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Authorship: why not just toss a coin?

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IF YOU ARE READING THIS COMMENTARY, the title probably irked your professional sensibilities. That's good. During 32 years of publishing, I've experienced two authorship disputes. Both of these problems have demonstrated to me that there is a disturbing and pervasive lack of understanding of what authorship on scientific papers means, of the responsibilities that it conveys, and of how it is determined. The goal of this article is to discuss the ethics and responsibility of authorship and to raise awareness of an issue that is fundamental to the health of our profession. I provide an overview of the extensive discussion of authorship that has been ongoing within the scientific community for over three decades, use personal experiences with authorship disputes to illustrate aspects of this discussion, and provide recommendations on how to resolve and prevent authorship problems. It is my hope that this commentary sparks debate and action that will help to minimize abusive and damaging authorship practices.

A Brief History of Scientific Authorship

The scientific enterprise expanded dramatically after World War II, ushering in what Jones (25) termed the "era of Big Science." This expansion was due in part to the increase of government funding for research, increases in science education, technological developments, and increased commercialization of scientific discoveries (11). As the scientific workforce expanded, so did the number of science publications (11) and the number of coauthors on those publications (8, 9, 19, 42). Science publishing became big business and today comprises a multibillion dollar a year industry (3). Along with the expansion of the science workforce came increased competition for jobs and funding, and publications thus became a valued currency of the scientific enterprise.

The Benefits and Responsibilities of Authorship

Scientists uniformly understand the benefits of authorship. If they didn't, authorship would not be something that was sought after and at times hotly contested. What is disturbing though are the varying standards that are applied in deciding authorship and the frequency of "promiscuous authorship," which is the awarding of authorship to someone who has not contributed in an intellectually significant way to the paper (14, 15). A distressing example of the varying standards applied to authorship came recently from a physician colleague. She had asked me about the definition of "senior author." Her understanding was that it was an individual who was one of the main contributors to a paper, which is an incomplete but still reasonable definition (see below). However, a coworker had informed her that the last or "senior author" position on a paper was given to a chairman or other senior person as a gesture of respect and didn't have any meaning. The case of Gerald Schatten discussed below is the quintessential example of how terribly misguided that notion is.

The following is an excerpt from *The Guidelines for the Conduct of Research in the Intramural Research Program at NIH* (39) that defines succinctly the importance of authorship on scientific papers: "Authorship refers to the listing of names of participants in all communications, both oral and written, of experimental results and their interpretation to scientific colleagues. Authorship is the fulfillment of the responsibility to communicate research results to the scientific community for external evaluation. Authorship is also the primary mechanism for determining the allocation of credit for scientific advances and thus the primary basis for assessing a scientist's contributions to developing new knowledge. As such, it potentially conveys great benefit, as well as responsibility."

Authorship obviously conveys professional benefit. Students in many biomedical research graduate programs cannot earn a Ph.D. without publishing one or more first-authored papers. Promotion and tenure at research institutions are determined in part by publication. External professional recognition, including extramural funding, requires publication as a demonstration of research innovation, productivity, independence, and expertise in a research area. Awarding authorship to someone who has not contributed significantly to a scientific investigation inappropriately and dishonestly conveys benefit to them. It can also reduce appropriate benefit to those who actually contributed to the work. For example, the perils to an independent junior investigator's career if he or she publishes with senior scientists are well known. In such instances, a common question asked on promotion committees and study sections is, who was intellectually responsible for the work?

Importantly, authorship also conveys responsibility. Authoring a scientific paper implies an unqualified endorsement of the quality and integrity of the work performed as well as the appropriate distribution of credit for that work. You can only assume responsibility if you were intellectually engaged in the work and in writing the manuscript. Assuming the responsibility that goes with authorship is not only an ethical obligation, but also a debt we owe for the patronage of taxpayers and private benefactors.

The Tactics of Authorship Abuse

Promiscuous authorship assumes many forms. "Coercive authorship" has been defined as authorship conferred to individuals in response to their exertion of seniority or supervisory status over subordinates and junior investigators (11, 29; see also 6, 33, 56). A department chair, for example, is using coercion when he/she requires authorship on all papers published from his/her department, but has little or no intellectual input into them. Kwok (29) has termed the attempt by senior individuals to force their way onto the publications of subor-

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dinates and junior investigators in the absence of appropriate intellectual contribution as the "White Bull effect" and has argued that such behavior is a form of fraud and scientific misconduct.

Authorship coercion does not occur exclusively between senior and junior investigators. Coercion tactics were used in my two authorship disputes. In the first dispute, a threat was made to university administrators to withdraw an in-press manuscript authored by one of my students if authorship was not granted. The second dispute deteriorated into, among other things, threats to remove graduate students from my laboratory. Both of these disputes involved demands by individuals who had not fulfilled key authorship criteria that are discussed in detail below.

Intimidation tactics can impact not only those who rightfully should be authors, but also individuals charged with helping to resolve authorship disputes. Unprofessional behavior leads some individuals to choose a path of expediency in an effort to make problems go away quickly and quietly. I learned of my first authorship dispute only after complaints had been made to two senior administrators. Both administrators urged me to put the name of the person demanding authorship on the paper "just this once." In exchange for this, I was told that they would write and get this individual to sign a letter stating that no demands for authorship would be made on any of my future publications.

Other forms of authorship abuse include "honorary," "guest," or "gift authorships," which are defined as the awarding of authorship out of respect or friendship, in an attempt to curry favor, and/or to give the paper a greater sense of legitimacy (11, 15, 45, 49). "Mutual support" authorships have been defined as an agreement by two or more investigators to place their names on each other's papers to give the appearance of higher productivity (11). "Duplication authorship" is the publication of the same work in multiple journals (13, 38). Reward systems that emphasize numbers of papers over quality foster "mutual support" and "duplication" authorship abuse.

"Ghost authors" are authors whose names are omitted from a paper (11, 18, 37, 41, 45). There can be numerous deceitful reasons for ghost authorship. For example, it is well known that some pharmaceutical companies hire professional writers to write papers favorably describing their products. A bona fide academic is then asked or hired to sign their name to the paper to give it and the product legitimacy (11, 37). Ghost authorship has figured prominently in the recent legal actions over the drug Vioxx (46). The well-publicized problems with Vioxx represent an example of how abusive authorship practices can directly impact human health.

A particularly serious form of ghost authorship is termed "denial of authorship" (25, 27). The most typical example of this involves individuals who participate in generating data for what they presume is a legitimate scientific collaboration. However, the other so-called "collaborators" publish a paper using these data without giving the investigators coauthorship or accurately acknowledging their contribution. I have unfortunately heard multiple stories about this type of authorship abuse. It should be stressed that denial of authorship can rightfully be considered a form of plagiarism and therefore scientific misconduct. Table 1 summarizes the forms of authorship abuse described above.

The Consequences of Authorship Abuse

Inappropriately assuming authorship on scientific papers can and should have significant negative consequences for those who choose to do so. One of the most infamous examples of the consequences of promiscuous authorship is the "Darsee affair" (12, 25, 51). Dr. John Darsee was a clinician investigator who worked at Harvard Medical School and Emory University School of Medicine. From 1978 to 1981, Darsee authored or coauthored 18 full-length research papers and over 100 abstracts, reviews, book chapters, and short papers in the field of cardiology. In May 1981, Darsee admitted to fabricating data in a single paper. However, investigative committees at Harvard, Emory, and the National Institutes of Health (NIH) ultimately concluded that more than 100 of his publications contained fabricated data (51). Many of the fraudulent publications listed authors who had made no contribution to the work. In some cases these authors became aware that their names were associated with the work only after publication, while in other cases, individuals knowingly accepted the "gift authorship" (25, 51). When the publications were shown to be fraudulent, the "gift authors" were placed in the disquieting position of proving that they had not participated in the fraud and rationalizing why they could take no responsibility for the work even though they had assumed authorship of it.

Another infamous case of fraud and promiscuous authorship is that of Robert Slutsky, a clinical investigator at the University of California at San Diego (UCSD). From 1983 to 1984, it was estimated that Slutsky published on average one paper every ten days (32, 35). An investigating committee at UCSD concluded that as many as 68 of Slutsky's publications were likely to be fraudulent or of "questionable validity" (35). As with Darsee, gift authorships were a common feature of Slutsky's publications. The UCSD report states that knowing acceptance of coauthorship by investigators who had made no

Table 1. *Types and descriptions of authorship abuse*

Type of Authorship Abuse	Description
Coercion authorship	Use of intimidation tactics to gain authorship. Arguably a serious form of scientific misconduct (see Ref. 29).
Honorary, guest, or gift authorship	Authorship awarded out of respect or friendship, in an attempt to curry favor and/or to give a paper a greater sense of legitimacy.
Mutual support authorship	Agreement by two or more investigators to place their names on each other's papers to give the appearance of higher productivity.
Duplication authorship	Publication of the same work in multiple journals.
Ghost authorship	Papers written by individuals who are not included as authors or acknowledged.
Denial of authorship	Publication of work carried out by others without providing them credit for their work with authorship or formal acknowledgment. A form of plagiarism and therefore scientific misconduct.

significant contribution to the work made a "mockery of authorship of scientific manuscripts, and in this case may have contributed to the perpetuation of research fraud" (35).

A recent example of promiscuous authorship is the "Korean stem cell scandal." Dr. Woo Suk Hwang is a South Korean scientist who published two high-profile papers in *Science* in which it was claimed that embryonic stem cells could be generated by somatic cell nuclear transfer (22, 23). Both papers were shown to contain fabricated data and were retracted (28). Dr. Gerald Schatten, a scientist at the University of Pittsburgh, assumed senior authorship of one of these publications (22). When the work was revealed to be fraudulent, Schatten made significant efforts to distance himself from it (21, 34, 53). He was subsequently placed under investigation by the University of Pittsburgh. No evidence was found that Schatten had falsified any aspect of the *Science* publication, but he was found guilty of "scientific misbehavior" (21, 34, 53). The phrase "scientific misbehavior" is probably unfamiliar to most scientists. However, a recent paper in *Academic Medicine* defines "scientific misbehavior" as "problematic" or "questionable" behavior and is distinct from scientific misconduct, which is fabrication and falsification of data and plagiarism (4).

Schatten claimed that he had helped write the fraudulent manuscript. However, he had not participated in or overseen any aspect of the investigation and had little or no interaction with most of the scientists involved in the studies (21, 34). He therefore could not take responsibility for the integrity of the studies and could not ensure that the listing of the coauthors reflected correct distribution of credit (or discredit in this case). In addition, Schatten could not ensure that all coauthors had approved the manuscript for submission even though he stated in a signed cover letter that they had done so (21, 34). The University of Pittsburgh investigators concluded that Schatten's authorship of the paper was appropriate given the role he played in writing the manuscript, but they criticized his assumption of co-corresponding and senior authorship. A summary of the report stated that "Dr. Schatten's listing as the last author not only conferred considerable credibility to the paper within the international scientific community, but directly benefited Dr. Schatten in numerous ways including enhancement of his scientific reputation, improved opportunities for additional research funding, enhanced positioning for pending patent applications, and considerable personal financial benefit. However, these benefits are accompanied by responsibilities for the manuscript as a whole, approval of the manuscript by all co-authors, and the veracity of the data reported. Dr. Schatten shirked these responsibilities, a serious failure that facilitated the publication of falsified experiments in *Science* magazine" (53).

University of Pittsburgh investigators also examined a *Nature* paper coauthored by Hwang and Schatten (31) that described the cloning of a dog. The so-called "Snuppy paper" was not fraudulent, but the investigating committee questioned Schatten's assumption of coauthorship since his only contribution was to suggest "that a professional photographer be engaged so that Snuppy would appear with greater visual appeal" (53). Some scientists have questioned whether the University of Pittsburgh report went far enough in penalizing Schatten for his behavior (34).

How to Minimize and Prevent Authorship Abuse

Who gets to be an author? Most scientists are unaware of the extensive discussion of authorship that has gone on in the scientific community for at least three decades and of the formalization of authorship criteria. The most prominent and widely utilized authorship guidelines are those established by the International Committee of Medical Journal Editors (ICMJE). The group first met in 1978 in Vancouver, British Columbia, Canada, to develop standards for publication of papers in biomedical journals and produced its first set of authorship guidelines, the Uniform Requirements for Manuscripts Submitted to Biomedical Journals, in 1979. These guidelines have been revised several times and have been adopted by hundreds of journals. The most recent version of the Uniform Requirements (24) states that "Authorship credit should be based on *1*) substantial contributions to conception and design, or acquisition of data, or analysis and interpretation of data; *2*) drafting the article or revising it critically for important intellectual content; and *3*) final approval of the version to be published. Authors should meet conditions 1, 2, and 3. Acquisition of funding, collection of data, or general supervision of the research group, alone, does not justify authorship. All persons designated as authors should qualify for authorship, and all those who qualify should be listed. Each author should have participated sufficiently in the work to take public responsibility for appropriate portions of the content." Table 2 summarizes the ICMJE author requirements and outlines contributions that do not qualify for authorship.

A concern that has been raised about the Uniform Requirements and other authorship guidelines is the definition of "substantial contributions." What constitutes a "substantial contribution" to a scientific paper? Perhaps this will always represent a gray area in any set of authorship guidelines. However, I believe that the Uniform Requirements provides two important thresholds that must be met before a contribution is deemed significant enough for authorship. The first threshold is the requirement that all authors participate in the drafting or revising of the manuscript for "important intellectual content." Someone who has made a significant contribution to the work should at a minimum be able to draft or revise the portion of the manuscript in which that contribution is

Table 2. *ICMJE requirements for authorship and examples of contributions that do not qualify for authorship*

Requirements for authorship
"Authorship credit should be based on
1) substantial contributions to conception and design, or acquisition of data, or analysis and interpretation of data;
2) drafting the article or revising it critically for important intellectual content; and
3) final approval of the version to be published.
Authors should meet conditions 1, 2, and 3."
All authors should be able to take public responsibility for their contribution to the work.
Examples of contributions that do not qualify for authorship but that should be acknowledged in the paper
1) Providing funding, technical advice, reagents, samples, or patient data.
2) Providing students or technical personnel who perform studies.
3) Routine collection of data.
4) General supervision of the research group.

described. On the other hand, individuals who have made ancillary contributions will be unable to describe those contributions within the intellectual context of the manuscript. For example, imagine someone who demands authorship in exchange for providing funding, a reagent that has been described in a previous publication, or technical advice. Because there is nothing intellectually original or significant about such contributions, there is nothing that can be written about them in the manuscript. Providing funding, reagents, or advice deserves acknowledgement, not authorship.

The second threshold that needs to be met is the requirement that all authors must be able to take public responsibility for the contributions they have made to a paper. If you have done something significant for a paper, then you should be willing and able to take public responsibility for it. Individuals who have not participated in a significant way in the work are unable to take responsibility. Indeed, promiscuous authors are often the first to duck and hide when there are problems with a paper. Gerald Schatten's attempts to distance himself from the fraudulent stem cell paper (22) is a good example of this.

Numerous organizations, universities, and research institutions have also established formal authorship guidelines. These include the National Institutes of Health (39), the Society for Neuroscience (50), Harvard University (20), Yale University (58), the University of Michigan Medical School (52), and Washington University (57). In reading these and other guidelines, I found that there is broad consensus. Authors of scientific papers must have contributed in an intellectually significant way to the work, they must be able to take public responsibility for that contribution, and they must have participated in writing the manuscript.

The U.S. Department of Health and Human Services' Commission on Research Integrity recommended in 1995 that all research institutions, journals, and scientific societies establish and make public authorship policies (54). This recommendation has by no means been fully heeded. I have little doubt that the establishment of authorship policies and their inculcation into our scientific culture would lessen the frequency of authorship abuse and contribute to more rapid resolution of authorship problems.

Should technicians be authors? The answer to this question is, yes, as long as they have contributed to the paper in an intellectually significant way. Jones (26) describes authorship guidelines of Rush Medical College that specifically addresses the question of technician coauthorship. The guidelines state that "a technician. . .may be a co-author of a publication if, in the opinion of the Principal Investigator, the said individual has made a substantive contribution to the work over and above actually performing required tasks. If the technical staff (support) person has performed studies prescribed by the PI, but has not made contributions to the experimental design, data analyses, data interpretation, or rationale for the study, then co-authorship is not automatically earned."

My policy, which I discuss with all technician candidates during the interview process, is that simply performing routine experimental tasks does not qualify them for authorship. I encourage all technicians to engage themselves intellectually in their projects. Authorship is an incentive to do so. Technician contributions that I consider worthy of authorship include independent establishment of new, nonroutine methods essential for a project and participation in experimental design and data interpretation. I use the same thresholds for authorship with technicians as I would for any coworker. Their contribution must be significant enough such that it requires their participation in the drafting and revision of the manuscript, and they must be able and willing to take public responsibility for it.

Authorship order and its meaning. Scientific papers were most commonly authored by single individuals from the late 1600s until the 1920s. However, in today's multidisciplinary research world, papers coauthored by multiple individuals are the norm (19). Appropriate assignment of credit and responsibility represents a critical challenge in multiauthor and multidisciplinary publications.

While there is good agreement on the minimum requirements for authorship of scientific papers, the benefit and responsibility conferred to a specific position on an authorship list seems to be somewhat more obscurely defined. With the exception perhaps of papers describing "big science" projects such as genome sequencing and analysis (e.g., 7) or particle physics (e.g., 1), where there can be literally dozens if not hundreds of coauthors, it is not clear why there should be problems with definitions of authorship order. In the case of most biomedical research publications, it is widely accepted that the first author is the person who has carried out a majority of the experimental work described in the paper (5, 17, 47). For example, Ph.D. students are obviously required to perform the bulk of their thesis work, and they must contribute significantly to the intellectual development of their project. It follows logically therefore that the student should be first author on at least one or more publications arising from that work. Indeed, many Ph.D. programs require publication of at least one first-authored paper for graduation.

As discussed above, there are some disturbing notions about the meaning of "senior author." Senior author is typically the last person on an authorship list. The Schatten case illustrates that senior authorship must never be awarded to someone simply because of their seniority, rank, or standing in the field. McKneally (36) defines senior authors as individuals who "generally direct, oversee, and guarantee the authenticity of the work reported" and "implicitly take responsibility for the work's scientific accuracy, valid methodology, analysis, and conclusions". Baerlocher et al. (5) define senior author in a similar way. I believe that the most important role of the senior author is to take responsibility for the project as a whole. You cannot do this if you were not actively engaged in all aspects of the study, including checking and analyzing the data and writing the manuscript.

Corresponding author is an individual charged with communicating with editors and readers. Callaham (10), in an editorial on publication policies of the *Annals of Emergency Medicine*, states that the corresponding author should also provide specific information on the contributions of all coauthors to the paper. Other journals have a similar requirement [e.g., *PLoS Biology* (43)]. *PLoS Genetics* requires that the corresponding author "ensure that all authors are aware of and approve the submission of the manuscript, its content, authorship, and order of authorship" (44).

The corresponding author is typically the first or last author (5). However, corresponding authorship is frequently used as a way to "share" credit between senior individuals and is also assumed by others, typically the second to last author. Whether

that credit is actually deserved is an important point. As with the senior author, the corresponding author needs to be extensively involved with the work to address the concerns/questions of editors, reviewers, and readers and to provide information on coauthor contributions. The position of corresponding author must be assumed only by someone who can fulfill these important obligations and responsibilities. Corresponding authorship should not be used simply to resolve conflicts over senior authorship.

"Middle" or "contributing" (5) authors of a paper are those individuals listed between the first and senior authors. The ordering of middle authors should reflect their relative contribution to the work. Ahmed et al. (2) suggest a scoring method that may be useful for assessing relative contributions in contentious situations. Table 3 summarizes the requirements and responsibilities of first, senior, corresponding, and middle/contributing authors.

Publication of author contributions. Some journals such as the *Proceedings of the National Academies of Sciences* require coauthors to publish their contributions to the work as a footnote in the paper. *Nature* journals encourage authors to do so. In a recent issue of *Nature* that I examined, 12 of the 16 articles and letters published included descriptions of coauthor contributions. Even an article coauthored by 68 investigators did so. In my opinion, publication of coauthor contributions, either in the printed text or as an online supplement to the paper, should be uniform policy for all journals. For publications from my laboratory, I now include this information in the acknowledgments section of the paper unless otherwise specified by the journal. As with the scientific content of a paper, the knowing falsification of published coauthor contributions should be viewed as a form of fraud and therefore scientific misconduct. Holding the publication of coauthor contributions to such a high level of accountability would undoubtedly reduce authorship abuse.

Table 3. *Requirements and responsibilities of coauthors*

Author Category	Contribution and Responsibility to the Work and Publication
First author	Fulfills ICMJE authorship criteria. Performs bulk of the experimental work.
Senior author	Fulfills ICMJE authorship criteria. Typically the last person on an authorship list. Directs, oversees, and guarantees the authenticity of the work. Takes responsibility for the scientific accuracy, valid methodology, analysis, and conclusions of all work described in the paper. Able to explain all of the results described in the paper.
Corresponding author	Fulfills ICMJE authorship criteria. Typically assumed by the first or senior author. Communicates with editors and readers. Provides specific information on the contributions of all coauthors to the paper. Ensures that all authors are aware of and approve the submission of the manuscript, its content, authorship, and order of authorship.
Middle/contributing author	Fulfills ICMJE authorship criteria. Contributions do not rise to those of first or senior author. Order of middle/contributing authors should reflect their relative contributions to the paper.

ICMJE, International Committee of Medical Journal Editors.

Keeping intra- and interlaboratory collaborations on track. An important strategy for preventing authorship disputes is to choose and structure intra- and interlaboratory collaborations carefully. *PLoS Computational Biology* recently published an article entitled "Ten simple rules for a successful collaboration" (55). Many of these rules represent excellent strategies that would help avoid authorship problems. The rules that I think are particularly important are summarized below.

"Rule 1: Do Not Be Lured Into Just Any Collaboration." I suspect that many collaborations are "marriages of convenience." Someone needs you to do something for them or vice versa. One should enter a collaboration only because of a shared passion for the science. Everything else including ideas, reagents, and expertise should be shared without strings attached. Only assume authorship if you are truly intellectually engaged in the work and engage yourself intellectually only after working out an authorship agreement.

"Rule 2: Decide at the Beginning Who Will Work on What Tasks." I firmly believe that everything, including authorship, should be established in writing at the outset of a collaboration. The NIH Ombudsman and others have proposed the use of "collaborators' prenuptial agreements" or written guidelines when establishing scientific collaborations (16, 30, 48). Defining the parameters of a collaboration in writing is something I now do unfailingly, even with good friends with whom I've worked for years. Some might argue that the use of written agreements runs counter to the informal nature of science and that it can undermine collegiality and trust. However, collegiality and trust are undermined by unprofessional, unscrupulous, and opportunistic individuals, not by thoughtful hashing out of how a collaboration will be carried out and how the work will be published.

In addition to establishing written authorship agreements at the outset of a collaboration, I have now made it official laboratory policy to include an "authorship verification document" with all manuscript submission letters. This helps to underscore the importance and responsibility of authorship, particularly with students and fellows. The basic text of the document is as follows: "We the undersigned attest that the contributions outlined below of the co-authors of the manuscript describing THE RESEARCH are accurate. The senior author further attests that no individuals other than the undersigned contributed to the intellectual development of this project. Intellectual development includes proposing, designing, performing and supervising experiments, analyzing and interpreting data, formulating hypotheses and ideas described in the manuscript, and writing and approving of the final version of the manuscript. Individuals who have provided reagents or technical and financial support have been noted in the acknowledgments section."

"Rule 5: Feel Respect, Get Respect." The lack of mutual respect in a collaboration is a serious problem. Watch for and pay attention to seemingly little signs from "collaborators" such as "one-ups-manship," unwillingness to share information and reagents, failure to perform agreed upon tasks in a timely manner, and passive/aggressive behavior. These are strong indicators of possible bigger problems to come.

"Rule 6: Communicate, Communicate and Communicate." I don't believe that there is such a thing as overcommunicating when involved in a collaboration. The progress of a project should be discussed frequently to anticipate and correct problems in a timely manner and to ensure that everyone is holding up their end of the agreement. Very importantly, as the project develops, it may be necessary to renegotiate authorships and to redefine them in writing.

How to Resolve Authorship Problems

Once an authorship problem occurs, it can be exceedingly difficult to resolve. In my opinion, a principle of expediency should never be applied in addressing authorship disputes. Authorship should only be earned through significant intellectual contribution to the work, and the order of authorship should reflect the appropriate distribution of credit and, importantly, responsibility. Of course, when students are caught in the middle, careers and funding are at stake, and there is an imperative for rapid publication of important findings, authorship disputes can become a true test of one's willingness to adhere to high standards of professionalism, ethics, and responsibility. Ethical compromises are possible and reasonable solutions to some problems. For example, disputes over assignment of first author when multiple individuals have performed significant and critical amounts of work can potentially be resolved by assignment of co-first author with notation of such in the text.

When authorship disputes cannot be resolved by the authors themselves, the institution in which the work was performed needs to engage in some sort of conflict resolution. Importantly though, the institution, in my opinion, must never be allowed to insert itself into the publication process as a decision-making body. Repeated demands were made during one of my authorship disputes for the formation of committees to "decide" authorship order through a process of "binding arbitration."

I find the notion that an institution can decide the authorship of scientific papers and make such a decision "binding" extremely unsettling. The only people who should decide authorship, order of authorship, and content of a scientific paper are those who did the work. To allow others to make such decisions represents a dangerous precedent with considerable negative consequences for the research and publication process and academic freedom.

An institutional committee engaged in authorship conflict resolution should be fact seeking and advisory only. The committee's job should be to provide a fresh set of eyes on the problem and to assist the individuals involved in the dispute to arrive at an ethical and professional solution. Of course, arriving at such a solution requires adherence to well-established ethical and professional standards. As I argued previously, it is essential that all research institutions have in place well defined authorship policies. This would help resolve many authorship problems quickly and ethically, and it would limit the amount of politics and personal biases that individuals might bring to an advisory committee.

Another function of an authorship conflict resolution committee should be to recommend that disciplinary action be pursued if clear evidence of abusive authorship practices is uncovered. At a minimum, I believe that individuals who abuse authorship should be required to satisfactorily complete the same bioethics course that graduate students and postdoctoral fellows are required to take in NIH-funded institutions. Particularly serious forms of authorship abuse such as "coercion authorship" and "denial of authorship" (see Table 1) should be treated as scientific misconduct and referred to appropriate institutional bodies for further investigation and disciplinary action.

All research institutions should have in place a well-defined and well-recognized mechanism for addressing authorship disputes. Ad hoc development of such a mechanism while one is in the middle of a contentious dispute can be an uncomfortable task for all involved. During one of my authorship disputes, I found myself in the unenviable position of having to educate senior level administrators on what constituted authorship on scientific papers and what the institution could and could not do to address the problem.

Institutional committees charged with examining authorship problems should be composed of both senior and junior inves-

Table 4. *Recommendations for minimizing and resolving authorship disputes*

1. All research institutions, journals, and scientific societies should have in place formal authorship policies. The threshold for authorship on a scientific paper should be a direct and significant intellectual contribution to the study. All authors should have contributed to the writing of the manuscript. At a minimum, each author should have written at least the portion of the manuscript in which his/her contribution is discussed and should be able to take public responsibility for that contribution.
2. All research institutions should have in place a well-recognized mechanism for addressing authorship disputes that cannot be resolved by the authors themselves. Authorship dispute resolution committees should comprise both senior and junior investigators and should be free from all real and perceived conflicts of interest.
3. Research institutions should never be allowed to be decision making bodies in authorship disputes. The role of the institution is to provide a fresh set of eyes on the problem and to assist the individuals involved in the dispute to arrive at an ethical and professional solution.
4. Authorship dispute resolution committees should have the authority to recommend that disciplinary action be pursued if clear evidence of abusive authorship practices is uncovered. At a minimum, individuals who abuse authorship should be required to satisfactorily complete a bioethics course. "Coercion authorship " and "denial of authorship" (see Table 1) should be treated as scientific misconduct and be referred to appropriate institutional bodies for further investigation and disciplinary action.
5. All letters of submission accompanying manuscripts should include an authorship verification statement that is signed by each coauthor and that describes his/her specific contributions.
6. The specific roles of all coauthors should be included in the published article. Deliberate falsification of the description of coauthor contributions should be viewed as scientific misconduct.
7. Every effort should be made to avoid authorship problems from the outset. Authorships should be negotiated and defined in writing at the beginning of an investigation. Frequent communication between all coauthors should occur while investigations are ongoing. Authorship should be discussed regularly and redefined in writing if necessary.

tigators. It might also be worthwhile to consider including senior graduate students and/or postdoctoral fellows on such committees as observers or even participants. This would help to increase awareness among trainees of the importance and responsibilities of authorship and of the consequences and difficulties of authorship disputes. It could also have a "clarifying effect" on individuals inappropriately demanding authorship. After all, no one wants to have a reputation with trainees as one who makes unethical and unprofessional authorship demands and thereby attempts to lessen credit rightfully deserved by others.

A serious concern with institutional involvement in resolving authorship disputes is the need to scrupulously ensure that such involvement is free of conflicts of interest and institutional and interpersonal politics. This can be an exceptionally difficult task and requires diligent and thoughtful effort by administrators charged with addressing the problem. The committee that was formed to review one of my authorship disputes included a member who had published several papers with the individual contesting authorship. It is critically important therefore that all members of an authorship dispute committee sign a declaration stating that their participation is free from real and perceived conflicts of interest.

What happens if a decision on authorship cannot be reached even with the help of an advisory committee? No reputable journal that I am aware of will publish a manuscript if there are disagreements over its authorship or content. Therefore, failure to agree on authorship effectively renders the manuscript unpublishable. This is a disturbing but unassailable conclusion and underscores the critical importance of working diligently to avoid authorship problems from the outset. My specific recommendations for minimizing and resolving authorship disputes are summarized in Table 4.

Summary and Conclusions

We all know that authorship is important. It dictates the course and success of a scientist's career and confers enormous responsibility. However, despite its importance, it is clear that authorship abuse is not an infrequent occurrence. Indeed, of the various forms of unethical scientific conduct, I suspect that authorship abuse is the most prevalent and most tolerated. Authorship is awarded promiscuously as an expedient solution to real or perceived problems and due to outright unethical and unprofessional behavior. It is essential that as scientists we work together with our institutions, our professional organizations, and the journals we publish in to establish uniform authorship policies and practices that will minimize authorship abuse and that we train our students and fellows in the highest standards of publication ethics.

Some might argue that the establishment of formal authorship policies and having written authorship agreements between investigators could hinder scientific progress. I disagree strongly. Hearing about and experiencing first-hand authorship problems has a chilling effect on one's willingness to enter into collaborations and creates a climate of distrust. Furthermore, it is not difficult to imagine how research integrity, quality, and productivity could be improved if all coauthors participated seriously in the work leading to publication. Anyone who desires authorship should be required to engage in research instead of abusing the reward system by holding the legitimate work of others hostage in exchange for reagents, technical advice, patient data, and other ancillary contributions or by using coercive tactics. In addition, tucked away in the minds of those who desire authorship, but who are unwilling to actively participate in the work, could be useful ideas and insights that might actually enhance an investigation or help to establish new lines of research. Finally, the harm that fraudulent papers of people like Darsee, Slutsky, and Hwang have on their fields and on the trust in and respect of science might be prevented or at least reduced if all coauthors were held to high standards of authorship responsibility.

Even with the establishment of well-defined authorship guidelines and mechanisms for resolving and preventing problems though, authorship abuse will still occur. Acquiring something of value is always going to be subject to unscrupulous and opportunistic behavior. However, ignoring or tolerating authorship abuse is unacceptable and dishonest. We owe it to our profession, our trainees, and the people who support our research to work diligently to ensure that authorship on scientific papers reflects the truthful distribution of credit and responsibility for the work. Those who clamor inappropriately for scientific recognition, whether out of a sense of desperation and/or because of bloated and overwrought egos, would do our profession a valuable service by following the advice articulated clearly in a recent *Nature* editorial entitled "Ethics and fraud" (40): ". . . no one should argue ever again that . . . promiscuous authorship on scientific papers . . . can be tolerated . . . Research ethics matter immensely to the health of the scientific enterprise. Anyone who thinks differently should seek employment in another sphere."

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