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## Peer Review and the Structure of Science

In recent months, the process of peer review of scientific projects has been much in the public eye. All sorts of questions have come up: Is peer review fair? Does it provide for the support of the best science? Can it recognize potential breakthroughs? Are the reviewers chosen well? Do they respond objectively? Such questions as these do not have one simple answer because they really refer not just to the immediate issue of how peer review works, but to the structure and nature of science in general and in particular. On closer examination, there are many different versions of peer review, each adjusted to apply to the science at issue. All of these versions have one purpose: To help decide how the limited funds available for the support of science can best be spent to advance both science itself and the national purposes to which it contributes. Science is a complex and multifaceted attack on the unknown. Guesses as to how it will work can most accurately be made by people who have themselves succeeded in such attacks on the unknown. These people are the peers.

*Which peers?* In a recent hearing it was proposed that some peer reviewers be picked "at random" from some list. This would tend to produce some reviewers who are not knowledgeable about the proposed projects. For many scientific problems there are only a few peers—perhaps only one or two—who really understand the technicalities at issue and the possible outcomes. Thus, reviewers must be chosen by knowledgeable people. Because of the wide variety of expertise needed—often much more than can be found on any one panel of reviewers—many branches of science require written reviews. This way is more likely to obtain a perceptive, well-informed review for each project.

*What breakthroughs?* At recent congressional hearings a number of witnesses expressed concern that the present peer review system might be biased against really innovative proposals, those which go against the general opinion in the field and which could lead to major conceptual changes. Now, it is clear that scientists, and in particular peer reviewers, should be alert to recognize potential breakthroughs. This is by no means easy. It is also clear that some ideas claimed to be potential breakthroughs are nothing of the sort. The hearings brought out no hard evidence that any really decisive breakthrough ideas had been ignored. They did bring out various complaints. This is hardly surprising at a time of shrinking budgets, when it is certain that some solid proposals will be passed over.

*Which panels?* Some commentators have urged that most peer review be done by reviewing panels in regular meetings. The panel device is one that works well in certain fields, such as in some of the biological sciences, where it has long been the practice for the National Institutes of Health to make extensive use of study groups. In big science, where the choice is between several large projects, panels may be necessary because of the size and complexity of the financial decision to be made. However in other fields panels just do not work well, in part because many different and intricate specialties are involved. With many small proposals, each of which requires particular expertise, there is really no way to assemble a panel of reasonable size with the requisite experts to cover everything. For that matter, it is by no means clear that the most incisive judges of the merits of a particular new idea are identical with those who are willing to come to Washington for a panel meeting.

Ultimately, peer review has the task of picking which scientific projects to support. Getting the right projects is not (as sometimes claimed) a question of openness, nor should it be one of responsiveness to political issues. It is fundamentally a choice between projects on the basis of promised quality. Comparable choices arise for scientific journals. There the knowledgeable editors pick the appropriate expert (and usually anonymous) referees to judge the merits of manuscripts. That method of choosing referees has played an essential and effective role in the development of science. For referees, as for peer reviewers, the system depends on individual judgments of quality. —SAUNDERS MACLANE, *Department of Mathematics, University of Chicago, Chicago, Illinois 60637*