Science and Education

Among those who are thinking and writing about the crisis in contemporary education James Bryant Conant is respected as the model of the scientist-turned-educator, the scientist who approaches the problem of preparing the next generation for life in a free society as he would a problem in chemistry. He formulates his questions clearly, examines his assumptions, marshalls the relevant facts, draws his inferences cautiously, and where the facts are insufficient, as is usually the case in education, concludes by asking further questions. His recent books have stirred up a good deal of invigorating controversy among educators, and it may well be that the future historian will rank him with John Dewey as one of this country's really constructive educational rebels.

This little book, **Two Modes of Thought: My Encounters with Science and Education** (Trident Press, New York, 1964. 128 pp. $3.95), edited by Ruth Nanda Anshen, is also about education. It is not Conant at his best, but it is eminently worth reading. The "Credo Series," to quote from the editor's eloquent if somewhat inappropriate preface, is "designed to present a kind of intellectual autobiography of each author, to portray the nature and meaning of the creative process for the creator and to show the relevance of his work to the feelings and aspirations of the man of flesh and bone." Few self-respecting scientists would care to bare their souls in this way, and certainly not Conant. He makes a polite but slightly embarrassed bow to the series, but his "credo" is essentially a sober examination of a question that has become increasingly pertinent in 20th century America: Are the ways of thinking which we have developed in the natural sciences applicable in the fields of the social sciences, and especially in the field of education? The question is not a new one, nor is Conant's answer a simple yes or no. The book provides a clarification of the question rather than a firm answer.

Anyone who has lived on both sides of the Atlantic will recognize the stereotypes of the theoretical-deductive European and the empirical-inductive American. These are obviously oversimplified, but certainly there is a difference between the "typically American" Edison and the "typically European" Clerk Maxwell or Helmholtz; and Conant finds counterparts of these in American and European approaches to education. To American eyes the European seems lost in a fog of theory; the practical American, as seen by the European, is lacking in *Gründlichkeit*. Do these really represent two different ways of thinking? Was Bacon right in his radical distinction between inductive and deductive methods in science? Conant draws on his knowledge of the history of science and technology to demonstrate, not surprisingly but very cogently, first, that the distinction is meaningful but not nearly as sharp as we have sometimes been led to believe, and, second, that an overemphasis on either may have unfortunate consequences. Certainly there are two modes of thought, and perhaps more than two, but none of the great scientists and inventors, or even philosophers, has ever been exclusively inductive or deductive. Both approaches are necessary, but there must be some sort of meaningful balance between the two.

This does not sound like a very exciting or disturbing judgment; and it is not, as Conant presents it. As a physical scientist and a gentleman Conant is always courteous to his colleagues in the social sciences, hinting between the lines that he is not deeply impressed by their accomplishments, but evidently hoping that a friendly word or two will spur them on. One would like him, perhaps in his next book, to speak out more forcefully. Social scientists, and especially those whose work borders on the field of education, are open to two criticisms; either, to use Conant's terms, they are too theoretical-deductive or they are too empirical-inductive. At one extreme are the self-styled "learning theorists," whose elegant miniature models bear little relation to human learning in human situations. At the other extreme are the survivors of the ultrapositivistic age, who recoil from theory of every sort and for whom science seems to mean laborious accumulation and meticulous statistical analysis of unconnected trivialities. Neither type has much of value to say to the educator, and each might with profit give heed to Conant's interpretation of both science and education.

Whether or not there can be a proper "science" of education is a debatable question, but probably not worth debating at great length. As Conant points out, with apt illustrations from a variety of fields, the distinction between science and technology is at best a tenuous one. But, he intimates, there can be an *approach* to the problems of education that is scientific in the best sense of the term, and this must involve a nice balance between the two modes of thought. To repeat, this is not a particularly startling thesis, but it is an important one, and Conant presents it with the wisdom and clarity which we have come to enjoy in all his writing.

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Russian Translation

Radiation Biochemistry. A. M. Kuzin. Translated from the Russian edition (Moscow, 1962) by Y. Halperin. M. R. Quastel, Translation Ed. Israel Program for Scientific Translations, Jerusalem; Davey, New York, 1964. iv + 284 pp. Illus. $15.25.

In the Russian edition of 310 text pages, reduced to 284 in this able translation, Kuzin defines radiation biochemistry as that broad area lying between the extremes of pure radiation chemistry and the radiation biology of intact living organisms. The author is an active contributor to the field, and the text is intended primarily for scientific workers and graduate students. As a result of its tardy appearance, the English language edition has lost some of its usefulness. The radiation effects

observed must be interpreted in terms of current concepts of biochemistry, and in such a rapidly developing field it is regrettable that a book published in 1964 is based on material gathered in 1961 or earlier.

A brief description of the physical characteristics of ionizing radiations and modes of energy transfer to absorbing matter precedes some 80 pages devoted to a review of radiation effects in biologically important systems. The radiolysis of water is discussed in detail, and a separate chapter is devoted to the formation of peroxides. Radiation effects in simple proteins, nucleic acids and nucleoproteins, carbohydrates, lipids, and enzymes and vitamins are considered in separate chapters. In part 2, 160 pages are devoted to the effects of radiation on the metabolism of living cells and tissues. A final chapter presents a biophysical and chemical interpretation of radiation injury in cells.

Although the present volume is more of a review, one cannot resist comparing it with Lea's classic *Actions of Radiation on Living Cells*. In Lea's treatise much emphasis was placed on the target theory. Kuzin, writing with a wealth of new concepts and experimental findings at his disposal, gives more attention to the fate and biological action of the primary products of radiation absorption.

This book will be valuable to workers in the field and to advanced students. The bibliography of 1000 items is separated into the Russian and non-Russian languages. For those with capabilities in the Russian language, references are given to the translation and the original text.

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Nematodes: A Review and Résumé

The Physiology of Nematodes. D. L. Lee. Freeman, San Francisco, Calif., 1965. 164 pp. Illus. Paper, $2.50.

During the 13 years since publication of Von Brand's *Chemical Physiology of Endoparasitic Animals*, the thin stream of work on nematode physiology has grown to a small rivulet. Lee has written an important and timely review of our knowledge of the physiology of this neglected group. The complexion of work in nematology has changed from the narrow emphasis which in the past was placed on nematode parasites of animals, and, in addition to the familiar *Ascaris* and *Trichinella*, we are now concerned with a growing group of such plant parasites as *Heterodera, Meloidogyne,* and *Ditylenchus*. Because these parasites inhabit soil during a part of their life cycle, and it is possible to control nematodes in soil, study of the physiological aspects of the ecology of nematodes in the soil has begun. New techniques of in vitro culture of animal parasites, free-living forms, and plant parasites have opened many possibilities for studies of nematode physiology.

Lee begins with a short discussion of nematode morphology, then proceeds to feeding and digestion, metabolism and oxygen transport, osmoregulation and excretion, hatching and moulting, the nervous system and sense organs, and locomotion and behavior. He provides 161 references that guide the reader toward the most important work in the field. Unaccountably, the author fails to discuss important recent advances in techniques of nematode culture.

It was refreshing to note the close attention paid to developments in phytonematology as well as to classical parasitology. The book emphasizes our vast ignorance of the physiology of the great majority of types found in soil and the total lack of work on marine nematodes. Nematodes have attracted attention as important agents of human and animal disease. The recent addition of phytoparasitic forms still leaves the bulk of the group unstudied.

Lee's monograph shows that nematodes utilize many of the usual biochemical and physiological processes, but that they are peculiar in some respects. At least one nematode synthesizes many of the so-called "essential" amino acids. Many forms are partially anaerobic; some marine nematodes inhabit mud that is completely lacking in oxygen. Lee's *The Physiology of Nematodes* should help to attract general physiologists to the study of nematodes.

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Reliability Analysis

Mathematical Theory of Reliability. Richard E. Barlow and Frank Proschan. With contributions by Larry C. Hunter. Wiley, New York, 1965. xiv + 256 pp. Illus. $11.

From sparse beginnings, reliability theory as an independent discipline has developed considerably during the last 20 years. This book attempts to provide mathematical justification for some of the practices now being used to solve reliability problems. It is my opinion that, mathematically at least, the authors have accomplished their objective. As they are careful to point out, however, statistical problems are in general not treated.

The format of the book is basically theoretical and requires a sound background in calculus and a knowledge of probability theory at the level of Feller (1957) for reading ease and appreciation. Even so, proofs of theorems are precise and not always easy to follow. Also, there is little or no discussion of the significance of the results obtained. Notation is consistent throughout and is basically identical with what has now become "standard" notation in reliability analysis. There appear to be no errors in the material presented other than an occasional misprint.

The authors derive some useful properties of probability distributions having monotone failure rates and use these in the solution of problems relating to estimation and prediction of the probability of survival for components or systems, maintenance policy, optimization procedures, and system availability. Generally speaking, system reliability is characterized either by a stochastic model (Markov Process) or by a "structure function" which attempts to describe the qualitative relationships that exist between a system and its components.

Specifically then, the book contains chapters on failure distributions, operating characteristics of maintenance policies, optimum maintenance policies, stochastic models for complex systems, redundancy optimization, qualitative relationships for multicomponent structure, and a brief discussion of pertinent reliability definitions. The useful bibliography cites most of the important contributions to reliability analysis.

Renewal theory is reviewed in the chapter on operating characteristics of maintenance policies. The renewal