placing one's name to a manuscript implies equal responsibility for all authors, on the validity of the work submitted for review (31). Scientific journals generally require that *all* authors ''agreed to its submission,'' assume ''responsibility and accountability for results,'' and transfer copyright to the publisher (5,7). Some journals will require this agreement in writing from all parties involved in the work (7). Any impropriety concerning a manuscript committed by one of the authors reflects badly on all, sometimes adversely affecting innocent parties involved in the work (20). A journal will retract the offending article, publish its retraction notice including a posting in PubMed, and take significant action by banning the offending author from publishing in its journal (5). The editor may even notify the author's employer of this offense (5,6,51). Publishing in most journals (5) also infers responsibility by the author(s) to make available to other researchers any cell line, strains, isolates, plasmids, or specific reagents (e.g., monoclonal antibody) described upon request. Nucleotide and amino acid sequences must also be deposited in GenBank (http://www.ncbi.nlm.nih.gov/Genbank/index.html).

The most important authors are the first author, the senior author, and the corresponding author, especially with regards to assigning credit as it pertains to employment, promotion, and merit raises. The first author is generally viewed as the individual who made the most significant contribution *and* wrote the majority of the first draft (39). The senior author is responsible for the idea(s) for the study, securing funding necessary for the study, generally the study and experimental design, and coordination of the research efforts. The senior author is involved in not one but most facets of the work and the impetus behind the work described in the manuscript. The senior author's name generally appears last in the list of authors. The corresponding author is responsible for communicating and synthesizing all coauthors' work and comments into the final manuscript and submission of and correspondence about the manuscript to the journal (39). Once published, the corresponding or senior author is the conduit through which information including strains, plasmids, etc., is disseminated to the general public upon request (5). The corresponding author is usually the first or senior author. The other authors are listed in the order relative to their contribution or effort associated with the manuscript, with the second author providing major contributions following the first and corresponding authors' efforts, and so on.

As a research scientist matures into an independent investigator, their publication record is also expected to change toward fewer first-author publications and more senior-authored papers. The first authors become the students and postdoctoral fellows trained and mentored by this new investigator, who now takes the mantle of senior author. However, some departments, research units, or colleges place more emphasis on first- or second-author status toward promotion, pay raises, and tenure (33), and this may generate conflict among authors concerning credit.

I have witnessed and been involved in many arguments over authorship concerning one's credit assigned to the manuscript relative to their contribution *vs.* others, as well as who on the list of authors actually deserves authorship. Who does deserve authorship, and who does not? Directors, department heads, or research unit leaders are not entitled to authorship just because the research was done in their unit, nor is their providing funds for their unit sufficient for authorship (25), without providing some intellectual contribution to the work presented for publication. As all authors are responsible and accountable, this practice of honorary authorship or gift authorship, authorship given to colleagues without fulfilling a necessary requirement of authorship (25), can have potentially negative consequences if the work proves fraudulent (32,40).

Others not entitled to, but who can be granted, authorship are any individuals who perform a specific activity used in the study that is part of their job description or is a routine service or function that they perform (39). Therefore, research technicians are not guaranteed authorship unless the contribution was more (e.g., writing and analysis) than dictated by the job description. Also, an individual, or their supervisor, who is paid to provide a service used in the study is not entitled to authorship. However, if the individual provided more than financially contracted (e.g., data analysis and interpretation), then a stronger case can be stated for coauthorship.

So how does one avoid these problems and conflicts? Discussions concerning authorship needs to take place before the study is even initiated, to work out conflicts before they arise and establish compromise that satisfies most everyone involved (19). These discussions probably need to be revisited during and upon completion of the study. The senior author may need to serve as an impartial mediator in disputes that may develop between coauthors, or solicit the help of an outside arbitrator concerning ownership issue and correspondence of said work. Probably most important, all authors need to be aware of each others' expectations concerning a work and its publication.

CONFLICT OF INTEREST

Conflict of interest is an issue that has garnered considerable discussion recently among editors of medical journals (28,29,30) and received the attention of the *Wall Street Journal* (14). Some medical and scientific journals are now requiring that authors disclose their financial dealings with a company where said company has a financial interest in the study under review (28,29,30). Also at issue is the financial motive behind a company's support of a clinical study. Is the study's intent to promote the benefits of the company's product and to serve as an advertisement (50)? The ethical dilemma is whether this financial arrangement will bias or cloud the researcher's judgment or conduct, putting at risk the truth, the public's trust, and possibly public health (28,50). Why would this issue in general concern those in agricultural and veterinary fields?

While U.S. federal support of medical research has increased exponentially, extramural funding of agricultural research has been modest, increasing only 1.6× over 20 years compared to 4.5× increase in the medical research budget (2). Private, corporate funding provides alternate avenues to fund research. However, a company's interest is, by its nature, one focused on commercialization and profit potential. While the scientist is interested in the timely publication of the industry-supported research, the company may want to withhold this information from the general public for proprietary reasons or delay publication pending patent application(s) (52). Therefore, this financial arrangement may prove contrary to the interests of both parties. It does not mean that researcher and company cannot find common ground and an arrangement that accommodates both sides. Ultimately, companies do have a vested interest in research published in peer-reviewed journals, as they may seek regulatory approval, and general interest in their product. There have been concerns that a company may pressure the researcher from disclosing any information from the study questioning their product's safety or efficacy, or the researcher may compromise standards in the performance, evaluation, and reporting of a study when there are financial conflicts (28). Several medical and scientific journals are now requesting full financial disclosures by authors regarding work involving a company's product or financial support of work described in the manuscript (28,29,30). Editorial boards are not against industry-supported research nor condemn financial arrangements between the scientist and a company but want transparency for readers to fully and critically evaluate and assess the validity and veracity of the study for themselves. This is the goal of every editorial board for every paper published, regardless of the study's funding source or researcher's affiliations. A company also wants transparency in the review process for the same reasons that they want the research published. Most researchers are quite capable of being objective and unbiased in their critical assessment of the data. A case in point is a recent assessment of financial conflict-of-interest disclosures for members of Food and Drug Administration advisory committees, which found a very minimal affect on voting approval for new drugs (37). In this study ethicists found that despite 28% of members' having some financial conflict with a company and its drug being evaluated, this did not appear to affect the vote favoring or opposing approval of the drug. The findings of this study suggest that despite financial conflicts, individuals can make unbiased decisions. As with authorships, conflicts can be avoided through early discussions and negotiations. Collaboration between academia and industry can and do work well to benefit all: researcher, the company, scientific community, the user, and ultimately the consumer. We need the translation of basic research into the commercial products, today's vaccines and antibiotics, used to combat poultry diseases, which sustain a multibillion-dollar poultry industry that produces a wholesome and safe product for consumers.

CONCLUSIONS

While greed and desire for fame fuel some to perform unethically, good people may do bad things out of fear, desperation, the pressure to produce, and ignorance. Many of us struggle with deadlines and priorities as we juggle our careers and personal life. So how do we avoid these conflicts and circumstances in our own lab? It starts with early and continuing dialog regarding expectations for 1) research, 2) authorship, 3) employment, and 4) promotion. This dialog is not just between students, our technicians, visiting scientists, and us, but we need to have this conversation with our department head, research unit leader, or dean. Subsequently, we then need to prioritize and periodically reevaluate our priority list: are we on track? The lab also needs to have a clear understanding of ethical and proper conduct of science from the start, and what it will take to become productive and successful.

Planning is the key to being a successful researcher. Planning is not just limited to the study and experimental design, identification of controls, repetitions needed, or data analyses required, but includes responsibilities and expectations for each researcher, the potential venues for publishing the study, authorship, and what it will take to bring the study to its fruitful completion and publication. All members involved in the study need be involved in some aspect of this process. Finally, careful and detailed record keeping is essential to the scientific process and the "timely" completion of any research study. The laboratory notebook needs to be kept in sufficient detail so that anyone in the lab can repeat any experiment described therein. Readers are referred to *Scientific Integrity* (38) and *At the Bench* for details concerning proper record keeping (17). This practice ensures reproducibility and the timely submission of the work described. Students will graduate, and postdoctoral fellows will move on to start their own research labs. A detailed laboratory notebook with complete records of data collected helps the investigator finish unfinished work. Problems arise when the researcher has difficulty repeating experiments or completing work described in a member's lab notebook due to 1) poorly described experiments, 2) inconsistencies and incompleteness in data collection and analyses, 3) poor-quality images, 4) absence of controls, and 5) missing data. The laboratory notebook also documents contribution, and if audited, verification that work was properly performed.

Ultimately, scientists need mentoring. Young researchers need help or advice navigating academia and the journal and grant review process. They need our assistance in handling personnel issues and conflicts. We senior scientists need to mentor young scientists. They are our replacements, if not our legacy. While independence is essential to maturation of the scientist, the junior researcher also needs to recognize when they might need advice. We all need to be aware of what is happening in our own labs, to be aware and actively participate in the research process. We also need to be willing to listen, discuss, and resolve problems. Most importantly, we need to periodically reflect and assess whether our actions are ethical in the performance of our job.

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