and laymen ran the full gamut in their views concerning the necessity for more or less stringent control measures. Those same issues as well as others raised at the public hearings held in February 1976 were subsequently reviewed in extraordinary depth by the director and his staff. The director then asked the Advisory Committee to again address certain issues. In April, after long and searching consideration, the Advisory Committee reaffirmed certain earlier recommendations and changed others. [This is discussed in the lengthy commentary accompanying the guidelines (*5*).]

Chargaff and Simring urge a slow approach to experimentation. It should be recognized that a "slow approach" is what was achieved by the voluntary deferral and the Asilomar guidelines. Research on recombinant DNA will proceed at only a fraction of the possible rate because of the need for certified host-vector systems, acquisition of sophisticated physical containment facilities, and the required deferral of a large group of interesting and important experiments. Presently, in addition to a slowdown, there is a far-reaching awareness on the part of investigators of the need for caution, and a largely cooperative atmosphere exists regarding the need for control of this type of experimentation.

Simring's attempt to draw analogies between recombinant DNA and the nuclear energy controversies obscures the facts. The discussions on recombinant DNA have been public since their beginning. The matter has been widely reported by the public press. The publicity permitted all concerned individuals and groups to enter the deliberations. No datum has been classified and no commentary has been withheld from the public. Indeed, most policy has been developed in public sessions. In addition to containment, the unquantifiable problems have been addressed. The problems may be difficult, but they can be dealt with in a rational manner.

Finally, we are deeply disturbed by the distortions, derision, and pessimism that permeate Chargaff's comments. He appears to see science as a curse on our time, and men as feeble. In our view it is knowledge and understanding derived from science and scholarship that lead men to rationality and wisdom.

MAXINE F. SINGER

National Cancer Institute, National Institutes of Health, Bethesda, Maryland 20014

PAUL BERG

Department of Biochemistry, Stanford University Medical Center, Stanford, California 94305

References

1. National Institutes of Health, *Guidelines for Research Involving Recombinant DNA Molecules* (National Institutes of Health, Washington, D.C., 1976).
2. M. Singer and D. Söll, *Science* **181**, 1114 (1973).
3. P. Berg *et al.*, *ibid.* **185**, 303 (1974).
4. P. Berg, D. Baltimore, S. Brenner, R. O. Roblin, M. F. Singer, *ibid.* **188**, 991 (1975).
5. D. S. Fredrickson, *Decision of the Director, National Institutes of Health, to Release Guidelines for Research on Recombinant DNA Molecules* (National Institutes of Health, Washington, D.C., 1976).

Environmental Impact Statements

In his editorial of 7 May (p. 509), D. W. Schindler criticizes ecologists involved in the legal procedure of environmental impact assessment. To summarize, Schindler says that environmental statements are used as a ploy by politicians to silence "ecofreaks"; that environmental statements are voluminous reports containing reams of uninterpreted descriptive data produced in insufficient time by incompetent scientists using an ancient, descriptive, tired old bag of tricks. He contends that the conclusions and recommendations of this "gray literature" are never scrutinized by the scientific community at large. Further, he asserts that the advancement of the scientific method is in jeopardy and the result will be a declining credibility for environmental science and scientists, a reduction in quality of personnel, and the degradation of our natural resources. To this we politely say, "bunk."

The fundamental basis for impact statement preparation was set forth in the National Environmental Policy Act (NEPA) of 1969. Congress, in enacting that statute, established a clear mandate to all federal agencies to consider and give appropriate weight to environmental factors in decision-making. The "detailed statement" required by section 102(2)(C) of that act serves at least three fundamental purposes. First, it provides assurances to Congress, the President, the Council on Environmental Quality, and the public that the agency has made a good-faith effort to consider the environmental amenities that NEPA is designed to protect. The courts have held that to accomplish that end the statement must "explicate fully its course of inquiry, its analysis, and its reasoning" (*1*). Second, NEPA has been properly characterized by the courts as "an environmental full-disclosure act," that is, it brings environmental issues to the attention of the public. An environmental impact statement, therefore, must be organized and written in language that can be understood by decision-makers and the general public and, at the same time, must contain sufficient technical and scientific data to alert specialists to particular problems within their area of expertise. Third, and perhaps most important, the "detailed statement" requirement of section 102(2)(C) helps ensure the integrity of the agency's decision-making process. It is wrong to presume, as Schindler does, that environmental impact statements are technical, scientific documents.

An environmental impact statement as we present it is a document issued by a federal agency [the Nuclear Regulatory Commission (NRC) or the Energy Research and Development Administration (ERDA)] planning a major action. Basically, these impact statements fall into two categories: (i) generic statements that examine a whole program [such as the liquid metal fast breeder reactor (LMFBR) program] or a concept (such as offshore nuclear power stations); and (ii) site-specific statements that relate to a given facility (such as the Indian Point Nuclear Station or the Clinch River Breeder Reactor). The purpose of the generic statement is to decide if a proposed activity should continue, say, to the point of siting and building a facility of the type described. Such continued action requires a site-specific impact statement. Although generic statements are sometimes voluminous because of the scope of the proposed activity (for example, that of the LMFBR program), site-specific statements are neither voluminous nor primarily descriptive. This kind of statement is an interpretation and analysis of data presented in a voluminous environmental report. In the case of nuclear power stations, the environmental report is prepared by a utility according to NRC specifications. Environmental data collected for a minimum of 1 year (usually much more) have been incorporated into the environmental report. The data collection program and methodologies are clearly spelled out in the utility's environmental report. If more data are required, they are furnished before proceeding with the assessment. Only after this data collection is considered adequate do we receive the environmental report and the assignment to assess the impacts and prepare the statement. An average of 8 months is spent in summarization and analysis of the data by an interdisciplinary team of professional scientists. The amount of money spent is a function of the potential for environmental degradation. The time spent is the amount of time needed to analyze the potential impacts for a specific setting

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and to make the proper scientific conclusions and recommendations. Every effort is made to write the environmental impact statement as a clear, concise statement of high factual quality and integrity.

Schindler asserts that environmental statements are never scrutinized by the scientific community. Our environmental impact statements (after extensive peer review) are sent out for comment not only to other federal agencies but to all interested parties, and are available to the general public. Additionally, in all cases the authors are required to defend their credentials and their work in a judicial hearing where expert witnesses are called by both sides (the applicant who wants to proceed and the intervenors who want to stop). Each side attempts to repudiate our methods, recommendations, and conclusions. Scrutiny of articles submitted for publication in scientific journals is hardly this intense. The purpose of our presentation is neither to advance nor repudiate a position but to represent the best scientific assessment of the action that can be made.

Our analyses do include predictions and models. These are based on the best data available, even though it is never as much as we would like. We don't know of any model in the ecological literature that has *all* the data. Models and predictions allow us to bracket the potential populational effects so that we can make some estimate of the upper limit of the potential impact and feed that information into the decision-making process.

The scientific method is not in jeopardy any more than it has been when any emerging science has attempted to venture out and apply the principles developed within it to real world problems. It is true that the environmental data base is far from complete. However, intelligent scientists presented with the type of data we demand can reach valid conclusions that go further in preventing the decay and dismemberment of our environment than any of us could hope to achieve from behind our desks or laboratory benches.

Schindler's editorial offers little that is constructive. He has leveled a sweeping broadside at environmental impact statements and the people who write them. We believe his opinions are premature. The endeavor is still in its infancy, and qualified scientists are becoming increasingly involved. Environmental assessment studies have a great potential for stimulating research and pointing out the critical questions needing answers. If allowed to develop, the environmental impact assessment part of environmental science can become a respectable, scientifically based discipline.

S. I. AUERBACH, R. W. BROCKSEN
R. B. CRAIG, F. O. HOFFMAN
S. V. KAYE, D. E. REICHLE
E. G. STRUXNESS
Environmental Sciences Division, Oak Ridge National Laboratory, Post Office Box X, Oak Ridge, Tennessee 37830

References

1. Silva *v.* Lynn, 482 Fed. Rep., 2nd ser. 1282 (First Circuit Court, 1973).

Schindler makes some rather serious accusations directed at individuals and agencies that conduct environmental impact investigations. However, he does make some valid points which those of us who are engaged in impact studies have recognized for several years. One is the very short duration of time available to make an investigation. In most cases, there isn't time for lengthy research and the testing of hypotheses or other processes which are the usual part of a scientific study. It is also true that there have been abuses in the type of personnel utilized to make an impact statement, and there are cases where "traveling circuses" are employed to jump in and out of areas, generating an environmental impact statement as they go. There have also been reams of useless material written that contain very little, if any, beneficial information.

However, Schindler seems to imply that the environmental impact statement is generally the product of scientists who "cannot successfully compete for funding from traditional scientific sources." There may be instances where this is true, but most of the scientists involved in applied environmental studies are competent individuals who were formerly a part of the academic-scientific community and who successfully competed for and received funding in the usual ways.

The problem is that most projects for which environmental impact statements are written cannot be delayed for the period of time necessary for them to be published in scientific journals or digested by the scientific community at large. Often a controversy generated by an investigation can be debated for years and never really be resolved. Such delays could increase the cost of the project far more than the relatively minor cost of an environmental statement. As for Schindler's statement concerning scientific integrity, it would appear that more damage has been done to the scientific community by the premature release to the news media of statistical studies which have a "bombshell" effect on the public. A case in point is the aerosol controversy. The possibility of ozone deterioration is certainly serious, but the proposition that aerosols are the factor causing the deterioration is still being debated. The public, in the meantime, is left stunned at the news of aerosol pollution and then is slowly bombarded by short press releases which seem to indicate that maybe it isn't so. The "on-again, off-again" crisis is a much more serious problem for the integrity and credibility of the scientific community than is a poor-quality environmental impact statement.

Any time there is a rush of money and effort into a new area of concern, abuses and poor-quality work will follow. This is true whether the area is the environment, energy, cancer, or drugs. Those who produce poor-quality work will hopefully be gleaned out, leaving behind individuals in government, academia, and business who are interested in producing high-quality environmental studies using the best possible (and practical) methodologies.

C. MICHAEL COWAN
Aesco Environmental Consulting Specialists, 123 South 84 Street, Lincoln, Nebraska 68510

Schindler raises the interesting issue of the quality of and responsibility for scientific data which find their way into environmental impact statements. While his point is well taken, it appears that he has a misconception of what an environmental impact statement is and what it is designed to achieve. The Council on Environmental Quality's 1975 annual report (*1*) represents an outstanding summary of the structure, function, mechanism, problems, and achievements of the process so far.

Most of all, an environmental impact statement is *not* a scientific document, gray or otherwise. It includes such scientific data as are available in its assessment of the environmental implications of a proposed action; but it is a judgmental, not a scientific, report. Confusion arises because research may be instigated to provide these data or to answer questions arising from the statement itself. Apparently this is the area where the boondoggling alleged by Schindler occurs.

Any policing of the quality and conduct of research so engendered is the province of the scientific community. This research should be published independently of the impact statement and be subject to peer criticism. If

there is second-rate science involved, this will be duly determined.

Though imperfect and evolving, the impact evaluation process has, on balance, been one of the more important advances in decades for the protection of environmental quality. It has been used at federal and state levels to bring the environment to the planning table and drawing board where before it was absent. It has opened the courts to environmental concerns. The issues that Schindler raises are largely issues for science itself, and not for the environmental impact evaluation process.

HORACE LOFTIN
Office of State Planning,
116 West Jones Street,
Raleigh, North Carolina 27603

References

1. Council on Environmental Quality, *Environmental Quality—The Sixth Annual Report of the Council on Environmental Quality* (Government Printing Office, Washington, D.C., 1975), pp. 626–651.

The correspondence resulting from my editorial has shown that most readers grasped the spirit of my comment—that is, to attempt to stimulate a widespread scrutiny of impact science. A few did not correctly judge my intentions.

Among these were "pure" ecologists, who continue to ignore current environmental problems in order to pursue their passion for determining the niobium content of horsefeathers, or whatever.

Another large group of correspondents were impact scientists, most of whom agreed with the editorial, but who almost universally said, "Our impact statements are not like that." Many (not all) of the examples they enclosed were.

I have no quarrel with the impact study concept and do not mind that my own work is regarded as such by most scientists [for example (*1*)]. But much of the work that I have seen has not been of the rigorously documented sort described by Auerbach *et al.*

Loftin's last sentence describes a general philosophy of science with which one must agree. Science has traditionally developed as he describes, and one is confident that correct results will always come eventually, leaving only a relatively harmless pile of worthless papers, wasted man-hours, and broken test tubes behind. But we cannot afford to let impact science follow tradition. The legacy will not be broken test tubes, but hopelessly and permanently crippled ecosystems.

It is this belief that leads me to think that impact work should be published, even if it is after the decisions relevant to a particular study have been made. We must develop an international, accessible, and comparative body of impact-related literature in order to allow extrapolation and generalization. It is simply not economical to treat each impact as though it were entirely unique. Synthesis will be impossible as long as relevant scientific work is hidden in inaccessible impact literature. The long-term loser will be the North American public, already subjected to high resource prices, which must be still higher if impact statements are not efficiently done.

Finally, I believe that it is time for educational institutions to pay more attention to the multidisciplinary training that good impact science demands. We would benefit in the long run if some impact dollars were diverted into such training programs instead of being applied to immediate problems.

D. W. SCHINDLER
Experimental Limnology Project,
Freshwater Institute,
501 University Crescent,
Winnipeg, Manitoba R3T 2N6, Canada

References

1. D. W. Schindler, *Science* **184**, 897 (1974).

The Origin of Pulmonate Land Snails

It has been brought to my attention that in my review (7 May, p. 547) of V. Fretter and J. Peake's *Pulmonates* (*1*) I ignored evidence that a higher limmic Basommatophora (including major freshwater families such as the Physidae, Lymnaeidae, Planorbidar, and Ancylidae) almost certainly are derived from air-breathing forms rather than the other way around (*2*). Thus the presence of air in the lung would not be a "preadaptation" but a holdover, and I am probably wrong in having criticized Ghiretti and Ghiretti-Magaldi. Fretter's statement that the terrestrial pulmonates originally came from the sea via fresh water is still probably valid, but what group or groups were involved is an enigma.

ROBERT ROBERTSON
Academy of Natural Sciences,
Philadelphia, Pennsylvania 19103

References

1. V. Fretter and J. Peake, Eds., *Pulmonates*, vol. 1, *Functional Anatomy and Physiology* (Academic Press, New York, 1975).
2. W. D. R. Hunter, in K. M. Wilbur and C. M. Yonge, Eds., *Physiology of the Mollusca* (Academic Press, New York, 1964), vol. 1, pp. 1 and 93.