EMBO reports

analysis

Who did what?

Uneasiness with the current authorship system is prompting the scientific community to seek alternatives

Authorship on scientific publications has become the currency of modern science and a measure of a scientist's participation in the international community. The number of papers a scientist publishes, the journals in which they are published and the position of a scientist's name on the list of authors are all crucial when it comes to promotions, funding and employment decisions. Nevertheless, the attribution of authorship in contemporary academic science has become an increasingly delicate issue. Obvious shortcomings in the system and an inability to react to new developments in science, such as larger research groups and collaborations, have led scientists, editors and science administrators to debate whether the present authorship system should be modified and how best it should operate.

Authorship is the fulfilment of a responsibility. This applies both to receiving appropriate credit and recognition and to taking the blame when something goes wrong, such as in cases in which data are found to be incorrect, results are irreproducible or conclusions are grossly exaggerated. As Drummond Rennie, Deputy Editor of the *Journal of the American Medical Association*, put it: "the coin of publication has two sides: credit and accountability" (Rennie D, Yank V, Emanuel L (1997) When authorship fails: a proposal to make contributors accountable. *J Am Med Assoc* **278:** 579–585). However, it is becoming increasingly difficult to assign both credit and accountability owing to the ever-growing lists of authors, which make it hard to establish whether and how much each has contributed to the publication, and who is to take the blame if data are found to be wrong.

Authorship is the fulfilment of a responsibility

Furthermore, the need to produce a long list of publications when applying for positions or funding has further contributed to an inflation in the number of contributors. If group or department leaders put the names of their junior scientists on a paper to give them an advantage in the 'rat race' for jobs and money, this is certainly generous, but it ultimately dilutes the work of others. "I think that the one thing that is wrong with the authorship system is when someone becomes an author on a paper to which they have contributed nothing, in other words, honorary authorship," said Iain Mattaj, Scientific Director of the European Molecular Biology Laboratory (Heidelberg, Germany) and Executive Editor of *The EMBO Journal*.

Large author lists are a relatively recent phenomenon. Until the emergence of large-scale multi-authorship in biomedical research, it was possible to attribute a paper's content to one or a few individual scientists, similarly to authorship in literature. But research was different then: it was reasonable to think of a scientific author as a scientist who, often under a mentor's supervision, had discovered something and made it available to the rest of the community in the form of a publication, a privilege bestowing them recognition. The inflation in authorship is associated with the extensive collaborative dimension that science has assumed. Laboratories have grown bigger, the questions addressed are more complex and projects have become large interdisciplinary efforts, which often involve different subspecialties. In 1930, the average number of authors for biomedical research papers was 1.3; by 1989, it had escalated to 6.0 (Cho M, McKee M (2002) Authorship in biomedical research: realities and expectations. *Science's Next Wave*, 1 March, nextwave.sciencemag.org). At the extreme, the new organization of science has produced some articles with hundreds of names, stretching the authors' byline over an entire page.

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This leaves the scientific community with the question of who qualifies as an author. Unfortunately, there is no universally defined system for such an assessment. The International Committee of Medical Journal Editors (ICMJE), a body representing hundreds of general biomedical journals, has long been concerned with this problem and has attempted to provide sensible and standard criteria for the definition of authorship. "Authorship credit should be based on 1) substantial contributions to conception and design [of the project], 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," is the ICMJE's present definition (www.icmje.org). If an individual does not meet these criteria or if no task can reasonably be attributed to them, then they should not be credited with authorship.

The US National Institutes of Health (NIH) have similar directions and instructions in their 'Guidelines for the Conduct of Research in the Intramural Research Program', in which they state that "individuals who have assisted the research by their encouragement and advice or by providing space, financial support, reagents, occasional analyses or patient material should be acknowledged in the text, but not be authors." If, for instance, scientists conduct field research on a remote island and a fisherman provides access to his property for the collection of biological material, the fisherman will have made a vital contribution to the actualization of the study, but his efforts will probably not grant him authorship in any resulting publication. Similarly, someone providing a bench, a microscope or donating part of their funds towards the research of others should not automatically be granted co-authorship. "In my view the problem is not necessarily to define a contribution tightly, but to really be sure that people who are authors on a paper have made a significant contribution to it," Mattaj commented. In addition, honorary or ghost authorships and irresponsible or deceptive misconduct in publishing have created growing unease with the existing system and have encouraged scientists to seek alternatives.

The main alternative framework for scientific authorship, which has been implemented only marginally within the scientific community, has been the contributorship system. First put forward by Rennie and his collaborators in 1997, this system states that every individual who has usefully added to the work should be listed as a contributor (Rennie *et al*, 1997). Although the number of contributors would not be limited, each name should be linked to a description of that person's contribution. In addition, one of the contributors would be designated as a guarantor of the whole work. Similar to the role of a senior researcher on a project, the guarantor would ensure the integrity of the work and would be considered accountable for all of its parts.

Other initiatives have been proposed by the authors themselves. Similar to the contributorship system, the quantitative uniform authorship declaration (QUAD) encourages authors to state their "percentage share of the total credit" in each of the following four categories: conception and design of the project, data collection, data analysis and conclusions, and manuscript preparation (Verhagen JV, Wallace KJ, Collins SC, Scott TR (2003) QUAD system offers fair shares to all authors. *Nature* **426:** 602). "The least an author can contribute to a paper would be 10% within a single category and authors would be listed in descending order of total contribution across all four categories," the authors suggested.

> …someone providing a bench, a microscope or donating part of their funds towards the research of others should not automatically be granted co-authorship

The primary goal of these alternative systems is to reduce distortions of authorship and to provide more transparency to what is at present seen as an opaque process. The information describing each contributor's role would allow a reader to quickly understand who did what, and would clearly remove much of the ambiguity surrounding papers with several authors. However, these systems leave unresolved the question of the quantity and quality of each contribution, and whether all scientists' contributions would be accurately reflected. "I don't think having a contributorship rather than an authorship system would remove the possibility for abuses of the system, because if you can be a fake author, you can be a fake contributor, too," commented Mattaj.

However valid and effective the alternative methods might be, it remains unclear how they could be implemented. "The bottlenecks are to try and convince both editors and societies of the benefit and practicality of the new systems. This may be especially hard when such systems are only at a theoretical stage," said Justus Verhagen, a neurophysiologist from the Department of Experimental Psychology at the University of Oxford, UK, and one of the authors of the QUAD system.

Some claim that it would be sufficient if editors simply demanded a brief statement of each author's contribution as an additional requirement for manuscript publication. "It would appear to be a matter that is under the control of the journals," said Tom Scott from the College of Sciences at San Diego State University (CA, USA). "There is already a thicket of regulation to submitting an article—copyright transfers that must be signed, submission fees that must be paid, detailed instructions that must be followed. If the journal added a requirement that authors must declare their proportional contribution to any submitted article, that requirement would stand. Anything short of that, and authorship declaration will continue to be ignored."

Therefore, it would be up to the editors of the most authoritative scientific journals to take the initiative. Few prospective authors would sacrifice the opportunity to publish in any of these journals simply because they were required to state their respective contributions. Journals such as *Science* and *Nature* already welcome statements specifying the contribution of each author, but this is not a requirement. "I don't think it would be a difficult exercise to require that authors stated their contributions," said Mattaj.

> …there are no sanctions or other forms of punishment for fraudulent authors beyond firing them or denying them access to funding

In addition, directors of departments or institutes could enforce such declarations for all of the work produced at their establishments. "To the degree that directors must evaluate the productivity of their scientific employees, it would be to their advantage to have these additional data," concluded Scott. "The problem is not a lack of ability to get that information," commented Mattaj. "My imagination, though, of how this would develop, is that it would become formulaic and meaningless," he cautioned. "Very quickly people would copy phrases from one another such that the helpfulness would not be very high."

As authorship is often the most important criterion by which selection committees decide on the careers of scientists, radical or sweeping changes in the present system are unlikely. But change might come if these committees used a different ranking system; indeed, it would probably even simplify their work if they adopted a more quantitative method to assess authorship and made the award system more transparent. But authorship is not everything. "My opinion is and has been that one needs to look at the candidate in detail and beyond authorship," commented Mattaj. "You cannot measure someone's contribution by looking at a paper, at what they have done. You also need to look at the candidates themselves, interview them and talk to them in detail, to have a good idea of what really their capabilities and contributions are."

Regardless of any changes or adaptations, authorship will remain an intricate issue in science because of the logic of its reward system, which is distant from that of intellectual property law (Biagioli M (2003) in *Scientific Authorship. Credit and Intellectual Property in Science*. Routledge, New York, USA). The scientific community prides itself on the fact that its work is based on an ethos of meritocracy, impartiality and integrity. Its actions and conduct are generally, and particularly in the case of scientific authorship and accreditation, regulated by an acknowledged system of conduct and by individual honesty, which is separate from the legal jurisdiction that is normal for most other forms of copyright. Furthermore, there are no sanctions or other forms of punishment for fraudulent authors beyond firing them or denying them access to funding. The harshest measures are forms of exile or ostracism from the scientific community, but they carry no tangible legal consequences. This generally acknowledged integrity is a widely admired aspect of the scientific community, but it also explains why there is little perceived urgency to introduce a unified authorship system or create an external monitoring body to avoid abuses. "I feel one needs nothing short of a 'paradigm shift' in how authorship is viewed and 'felt' in order to be able to distance one from the current lack of a system and appreciate what quantitative systems could improve upon," concluded Verhagen.

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Waiter, there's a nanobot in my martini!

As nanotechnology gives birth to nanobiotechnology, definitions and perceptions are at risk of becoming mixed into an exotic cocktail

Barely a week passes these days without another report concerning nanotechnology and another reinforcement of the call for a moratorium on it. And, as if biotechnology had not suffered enough public scorn already, nanobiotechnology will surely attract even more. Nanotechnology itself is hard to define or communicate, so will the scientific community be able to convey what is behind nanobiotechnology before promising applications go sour in the public domain?

> But in these times of increasing scrutiny of science and technology, surely society and scientists should be grateful when someone raises a warning flag before a real public-relations disaster happens…

For a start, it might help to have a standard definition of nanotechnology, but that in itself is a problem. Although to scientists its meaning might be intuitively clear, there are many other versions floating around. To an intellectual commenting on a possible doomsday scenario, nanotechnology is synonymous with autonomous self-replicating nanomachines overrunning the planet. To a synthetic chemist, it is merely the modern term used to describe some by now ubiquitous synthesis. And a technology firm might use the word simply to spice up its latest advertising pitch. More worryingly, to a non-governmental organization (NGO), nanotechnology could be anything that involves phenomena at the atomic or molecular level.

Now, it should be possible to define nanobiotechnology, or at least some of its applications (see sidebar). How about "the manipulation of DNA at the nanometre scale?" If this sounds a bit like genetic modification all over again, it is no coincidence. It has the same critics. But in these times of increasing scrutiny of science and technology, surely society and scientists should be grateful when someone raises a warning flag before a real public-relations disaster happens, as was the case with genetically modified (GM) food. And this, after all, is the aim of the Action Group on Erosion, Technology and Concentration (ETC; www.etcgroup.org): to subject nanotechnology to a moratorium in order to develop international regulations that allow its development in a controlled manner. Otherwise, the ETC fears, this potentially useful technology could suffer a public backlash similar to that seen in the GM debate.

The problem with nanotechnology, as identified by the ETC, starts with the fact that what chemists thought of as the mere scaling down of an existing process or entity with known physical or chemical properties, is, in some cases, associated with the emergence of new properties that are not seen in the bulk material. The contention is that a new kind of regulatory framework is therefore necessary, over and above normal safety testing. Admittedly, 'buckyballs' and nanotubes are different from plain graphite, and new research even suggests that buckyballs can cause brain damage in fish (Feder BJ (2004) Health concerns in nanotechnology. *New York Times*, 29 March). However, many non-nanotechnology substances do that too, and the lead researcher, Eva Oberdörster, an environmental toxicologist at the Southern Methodist University (Dallas, TX, USA), does not think that a nanotechnology moratorium should be imposed. Another controversial case, which is frequently cited by the ETC, is that of SoilSET™—an organic–inorganic composite, which, when wetted, catalytically