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## EDUCATION

## Training for Peer Review

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**Learning the peer-review process by trial and error may not be the most effective way to train the next generation of scientists in how to be effective reviewers. Here are some suggestions from an editor's perspective.**

Peer review is a critical aspect of a career in academic science, but lessons in how to serve as an effective reviewer of primary research papers, grant applications, and promotion packages are not part of a scientist's formal training. Focusing on peer review of primary research papers, the reviewer has four main responsibilities: verifying the technical accuracy of the experiments, confirming that the conclusions are supported by the data, determining whether the results are new, and, last, providing a judgment regarding the suitability of a paper for a particular journal. For research that is technically sound, the primary responsibility of the reviewer is to ensure that it is made available to the scientific community as expeditiously as possible.

Most scientists learn the reviewing process by trial and error, typically starting by reviewing manuscripts as a graduate student or postdoctoral fellow in conjunction with their thesis adviser or postdoc mentor. Reviews by novice referees are frequently full of nit-picky details about the text and word choice with little critical analysis of the scientific content, or they are extremely critical with an indignant tone that can border on hostility. Novice referees should remember that the goal of the peer-review process is either to help improve a manuscript so that it can become published or the conclusions can be validated or to weed out unsuitable manuscripts that are not technically sound. The goal is not to prevent publication of research for reasons that can be technically addressed through experimentation or revision of the text. Reviewers should recommend reasonable experiments that would help the authors bolster their conclusions or validate the results, not just say the data are not good enough.

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Perhaps graduate students and postdocs should receive formal training in peer-reviewing manuscripts. Although graduate students must learn to critically evaluate published literature, few receive formal training in peer reviewing. Training should include guidance on proper tone as well as the appropriate content of an evaluation. In this regard, journal editors may be in a position to aid in educating the teachers regarding what constitutes an exemplary review and what to avoid. Although different journals have different criteria for accepting manuscripts, a brief analysis of the referee guidelines from several publishers, including AAAS, Cell Press, Society for Developmental Biology, and Nature Publishing Group, shows that the evaluations of technical rigor and novelty are among the critical common elements requested of the peer reviewer. As stated in the *Science Signaling* information for referees of primary research papers, reviewers should

- Evaluate whether, or to what extent, the data and methods substantiate the conclusions and interpretations. If appropriate, indicate what additional data and information are needed to validate the conclusions or support the interpretations.
- Indicate if the conclusions are novel or are very similar to work already published.

What makes a good reviewer? A reviewer should provide a prompt response that is thoughtful, fair, and balanced. If the data are novel and accurate, the reviewer should point out ways in which the work can be improved. There are times when a manuscript is not suitable for publication. In this case, the reviewer should concisely state the major flaws and enable the author to understand why the referee recommends against publication. The review should also be considered from the perspective of the

recipient. Reviewers should read their comments and consider what their reaction would be if they received the comments. Is it clear that the reviewer understood the main points, and are these points summarized clearly? Are the deficiencies clearly stated in a constructive manner without attacking the authors personally and without hostility? Are the most critical concerns identified defined as such and minor concerns noted as such?

Many journals offer the reviewer both a place to provide comments to the editors and one for comments to the authors. These, of course, should be consistent with each other. The comments to the authors should not be overwhelmingly positive, yet the comments to the editors recommend rejection. The comments to the editors should clearly indicate the reviewer's recommendation for the manuscript: accept with or without revision, re-review following revision, or reject. If a reviewer cannot be objective, if the paper is so poorly written that it is difficult or impossible to evaluate, or if a reviewer becomes so overwhelmed with other responsibilities that sufficient time cannot be devoted to do a good job, then the reviewer should notify the editor of the need to withdraw as a referee. If there are aspects of the manuscript that are beyond the reviewer's area of expertise, those should be noted for the editor. This information ensures that the editor obtains input from scientists in all areas necessary to ensure the technical rigor and novelty of the manuscript.

In addition to the two major criteria of technical rigor and novelty, reviewers are encouraged to comment on whether the presentation of the data in the figures and tables could be improved, and how, and whether information should be presented in the main body of the manuscript or can be presented as Supporting Online Material. If appropriate, reviewers should assess the validity of the statistical methods applied and indicate whether these are inappropriate for the analysis.

With formal training, the next generation of scientists will be better prepared not only to judge their peers, but also to communicate their scientific discoveries effectively.

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