dinarily happy I could be, if only I were not so slack and so *unproductively ambitious*. It is all completely clear to me, but that doesn't help at all. I can obtain as much pleasure as I want out of *everything*, but it's all like confectionery and marmalade—the bread is work that succeeds after exertion, and *there* I fail completely."

Klein has written a most absorbing book, the product of many years' study. He has used Ehrenfest's diaries and correspondence, especially letters exchanged with Lorentz and Einstein; interviews with Ehrenfest's associates and students, and with his widow; and, of course, Ehrenfest's published papers, which Klein has made his own. One can only quarrel with him for not including more from his rich sources, particularly the letters, many of which could have been printed *in extenso* without unduly enlarging the volume. Klein tells his story clearly and straightforwardly, with some repetition made necessary by his convenient (albeit artificial) segregation of Ehrenfest's life and work into separate chapters. One looks forward eagerly to the second volume, and to a fuller understanding of the rootless Viennese, the atheistic Jew, the insightful self-doubter, the pointed paradoxer who was Paul Ehrenfest.

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Public Exposure

'Population Control' through Nuclear Pollution. ARTHUR R. TAMPLIN and JOHN W. GOFMAN. Nelson-Hall, Chicago, 1970. xii, 242 pp. $6.95.

Few people, irrespective of their convictions on atomic energy, will feel any enthusiasm for *'Population Control' through Nuclear Pollution.* The book, which must be characterized as more political than scientific and more emotional than reasoned, is written in such inflammatory language that many readers may simply turn away from it altogether. Perhaps a more serious shortcoming than the style is that the authors sometimes confuse issues in a manner that opens their arguments to substantive criticism. The resulting loss of credibility may do the authors, their cause, and indeed the public more harm than good. As an example of such a confusion of issues, consider their discussion of radiation exposures from nuclear power plants (p. 155):

> What is wrong with nuclear power plants?
>
> The normal day-to-day operations of a nuclear power plant are regulated by the standards tabulated in Title 10, Part 20, of the Code of Federal Regulations. These are the reactor regulations that are promulgated by the AEC and represent the basis for the licenses issued to the nuclear power plants. As we indicated in the early chapters of this book, the primary standard which sets the allowable level for the radiation exposure of the population-at-large is much too high. We estimate that if the population of the United States were exposed to this guideline there would be an additional 32,000 cancer deaths each year.
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> In addition to that, we estimate that the genetic consequences of this could be far greater, leading to an increase of between 150,000 - 1,500,000 additional deaths each year. In addition to these genetic deaths, there could be a 5-50% increase in such debilitating diseases as diabetes, schizophrenia, and rheumatoid arthritis. So far as the secondary standards are concerned, that is the maximum permissible concentrations in air and in water, we demonstrated in this chapter that these standards are essentially meaningless.

There are two issues being discussed here: the FRC recommendations and the possible radiation exposures from reactors. The Federal Radiation Council recommends that for individuals in the general population the maximum allowable exposure should be 170 millirems a year. Since an exposure level of 500 millirems a year is taken as the operational limit at the perimeter of power stations, individuals 10 or 100 miles away would suffer very much smaller doses. Thus even with the present FRC limits, the overall exposure of the population to radiation from reactors would be orders of magnitude smaller than is implied by the authors. Furthermore, the Public Health Service stated in 1970 (*1*) that

> The average annual whole-body dose rate received by individuals living near the site boundaries of 10 of the operating power reactors, based on results obtained from environmental radiation surveillance programs, has been estimated to be generally less than 5 mrem. . . . Preliminary results from a study conducted at the Dresden boiling-water reactor indicate that offside external exposure at this power plant may vary between 5 and 14 mrem per year . . . At the Humboldt Bay boiling-water reactor, the maximum integrated doses above background measured offsite were 50 mrem in 1965 and 35 mrem in 1966.

Possible reconcentration of radionuclides is obviously not included in these estimates. The failure of the authors to distinguish between the maximum allowed individual exposure and the average exposure that the general population could be expected to receive results in such distortion as to damage their credibility.

The authors of course also treat other sources of potentially harmful radiation. For example, they analyze the Plowshare program designed to recover natural gas through underground nuclear explosions. They justifiably call attention to the radioactive contamination of this gas. They say that the Plowshare advocates would respond to their objections with "We won't deliver the gas into homes if it is *too* radioactive" (p. 113). Recent estimates indicate that the potential annual dose of tritium in natural gas resulting from large-scale exploitation is on the order of a few millirems (*2*). Presumably a very large number of people could receive this dose. Who is to decide whether the radioactive natural gas recovered would be an acceptable trade-off for the increased exposure?

The objections that the authors raise to nuclear reactors, Plowshare programs, and other Atomic Energy Commission projects are based on their claim that the risk incurred from exposure to radiation is much greater than was previously believed. They argue that the maximum permissible levels of exposure should therefore be reduced. (The controversy between them and the AEC was reviewed in *Science* 6 Feb. 1970 and 28 Aug. 1970.) It is not our purpose to analyze in detail the calculations on which they have based their conclusions. These calculations can be found in a series of papers presented to the Joint Committee on Atomic Energy at the recent hearings on "Environmental Effects of Producing Electric Power." The reader can find these papers, along with several criticisms, in part 2, volume 2, of the hearings. Even if their calculations overestimate the risks by a factor of 10, the underlying problem they address still remains: Who makes the judgments of what risks are acceptable in return for the benefits of atomic energy? How should such decisions be made?

At the present time the philosophy in setting radiation standards in the United States is that the statistical risks from atomic energy should be no more, and preferably a lot less, than the risks

that we otherwise routinely accept in a technological society. The Federal Radiation Council (which is composed of the Secretaries of Health, Education, and Welfare, Labor, Agriculture, Commerce, and Defense, along with the Chairman of the AEC and the Special Assistant to the President for Science and Technology) has until recently been responsible for setting these standards. It was the FRC that made the recommendations on which the AEC based its control regulations. That these recommendations are essentially identical with those of the National Council on Radiation Protection and Measurements and the International Commission on Radiological Protection should come as no surprise. Most of those who have prepared reports for the FRC have been members of the NCRP, and many members of the NCRP committee were also members of the corresponding ICRP committee (*3*, p. 28).

Gofman and Tamplin repeatedly make the point that the FRC has not always been an effective mechanism for protecting the public health from unnecessary radiation exposure. For example the FRC for a long time allowed the uranium miners in Colorado to be exposed to radiation that was 10 to 100 times the limit set by the ICRP (*3*, p. 26). Even after the Public Health Service drew attention to the problem the FRC was slow in taking action. At present, one of its most glaring failures is in ignoring excessive and unnecessary medical exposures. Studies have indicated that medical exposures, which now account for 90 percent of man-made exposures in the United States, could be reduced by a factor of 10 with very little effort (*3*, p. 27). Such excessive exposures could be prevented by effective action at the federal level. Furthermore, at the present time medical exposures are not included in the 170-millirem exposure suggested by the FRC. We think they should be.

The authors continually charge that the mechanisms for setting environmental safety standards (such as the FRC) are inadequate in that they too often focus on the short-term benefits of technology rather than the possible long-term adverse effects. They call for more public discussion and participation in weighing the costs and benefits of atomic energy and indeed of any new technology. They also call for new institutions in which independently financed scientists would serve as adversaries against the promoters of new technology. In these suggestions the authors are certainly not alone. We personally agree that there is an urgent need for participation by a well-informed public in future decision making.

The "technological assessment" of nuclear energy by the public has already begun. There are numerous court interventions all over the country in which citizens are asking for lower emission standards for nuclear power plants. Such reductions seem to be technically feasible. Both General Electric and Westinghouse offer augmented air- and water-treatment packages for their reactors which would add only about 1 percent to the cost of the plant. Should such devices be required on all nuclear power plants? Are they only "possible," in the words of the AEC, or are they also "practicable"—meaning economically feasible in some sense? Should the public—the consumers of electricity and the potential victims of radiation exposure—have some voice in this decision?

An important issue that the authors mention and that has not yet received the public attention it deserves is the need for some reasoned policy with regard to the future energy requirements of our society. Do we in fact need to increase our electric power consumption at the present rate of 9 percent a year while the population is growing at 1 percent a year?

We are still at the beginning of the nuclear age. In view of our limited ability to assess all the consequences of technological innovation we would be wise to exercise greater caution than has been so far manifested in setting environmental standards. Failure to do so in the case of radiation standards would appear to be singularly irresponsible, since there is little doubt that exposure limits in the United States could be substantially reduced without forcing people to live by candlelight in caves. Gofman and Tamplin have raised serious questions concerning the basis for and the mechanisms of technology assessment. We hope that the attention these questions demand will not be diverted because of their passionate and intemperate rhetoric.

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Apollo's Baggage

Moon Rocks. HENRY S. F. COOPER, JR. Dial, New York, 1970. x, 198 pp. + plates. $5.95.

The Lunar Rocks. BRIAN MASON and WILLIAM G. MELSON. Wiley-Interscience, New York, 1970. x, 180 pp., illus. $8.95.

These two accounts of the most carefully studied (and expensive) rock collections in history are surprisingly complementary. Cooper's journal gives some insight into the personalities and motivations of the men selected to examine the lunar samples, whereas Mason and Melson give a summary of the facts and theories derived from those samples as of January 1970.

Cooper's style is informative and has that delicious flavor of hot gossip characteristic of profiles and reports found in the *New Yorker*. I was grateful to Cooper when the installments of his book appeared there for his appraisal of what my colleagues were doing in the LRL (Lunar Receiving Laboratory), and I am now again grateful for this collection of anecdotes about those trying and hectic weeks.

Cooper uses confrontation as a stage drop for his journal, and his protagonists accuse each other of a variety of intellectual vices as they discuss whether the moon is hot or cold. (Most people I knew thought it was lukewarm, but such wishy-washy attitudes are not good journalism.) He follows a few individuals through the events of moon walk, initial examination of the rocks, and the lunar conference in Houston in January 1970. The choice of individuals is apparently those who would take time to talk or those whose reputations cannot be overlooked.

We get a fair spread of scientific styles, and the sense of hierarchy comes through very clearly as theoreticians, analysts, and natural scientists are suspicious of each other's competence. Cooper was not in a position to see much of the history of the LRL, and it is sad to realize we may never get a set of memoirs from the principals