Book Reviews

Our Threatened Planet: The Technological Plague

Science and Survival. BARRY COMMONER. Viking, New York, 1966. 160 pp. $4.50.

I remember the burden, though not the detail, of a short article by Merle Tuve in this journal some years ago: it was an eloquent plea for a return to the days of the lone investigator, the limited budget, and the garret laboratory. Those were the conditions of the great scientific discoveries in history, Tuve argued, and we should not forget it. That notion has had little influence on the allocation of research and development funds, probably because this century's advances—in atomic energy, in space exploration, in information technology—seem to belie its relevance.

A whole area of inquiry into the interactions of science and public policy has been marked out in the last 20 years to tell us that policy-making and policy-makers must henceforth be irreversibly different from what they were before the advent of atom bombs and rockets and data banks. In confirmation of that judgment, the policy-makers themselves have in the same 20 years been developing new policies, new ways of looking at policy, new partnerships with science, and new administrative procedures—all under the new name "science policy."

Can science itself remain the same amid this change? Can its objectives, methods, practitioners, and organization remain pristine and unchanged, while everything around it changes? There is a belief among scientists that science is inviolate at some essential level. But all our knowledge of societies argues that the institutional forms of science will change along with all other institutional forms. Indeed, should not science, as the source of innovation, properly lead the others? All our social wisdom says that we must recognize the inevitability of this change so that we can understand and control it. This is the next great challenge to thinking about science, I think. It may well define the central concerns of a second-generation science policy.

The importance of Barry Commoner's new book lies in its raising these issues about the future of science, not always wittingly or directly, but with a force that cannot be denied. Its weakness is in a residual confusion of the issues that ends by leading the argument astray.

Commoner's theme is that the massive opportunities potential in modern science and technology include opportunities to make massive mistakes and that it is therefore incumbent upon scientist and citizen to take a fresh look at science and its applications.

The first section of the book reviews the many ways in which we are polluting our environment and altering its natural patterns, and the accelerating rates at which we are doing so. We are reminded that we thus threaten not only our own well-being but also that of the unborn, the viability of plants and animals, the world's food, the very possibility, in the end, of supporting life on this planet. Increasing pollution is partly the simple result of increasing populations and the wastes they produce, of course, but technology adds to it, as in the deleterious effects of internal-combustion engines, nuclear fallout, detergents, insecticides, and weed-killers.

Commoner's account gains its impact less from any newness of this content than from the number of mutually reinforcing examples it brings together and from the detail in which each is given. The technical arguments are clear and reinforced by facts and frequent citations of documents from scientific and governmental sources. They are calculated to rid even the unschooled reader or ambitious program manager of any romantic illusions that science and technology are virtually unmixed blessings whose costs to society are incidental, accidental, and ignored with relative impunity:

> We have come to a turning point in the human habitation of the earth. The environment is a complex, subtly balanced system, and it is this integrated whole which receives the impact of all the separate insults inflicted by pollutants. Never before in the history of this planet has its thin life-supporting surface been submitted to such diverse, novel, and potent agents. I believe that the cumulative effects of these pollutants, their interactions and amplification, can be fatal to the complex fabric of the biosphere. And because man is, after all, a dependent part of this system, I believe that continued pollution of the earth, if unchecked, will eventually destroy the fitness of this planet as a place for human life.

To illustrate the danger Commoner cites the devastation of Lake Erie by sewage, industrial wastes, and runoff from chemically fertilized lands; the threat to the Antarctic ice cap—and therefore to the world's heavily inhabited coastal regions—of rising atmospheric temperatures caused by excessive carbon-dioxide concentrations in the air; and the quasi-permanent biological changes in plants, animals, and people induced by the radioactive debris already released into the atmosphere. Man now intervenes in nature, in short, to a degree that requires careful advance consideration of the effects of such interventions on the total system of nature.

Commoner finds that science is in large part responsible for the situation that technology has brought us to. He points in particular to the disparity between the present state of the physical and of the biological sciences:

> The separation of the laws of nature among the different sciences is a human conceit; nature itself is an integrated whole. A nuclear test explosion is usually regarded as an experiment in engineering and physics; but it is also a vast, if poorly controlled, experiment in environmental biology. It is a convincing statement of the competence of modern physics and engineering, but also a demonstration of our poor understanding of the biology of fallout. . . . If basic theories of physics had not attained their present ability to explain nuclear structure, we would not now be confronted with massive dissemination of man-made radioisotopes and synthetic chemicals. If biological theory had become sufficiently advanced to master the problems of cancer . . . we might be better prepared to cope with these new environmental contaminants.

The theme is thus balance—balance in nature and the needed balance in the pursuit of knowledge. This preoccupation leads Commoner, less than logically, to an extensive and impassioned examination of the current controversy between classical and molecular biologists over whether the secret of life is to be looked for in the cell or in the molecules that make it up. His own position in that controversy is squarely with the classicists: "The dominance of the molecular approach in biological research fosters increasing inattention to the natural complexity of biological systems," he argues, and is at the root of that wider scientific inattention to the natural complexity of the total environmental system which is already leading us to trouble. Why this widespread inattention? Because, Commoner says, the integrity of science has been compromised by political pressures to narrow the gap between discovery and application and to harness science to political and social goals. These pressures have corrupted scientists, so that "the public is no longer certain that scientists—all of them—'tell the truth'. . . . The citizen has begun to doubt what he used to take for granted—that science is closely connected with truth." By claiming a special partnership in the political process, scientists have tarnished their mantles and eroded the integrity and therefore the efficacy and reliability of science.

What is the solution? There is no single, magic one, says Commoner, but one may be fashioned from a number of elements. First, the scientist should function as a teacher to inform the citizenry about the technical content of political issues. He should not, *qua* scientist, become a partisan or an accessory. Second, science must rededicate itself to its historic integrity, which lies

> . . . in the minds of scientists, and in the system of discourse which scientists have developed in order to describe what they know and to perfect their understanding of what they have learned. It is these internal factors—the methods, procedures, and processes which scientists use to discover and to discuss the properties of the natural world—which have given science its great success.

Third, science must again seek its traditional "isolation from cultural effects" in order to have the freedom to judge "in which areas the new insights of science are powerful and effective guides to action [and] in which others they are too uncertain to support a sound technology."

One may share the author's concern about the undesirable effects of modern technology and agree with his statement of the values of science without allying oneself either with his evaluation of the biological debate or with his implicit belief in the efficacy of exhortations to return to a more honest time. The current state of biology may be illustrative of his argument, but the importance given it in this book seems *sui generis*. The exhortation, moralistic at times, occupies the longest chapter of the book, which includes also an informative account of the author's own efforts at public education with the St. Louis Committee for Nuclear Information and a severe indictment of the public information policies of the Atomic Energy Commission. Beyond that, it contains little that is new and much that is familiar, including the purest intentions, a few political axes, and some dubious philosophical formulations.

Yet the problem remains. It is perhaps most fruitfully seen, I have suggested, as one of modifying old forms into newer ones more nearly adequate to the changed role that the institution of science must play in society. My hypothesis—and Commoner's evidence —is that the successes of science are forcing a change in its own ground rules in several important and related ways.

First, a science become politically important unquestionably affects the objectivity and freedom traditionally associated with the image of the scientist. Commoner is not the only one concerned about that. The efforts of most of the responsible scientists in or at the periphery of government are directed to insuring against the danger.

Second, as the technologies that science spawns begin to affect the ecological balance of the planet, there arises a need to reconsider the wisdom of the traditional belief in the "duty" of science to explore the unknown unhampered by any other considerations.

Third, the prospect that new technologies will require a combination of scientific competences to gauge their full implications may indeed call for increasing concern about the comparative rates at which the various sciences advance and may furnish additional cause for the current search for cross-disciplinary patterns of inquiry.

Finally, it may be time to look again to the metaphysical foundations of science for some of the understanding needed to resolve the difficulties that Commoner points to. It is indisputable that the spectacular advance of science for three centuries was aided by release from ancient metaphysical constraints. It is equally indisputable that science profited from remaining largely unapplied. There was little feedback about the nature of the world to interfere with the freedom and the disciplinary specialization that it thrived on. But it does not follow from this history that science can forever be free of constraints imposed by the character of the natural world that it explores. A chief philosophical implication of modern technology may be that it reveals these constraints by serving as an explicit link between knowing and the known. It is fashionable these days to contrast the mutually independent careers of science and technology in the past with the science-based technologies of the present. The implications of this change for technology and for politics have been fairly extensively explored. Its implications for science have not. Yet the fact that technology now begins to reveal more general traits of nature than have the local and unconnected reactions elicited in the laboratory may be of capital significance for the assumptions, structures, practices, and values of the scientific enterprise.

I am not sure that Commoner put all this into his book, but I do not imagine he should be displeased that this is what one reader got out of it.

EMMANUEL G. MESTHENE
Harvard University,
Cambridge, Massachusetts

Questions and Methods in Number Theory

Sequences. Vol. 1. H. HALBERSTAM and K. F. ROTH. Oxford University Press, New York, 1966. 311 pp., illus. $10.10.

The "sequences" of the title are sequences of nonnegative integers. It should be said immediately, however, that this book is not accessible to the general reader. For although the integers are familiar to almost everyone, the material presented here is mathematically sophisticated and, in a few instances, very difficult. On the other hand, any serious student of mathematics will find a great deal to attract him, for the subject abounds with results of great elegance, power, and generality which at the same time are not overly technical.

Here are some problems of the type discussed in the book:

1) Given a sequence of nonnegative integers, can every nonnegative integer be written as a sum of two members of *A*? If the answer is "no," then will three suffice? And so forth. The best-known result of this kind is that every