starved areas of the world where solar energy is abundant. Distillation of seawater is one of the most promising applications of solar energy. The primary difficulty constantly encountered with respect to the utilization of solar energy is the large collection area required, the construction of equipment to cover such an area, and the subsequent maintenance of the equipment. The areas of the world where the use of solar energy can be an economical proposition are obvious, the applications—for example, in distilling water, heating homes, and cooking—are evident, and the difficulties confronting researchers are known. However, many new avenues of research, particularly of chemical research, exist where a dramatic advance would greatly change the outlook. It could readily be that the plant scientist will clearly excel the engineer in the utilization of solar energy available on a per capita basis for most of the world.

A few of the topics to which chapters are devoted include the history of the subject, a description of solar energy and its distribution, collectors, cooking, heating water, heating buildings, the distillation of water, solar furnaces, cooling and refrigeration, thermoelectric, photovoltaic, and photochemical conversion, and the storage and transportation of power. The well-bound book, with a garish cover of "sunlight" yellow, a comfortable print on good paper, and halftones on glossy paper, represents a pleasing contribution to the literature on solar energy. It is a fine summary of the research and applications to date, and it should be read by layman and scientist alike. Daniels is to be congratulated.

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Education, Manpower, and Economic Development

Manpower and Education: Country Studies in Economic Development. Frederick Harbison and Charles A. Myers. McGraw-Hill, New York, 1965. xiii + 343 pp. $9.

This volume contains the background studies for *Education, Manpower, and Economic Growth* by the same authors [reviewed in *Science* **145**, 917 (1964)]. Following a brief introduction, there are analyses by 11 other authors of the history, current status, trends, and problems of planning for improvement in the education and utilization of trained manpower in Argentina, Peru, Chile, Puerto Rico, Iran, Indonesia, Communist China, Senegal, Guinea, the Ivory Coast, Nyasaland, and Uganda. A final chapter contrasts manpower issues in East Africa and Southeast Asia. Each chapter (except the one about Communist China) was written by an American social scientist who has spent considerable time working on manpower and education problems in the country of which he wrote.

The nature and amount of information available about the countries varies, and so, necessarily, do the coverage and treatment. In general, each country (except Senegal, Guinea, and the Ivory Coast, which are treated together in one chapter) gets about 30 pages. The analyses are praiseworthy, but each author must often have wished for better data. There is no index.

Foreign aid programs and plans for economic development depend for their success upon many factors. Certainly among these factors must be included the knowledge that the planners and administrators have of the resources, economic conditions, educational status, cultural setting, and the motivation and organization of the country involved, and a sense of the fitness or appropriateness of a particular program or activity to the setting and stage of development into which it is being introduced. A reader interested in a particular country will find a certain amount of information about that country (if it is one of those included) and, with due caution because of the substantial differences, may also be helped by learning about some of the things that have been tried, how goals have been met, what obstacles have been encountered, and what suggestions can be drawn from experience in other countries. In the introduction, Harbison and Myers summarize a number of major principles of economic planning that emerge from the diverse experience they and their chapter authors have had in working in many countries.

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Science, Technology, Society

Science as a Cultural Force. Edited with an introduction by Harry Woolf. Johns Hopkins Press, Baltimore, 1964. x + 110 pp. $3.95.

This book consists of four essays originally delivered as the Shell Companies Foundation Lectures on Science, Technology, and Society at Johns Hopkins University. Two of the lecturers, James R. Killian, Jr., and Jerome B. Wiesner, who have been intimately associated with governmental activities in science and technology, deal with the outer, public life of science and technology; the other two lecturers, Michael Polanyi and Gerald Holton, deal with the inner, private world of scientific thought.

Both Killian and Wiesner have already expressed in other lectures and publications many of the points that they make in this volume, but the points are important enough to merit restatement, and here they are concisely and well put. Killian's essay, "Toward a research-reliant society: Some observations on government and science," stresses the growing importance of the "innovation industry" (research, development, test, and evaluation) in our national life. He is properly concerned with the government's role as the dispenser of funds for science, with the methods of handling scientific research conducted under governmental auspices, and with the problem of scientific advice to policy makers. Because the flourishing state of American science might lead us to relax our efforts and might tend to obscure areas of weaknesses that may develop in the future, Killian stresses the need to review our present practices and establish future goals so that the innovation industry can continue in its role as one of the "principal energizers of our society."

In his essay, "Technology and society," Wiesner gives handy guidelines for judging public investment in science and technology: "Technological development should only be undertaken to fulfill specific needs, and only if the proposed new development gives promise of being economically justifiable as well as technically sound. Basic research should be judged primarily on scientific merit and supported at a level which permits all meritorious work if available funds permit." He then proposes an annual budget of $1 billion for the productive allocation of R&D funds, with the major items ($100 mil-

lion or more) consisting of educational research and development, natural resources development, international development, and supersonic aircraft development.

Wiesner emphasizes the variety of uses to which the high-speed electronic computer can now be put. Most important among these is the simulation of complex dynamic systems not only for engineering design but also for the study of economic and social behavior, thereby making it possible to predict the consequences of human and social decisions in advance of their actual application.

From the hard realm of the dollars-and-cents relations of government with science and technology, Michael Polanyi's essay, "Science and man's place in the universe," changes orbits into that hazy realm of scientific philosophy which might more properly be known under its older title of "metaphysics." Polanyi's aim is to sketch "a theory of knowledge which abandons the idea of scientific detachment. . . . All knowledge is based on a measure of personal participation. . . . We can know more than we can tell." Speaking in terms of "subception" and "tacit knowing," he develops a theory of knowledge that "accepts indwelling as a proper way of discovering and possessing the knowledge of comprehensive entities." There is no possibility of the explanation of consciousness by the laws of physics and chemistry, he tells us, and we must not allow the ideal of strict detachment "to deprive our image of man and the universe of any rational foundation." The usual scientific theory of knowledge "requires that all stages of life be accountable by the laws governing inanimate nature," but Polanyi claims there are higher levels of existence that are inexplicable in terms of the laws governing the lower levels. Using the idea of evolution as his example, he finds that "evolution shows man arisen by a creative power inherent in the universe," thereby justifying the concepts of Teilhard de Chardin regarding emergent evolution. Although the editor's introduction claims that Polanyi's search to find a home for man in the universe "shatters the popular myth of the two cultures," the theories of personal knowledge and emergent evolution advanced in this essay are more likely to turn that myth into reality.

The final essay in this collection, Gerald Holton's "Presupposition in the construction of theory," does help to narrow the distance between the two cultures by showing that thematic hypotheses play similar roles in scientific and in humanistic scholarship. Demonstrating that Newton used thematic hypotheses in his theories of matter and gravitation, Holton points out the importance of such hypotheses in the early stages of a developing science, as a necessary component in efforts to bridge the gaps of ignorance. However, thematic questions "do not get solved and disposed of. . . . Rather, they rise and fall and rise again with tides of contemporaneous usefulness or intellectual fashion."

Despite its over-pretentious title—after all, as a "cultural force," science comprehends much more than is included within these four lectures—the book provides a useful compendium of the thoughts of some outstanding thinkers and doers with respect to some of the contemporary problems of science. But what about science as a cultural force in the arts, in literature, and in other fields of humanistic endeavor? We still await the "dialogue" that will convert that wordy battleground into a meeting ground and truly show science as a force of major dimensions over a much broader spectrum of our culture.

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On the Popularization of the Biological Sciences

A generation ago the popularization of science meant almost entirely the popularization of physics and astronomy. Today it is biology that receives the lion's share of the attention of public and publicizers. The change is only in part attributable to the greater visibility of the biological frontier. In addition, and for whatever reason, today's most able scientists-expositors are devoting their attention to biology rather than to physics. The Eddingtons and Jeanses have been replaced by the Stanleys and Stents and Boreks. Such a shift will surely affect the future recruitment of scientists.

The field covered by biochemist Ernest Borek in his latest book, **The Code of Life** (Columbia University Press, New York, 1965. 272 pp. $5.95), is a familiar one. It includes the story of the nucleic acids from Miescher to Nirenberg, Mendel's work, the development of x-ray analysis by the Braggs, Astbury, and Wilkins, and the growth of biochemical genetics from Garrod to Sanger. There is a good discussion of protein synthesis and the coding problem. Everywhere the text is enlivened by relevant anecdotes of the personalities involved. The reader is carried along by the enthusiasm and widespread interests of the author. Borek has a keen eye for telling historical quotation. At the very end of his account of the decoding of nucleic acids, he includes this now astonishing statement made by William Bateson in 1916:

> It is inconceivable that particles of chromatin or of any other substance, however complex, can possess those powers which must be assigned in our factors (genes). The supposition that particles of chromatin, indistinguishable from each other and almost homogeneous under any known test, can by their material nature confer all the properties of life surpasses the range of even the most convinced materialism.

This has been quite a half-century for materialists!

Of factual errors I found few. I reviewed the book from galley and noted a number of scrambled structural formulas, but these have been (I trust) corrected. The Danish geneticist W. Johannsen (misspelled) is wrongly identified as a Hollander. Nägeli is everywhere written as Nageli; if the umlaut is to be jettisoned the name should be Naegeli. The electron microscope is said to be only 50 times as powerful as the optical 'scope, an underestimate by an order of magnitude. But such errors are not terribly serious.

For a book of this sort it is more apropos to discuss stylistic lapses. In his preface the author puts himself firmly on the side of the angels in the debate started by C. P. Snow with the following assertion: "The dichotomy is not between two cultures; it is between culture and no culture," and expresses his great admiration for a polished paragraph. Having made this public commitment, he can expect criticism of stylistic details that a writer of lesser quality would be spared. In