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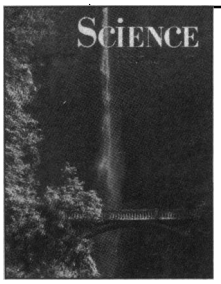
■ The American Association for the Advancement of Science was founded in 1848 and incorporated in 1874. Its objects are to further the work of scientists, to facilitate cooperation among them, to foster scientific freedom and responsibility, to improve the effectiveness of science in the promotion of human welfare, and to increase public understanding and appreciation of the importance and promise of the methods of science in human progress.



COVER Multnomah Falls, Oregon, on the Columbia River Plateau just below the Bonneville Dam. Seventeen million years ago, lava began to pour out of huge fissures across an area of 200,000 square kilometers (80,000 square miles) in the northwestern United States and eventually formed a basalt plateau with an average thickness of more than 1 kilometer (half a mile). The rock is now deeply cut by the Columbia River and its tributaries. See page 663. [Michael R. Rampino, New York University, New York, NY 10003]

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The Price of Progress

Scientists are feeling beleaguered these days, and there is some danger that their problems may be exacerbated if they develop a siege mentality. Recent charges—that they are cruel to animals but kind to colleagues accused of misconduct, that they show excessive zeal in trying to cure disease but lack of interest in protecting the environment—cause many scientists to react by labeling all critics as modern Luddites. Actually, this situation only illustrates the fact that science, like everything else in the world, is changing, and rapidly. What is needed is a careful appraisal of new rules to cope with the evolution of science and new approaches to public relations with a society that is increasingly threatened by the mystique of science.

One mistake in the face of these criticisms would be to argue that scientists cannot improve their own procedures. Some will argue that any change is an admission of guilt, but change and some misunderstanding are always the price of progress. Increases in the rate of discoveries, in the number of investigators, and in interdisciplinary research are having their impact on the old procedures. The days of the gifted amateur working with pins and sealing wax are over. When many authors from more than one laboratory are collaborating, it is impossible to expect everyone to know all of the experimental intricacies of all the work—but there is no escaping the fact that an author's name on the paper implies responsibility for all the work in that paper. If senior investigators share the credit when the work of students and collaborators is good, they must expect to share the blame when the work is poor. Hence, prudence suggests limiting groups to a size that can be competently supervised.

Those who expect progress without mistakes do not understand progress. When mistakes do occur, whether by fraud, sloppiness, or honest error, it is essential that they be corrected as rapidly as possible, and retractions, however embarrassing, must be made. In a smaller and cozier world, deviations from high standards of scholarship were dealt with informally; today's scientists need to realize that errors must be handled more formally, and in full view of an anxious public. In complex problems of fraud, misconduct, or error, scientists will need to develop procedures that nonscientists will find thorough, objective, and fair. Otherwise, the case will be made that laypersons must themselves be the judges, a potential nightmare when complex science is involved.

A new area of concern relates to the publication of all essential data for the verification of a research paper. Although it is axiomatic in science that such data should be available to the reader, some of modern science is so voluminous—DNA sequences, coordinates for x-ray structures, computer programs—that it cannot take up valuable journal space. Data banks are now available, but some investigators, out of laziness or desire to maintain proprietary advantage, fail to deposit their data. This should not be allowed. *Science*, together with a number of journals, has developed procedures to help ensure that any individual who publishes in these journals will send the appropriate information to data banks. In the old days of the small, old-boy network, such conditions could be enforced by word of mouth. The need for more formal procedures, which will be explained to authors, arises because of the exponential growth in the numbers of scientists and journals.

A willingness to examine our own procedures should not be interpreted as a need to change good procedures into cosmetic ones. Preserving the good, however, will require explaining the goals and procedures of modern science to an uninformed public. Scientists should, when possible, convert their specialized terminology into understandable language, so that scientific jargon is not interpreted as a protective device. The implications of new discoveries and our judicial procedures, warts and all, will have to be clarified. This can be done, and in many cases has been done brilliantly. Most of the public, in fact, hold scientists in high regard, and few would like to stop progress in its tracks. However, scientists must deal with the issues honestly. We cannot say we have eliminated all fraud, all pain to animals, all radioactive spills. We can say that science, like all other forms of human endeavor, will never proceed flawlessly, but scientists accept the responsibility to minimize the unpleasant side effects as well as to maximize the advance of the frontier.—DANIEL E. KOSHLAND, JR.