conduct might have been avoided if authorship standards were universally accepted. Having standards in place would help to identify those practices that are deemed to be appropriate and acceptable by the scientific and publishing communities. Even if authorship disputes arise, their resolution would be facilitated by having standards to which all parties can refer. Finally, promotion of clear standards by a journal may give it a marketable advantage in today's competitive environment. Thus, such standards are in the practical interest of scientists, the government, and publishers.

Conclusion
Publishing enables the scientist to disseminate new knowledge, gain membership in an academic community, and achieve professional recognition. However, the integrity of the publication can only be as credible as the standards adopted by the participating community. Universally endorsed authorship standards may serve to clarify requirements and responsibilities for authors and thereby deter those allegations of scientific misconduct presented to ORI or scientific journal editors that are characterized as authorship disputes. Because CBE's mission is to foster education and improve communication in biology and related fields, it is in a unique position to promote and endorse authorship standards. The CBE has the potential of enhancing its mission, increasing its visibility among the biological publishing community, and playing a vital role in educating the publishing community about the value of authorship standards.

References
[The] increase in team research and multi-authored papers has caused a number of problems for researchers, as well as editors and bibliographers. Frequently, authorship is awarded in an arbitrary manner, with political factors playing a more important role than actual contributions. . . . [Editors] do have the authority to establish guidelines for authorship. Of course, we know that no matter how fair and comprehensive guidelines are, they will not completely halt abuses in authorship.

Another voice was that of a widely read commentator on ethical issues in science, W J Broad (5):

The expanding web of coauthor relationships . . . raises questions about who is responsible for the work. . . . A simple but valuable reform would be for the scientific community to set formal guidelines for the assignment of credit, in particular for the authorship line. Two principles might be set. First, all people named as authors should have made a definable contribution to the work reported. Any minor contribution should be explicitly acknowledged in the text of the article. Second, all authors of a paper should be prepared to take responsibility for its contents in precisely the same measure as they stand to take credit.

Another stimulus to attention to standards for authorship was the Darsee affair (6), in which some coauthors allowed themselves to be listed as authors despite their not having been close enough to Darsee's eventually discredited work to be able to take responsibility for the papers on which they were listed.

My editorial (3) suggesting criteria and standards for authorship was stimulated in part by publication in *Annals of Internal Medicine* of the view (7) of Kenneth Burman, a worker in thyroid physiology, that justifications for authorship and authorship credit needed attention. His paper did not attempt to establish firm guidelines, but it did appear at this critical time of growing attention to problems in authorship.

As suggested above by the mention of pre-1982 references in MEDLINE, these attentions to authorship described above were certainly far from being the first in American biomedicine. Back in 1945 the eminent Harvard physiologist, Walter Bradford Cannon, described in his autobiography (8) how he decided on coauthorship:

If I have merely suggested the problem to be investigated, indicated the pertinent literature, demonstrated the method to be employed, and from time to time have supervised the work, I have not allowed my own name to appear on the published paper as a joint author. Although the beginner who has carried on research in these circumstances has usually thanked me graciously at the end of his report, that acknowledgement has never been requested. When I have participated in the experimental procedures, my name has appeared as one of the authors. If I have done a major part of the work my name has been placed first, but if my role has been secondary it has not had that prominent position.

Perhaps the most cogent statement preceding 1982—one that was the main basis for my 1982 editorial (3) on authorship—was that of Richard Hewitt, one-time head of the Section of Publications at the Mayo Clinic (9), in 1957:

The reader of a report issued by two or more authors has a right to assume that each author has some authoritative knowledge of the subject, that each has contributed to the investigation, and that each labored on the report to the extent of weighing every word and quantity in it.

Hewitt made an even more central point:

Authorship cannot be conferred; it may be undertaken by one who will shoulder the responsibility that goes with it.

Anyone reading the eventually surfacing statement on authorship from the International Committee of Medical Journal Editors (10) will quickly see that these points are its main foundations; the most recently published version of the statement [see sidebar], which is part of the "Uniform Requirements" document (11), does not differ in its essentials from those of its original version.

Additional documents relevant to both the pre-1982 period and questions of other early efforts toward establishing authorship standards are cited in a background paper I prepared in 1988 for the Institute of Medicine (12).

The minutes of meetings of the International Committee of Medical Journal Editors do not make clear who in the Committee suggested that it issue a statement on authorship or why the suggestion came up. The 1st mention of a possible statement is in the minutes of the 15 May 1983 meeting in Philadelphia:

It was agreed that the group should produce a statement on authorship. Dr. Huth will prepare a draft paragraph for the URM ["Uniform Requirements for Manuscripts" document which had already been issued] together with a longer statement to be distributed before the next meeting and discussed at the meeting. [unpublished minutes consulted with the permission of Kathleen Case]

At the next meeting in Cambridge in 1984, the Committee decided that a statement on authorship standards should be issued as separate from the URM guidelines. I could not attend because of a lumbar-disk problem, but the Committee asked me to revise the statement I had submitted and discuss it at the next meeting. I did present revised version of the statement at the next meeting [in Oslo and Tromso, Norway, June
1985). Although the minutes do not make clear the specific decisions made then on its content, the Committee did decide to publish the statement in 1985 (10) and subsequently it was incorporated into the URM document in its 1988 version.

Authorship
All persons designated as authors should qualify for authorship. Each author should have participated sufficiently in the work to be able to take public responsibility for the content.

Authorship credit should be based only on substantial contributions to a) conception and design, or analysis and interpretation of data; b) drafting the article or revising it critically for important intellectual content; and on c) final approval of the version to be published. Conditions a, b, and c must all be met. Participation solely in the acquisition of funding or the collection of data does not justify authorship. General supervision of the research group is also not sufficient for authorship. Any part of an article critical to its main conclusions must be the responsibility of at least one author.

A paper with corporate (collective) authorship must specify the key persons responsible for the article; others contributing to the work should be recognized separately.

Editors may require authors to justify the assignment of authorship.

This initial statement in the URM document is still essentially that in the 1997 version (11); the 1997 version has an expanded statement on multicenter clinical trials and corporate authorship, but the central points have not been changed. A standard for sequence authors was discussed at the committee’s meeting in Philadelphia in 1989 but was not adopted.

In a wide range of scientific disciplines, this URM standard appears to remain one of the most explicit and reasonably rigorous bases for decisions on authorship. Recently the National Science Foundation surveyed (13) the ethics codes of 90 broad-based professional organizations in disciplines funded by the Foundation, disciplines ranging from anthropology to zoology and including biomedicine. Many of these have been published in a collection, Society Policies on Ethics Issues (14), but the rest are available only individually from their issuing societies. Among these 90 codes, only 21 carry explicit statements on authorship standards. Of these 21, only 2 do I consider as providing detailed standards; one is that adopted by editors of the American Chemical Society (15) in 1985 and reaffirmed in 1989:

The co-authors of a paper should be all those persons who have made significant scientific contributions to the work reported and who share responsibility and accountability for the results. Other contributions should be indicated in a footnote or an “Acknowledgments” section. An administrative relationship to the investigation does not of itself qualify a person for co-authorship (but occasionally it may be appropriate to acknowledge major administrative assistance). Decedent persons who meet the criterion for inclusion as co-authors should be so included, with a footnote reporting date of death. No fictitious name should be listed as an author or co-author. The author who submits a manuscript for publication accepts the responsibility of having included as co-authors all persons appropriate and none inappropriate. The submitting author should have sent each living co-author a draft copy of the manuscript and have obtained the co-author’s assent to co-authorship of it.

The other statement, that by the American Psychological Association on “Publication Credit” (section 6.23 in its “Ethical Principles of Psychologists and Code of Con-

Authorship [1997 version]
All persons designated as authors should qualify for authorship. Each author should have participated sufficiently in the work to take public responsibility for the content. Authorship credit should be based only on substantial contributions to 1) either the conception and design, or the analysis and interpretation of data; and to 2) drafting the article or revising it critically for important intellectual content; and on 3) final approval of the version to be published. Conditions 1, 2, and 3 must all be met. Participation solely in the acquisition of funding or the collection of data does not justify authorship. General supervision of the research group is not sufficient for authorship. Any part of an article critical to its main conclusions must be the responsibility of at least one author.

Editors may ask authors to describe what each contributed; this information may be published.

Increasingly, multicenter trials are attributed to a corporate author. All members of the group who are named as authors, either in the authorship position below the title or in a footnote, should fully meet the above criteria for authorship. Group members who do not meet these criteria should be listed, with their permission, in the Acknowledgments or in an appendix (see Acknowledgment).

The order of authorship should be a joint decision of the coauthors. Because the order is assigned in different ways, its meaning cannot be inferred accurately unless it is stated by the authors. Authors may wish to explain the order of authorship in a footnote. In deciding on the order, authors should be aware that many journals limit the number of authors listed in the table of contents and that the U.S. National Library of Medicine (NL-M) lists in MEDLINE only the first 24 authors plus the last author when there are more than 25 authors. [11]
DUCT" and also to be found in reference 14), is similar. Most of the other scientific society codes say little more than a need for "substantial contributions to the reported research" as a justification for authorship and, unfortunately, do not define that potentially overly elastic adjective "significant".

Guidelines on authorship not represented in Society Policies on Ethics Issues (14) but in the other documents reviewed by the National Science Foundation are those of the American Anthropological Association, the American Association of Immunologists, the American College of Neuropsychopharmacology, the American Educational Research Association, the American Federation of Clinical Research, the American Geophysical Union, the American Political Science Association, the American Society of Microbiology, the American Sociological Association, and the Association of University Radiologists.

Some research institutes have their own standards. An excellent example in biomedicine is that developed by members of the Centers for Disease Control, Atlanta, Georgia, presented at a conference held at the National Academy of Sciences in Washington, DC, and reported in a CBE publication (16). Indeed, V N Houk and S B Thacker's dissection of activities justifying authorship is notably more thorough than that in the URM statement. Their "principles of primary authorship" are too long for quotation here, but its main points, each to be considered for every potential coauthor, indicate the rigor of their standards:

Outstanding contributions; major intellectual input; active participation in work; key scientific leadership; originality of contribution; major feature of manuscript; subject matter.

Some medical schools and other academic centers have also adopted specific standards for authorship; they have been collected in appendixes in Volume 2 of Responsible Science: Ensuring the Integrity of the Research Process, a publication (17) of the National Academy Press. Although the standards differ in rigor and detail, they all merit being quoted here. Here is most of the relevant statement (page 123 in reference 17) of the National Institutes of Health:

For each individual the privilege of authorship should be based on a significant contribution to the conceptualization, design, execution, and/or [sic] interpretation of the research study, as well as a willingness to take responsibility for the defense of the study should the need arise. In contrast, other individuals who participate in part of a study may more appropriately be acknowledged as having contributed certain advice, reagents, analyses, patient material, support, etc., but not be listed as authors. It is expected that such distinctions will be increasingly important in the future and should be explicitly considered more frequently now. Consideration should be given in interdisciplinary studies to preparing brief statements of the exact contribution of each author to the work described in each communication. . . . The submitting author should be considered the primary author with the additional responsibility of coordinating the completion and submission of the work. . . . The submitting author should assure that the contributions of all collaborators are appropriately recognized and must be able to certify that each author has reviewed and authorized the submission of the manuscript.

The statement of the Harvard University Faculty of Medicine (page 128 in reference 17) is, I believe, a bit less rigorous:

A gradual diffusion of responsibility for multi-authored or collaborative studies has led in recent years to the publication of papers for which no single author was prepared to take full responsibility. Two critical safeguards in the publication of accurate, scientific reports are the active participation of each coauthor in verifying that part of a manuscript that falls within his/her [sic] specialty area and the designation of one author who is responsible for the validity of the entire manuscript. . . . The committee considers the only reasonable criterion to be that the coauthor has made a significant intellectual or practical contribution. The concept of "honorary authorship" is deplorable. The first author . . . should provide [the head of each research unit or department chairperson] a brief description of the role of each coauthor. Appended to the final draft of the manuscript should be a signed statement from each coauthor indicating that s/he [sic] has reviewed and approved the manuscript to the extent possible, given individual expertise.

The Johns Hopkins University School of Medicine's statement on authorship (page 135 in reference 17) is relatively short:

Authorship should be given generously, but only to those who have contributed significantly to the research, are prepared to stand behind their findings, and have reviewed the entire manuscript. The referral of patients included in a clinical study does not, in and of itself, constitute a significant contribution warranting coauthorship. The principle of permitting "honorary authorship" is unacceptable and should be actively discouraged by primary investigators and heads of departments and research units.

The University of Michigan Medical School's statement (pages 147 and 148 in reference 17) is quite detailed:

1. Individuals should be considered for inclusion as authors on work submitted for publication if they have provided:
a. Significant contributions affecting direction, scope, or depth of research
b. Long-term guidance and development of the project;
c. Creative contributions to the project with clear understanding of its goals;  
d. Development of methodologies necessary for timely completion of the project;  
e. Data analysis or interpretation vital to conclusions of the project.  
2. Individuals should not be included as authors for contributions strictly limited to  
a. Providing lab space or use of instrumentation;  
b. Providing funding;  
c. Services, consulting, or materials provided for a fee, or reimbursement;  
d. Involvement in patient care or providing patient samples;  
e. Routine technical work (as provided by any individual in the lab);  
f. Status as supervisor, section head, or department chairperson;  
g. Proofreading or editing of manuscripts;  
h. Advice given to solve problems that are narrowly defined or unrelated to the project objective.  
3. Responsibilities  
a. Primary author:  
i. Inform all authors and contributors as to how their contributions will be acknowledged.  
ii. Be able to identify the specific contribution of each author.  
iii. Understand the general principles of all work included in the paper.  
iv. Be willing to share openly the data obtained and methodology utilized in the investigation.  
b. All authors:  
i. Be able to defend the methodology and data pertinent to their specific contributions to the project.  
ii. Agree with the general conclusions and interpretations of the paper.  

1. Honorary authorship is never acceptable. Authorship should be limited to those who have made a significant contribution to the conceptualization, design, execution, and/or [sic] interpretation of the research study. All those who have made such contributions should be offered the opportunity to be listed as authors.  
2. Each coauthor should take responsibility for the full evaluation of data and procedures and for the conclusion of the paper in his or her area of expertise. Ideally, all authors should take responsibility for the conclusions of the paper as a whole. Other individuals who have contributed to the study should be acknowledged, but should not be identified as authors.  

Guidelines developed by the Brain Tumor Research Center, Department of Neurological Surgery, University of California San Francisco (pages 216-8 in reference 17) are identified as based on the "Uniform Requirements" statement (see above) but elaborate on procedures designed to facilitate the selection of proper authors.  

There may be other medical institutions—academic centers, research institutes—that have established their own standards. I have personal knowledge of at least 3 additional medical schools that have either established standards or are working toward a standard.  

The evidence reviewed above shows that progress has been made in the United States toward a consensus in academic communities on standards for authorship. In view of the probability that much of this progress can be due to the efforts of many editors toward establishing standards that have gotten highly visible acceptance, at least in the United States, it is ironic that a group of editors appear to have felt compelled recently to stir the standards pot again. In 1996 a group of American and British editors met in Nottingham, United Kingdom, to debate the adequacy of present standards (18). The irony is compounded by the apparent stimulus for the meeting, an observation by Raj Bhopal, professor of public health in Newcastle, United Kingdom, that many researchers do not know about the guidelines and many who do know about them disagree with them and find them difficult to follow. This view is described (18) as coming from a survey in 1 department in the United Kingdom. If this is the problem accounting for continuing occasional abuses of authorship, then the solution would seem to be not yet another set of authorship criteria, but efforts by editors and other academicians to widen their communities' awareness of authorship standards. To me the odds seem high that a new set of criteria would also wind up being unknown to some of the academic community or, if known, disagreed with. Apparently, the International Committee of Medical Journal Editors decided on the next day to not tinker with their present standards.  

Editors can certainly help in building a consensus among authors and potential authors by stating their standards explicitly and in detail and enforcing them as far as possible. The 1991 editorial (19) by Kassirer and Angell defining more sharply the authorship standards held by the New England Journal of Medicine is an admirable example of what editors can and should do. But such efforts are likely to be limited in their effectiveness. Rigorous standards for authorship are likely to be widely adhered to only when the communities in authors' institutions see such standards as representing consensus among themselves and not only among editors. Editors could further help in the building of such consensuses by pressing for explicit standards in the institutions that are their own academic community.  

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References