

landscape, its map, and its photograph, in spite of qualitative differences, exemplify the same spacial structure. In the technical sense that would make it relevant for the argument, the distinction is either irrelevant or untenable. But I shall say no more about the realism issue which is, beyond doubt, the primary concern of "Human Knowledge." What I could say would not suit my admiration for an achievement that is, in logic, as monumental as Newton's or Einstein's in physics, or my respect for a man as venerable as Voltaire.

The last third of the book is a discussion of probability and induction. I, for one, find this part rather difficult to follow. As far as I understand the argument, and I am not at all sure that I do, I shall sketch it in six steps. (1) The two statements "The probability of throwing tails with this coin is one half" and "Probably all men are mortal" do not mention the same notion. Probability in the first is a matter of statistics, broadly speaking; the probability mentioned in the second is the objective counterpart of what philosophers have called rational belief. (2) Statistical probability can be subjected to the calculus of probability, which as such is a noncontroversial mathematical schema, provided the so-called law of large numbers is assumed. This law itself does not state a mathematical truth but a matter of fact and, therefore, if it is true, merely an inductive truth or generalization. (3) The "problem" of induction is the question on what "rational grounds" we "infer" a generalization, such as "Probably all men are mortal" or the law of large numbers, from the finite number of instances which are all that we can ever "know." (4) Hence, if one insists on the statistical interpretation of the probability calculus, attempts to furnish grounds of induction by an application of this calculus lead to circularity. (5) Having reached this point, Russell uses a proof of Keynes' to establish the following weakened form of the inductive principle: If a generalization has an initial probability greater than zero before it has been tested, then this probability will converge toward one with the number of confirmatory instances found. (Naturally, I omit here all sort of detail.) (6) Russell then proceeds to state five "principles" which he believes have such initial probability and constitute sufficient grounds for rational belief in the truth of scientific inference.

The first four steps are hardly controversial, except that some of us no longer understand what is meant by "rational grounds," do not consider it the business of philosophical analysis to provide such grounds, and are, therefore, not particularly impressed with the "problem" of induction. The difficulty I have with the fifth step is twofold. First, I do not know what it means to say that a law of nature has a statistical probability, either initial or otherwise, and I conclude, therefore, that what is involved in the last two steps is credibility. Second, though I am not at all sure what, if anything, is meant by credibility, I see no reason to believe that one obtains true or, for that matter, intelligible statements if the relation called probability in Keynes' abstract schema is interpreted as credibility. As for the sixth point, the author himself admits that his five principles are remark-

ably vague. Some of them have no other use than to buttress rational belief in the existence of the external world which, according to Russell, it is the task of science to establish. Some others attempt to state general structural features of the laws of nature, where the phrase "general structural feature" is so used that the homogeneity of time and space would be such a feature of the world of Newtonian mechanics.

It goes almost without saying that this very compact book contains many brilliant expositions of standard empiricist doctrine. For instance, the discussions of definitional techniques and of the interpretation of axiomatic systems in Part Four, showing that "laws, conventions, and observations are almost inextricably intertwined in the actual procedure of science" (p. 284) are particularly lucid. Again, the lay reader will probably enjoy the behavioristic accounts of meaning, truth, and belief, to be found in the earlier sections. In view of the condition of British and Continental psychology this sort of thing is, perhaps, still worth saying, provided that it is said by an author and in a manner that are not likely to encounter the resistance American psychology meets in those countries. Philosophers, on the other hand, at least if they are not pragmatists, will be disturbed by the frequent substitution of psychological for epistemological analysis that mars much that could otherwise be salvaged from this strange and bewildering book.

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Industrial Research

RESEARCH IN INDUSTRY—ITS ORGANIZATION AND MANAGEMENT. C. C. Furnas, Editor. 574 pp. D. Van Nostrand Company Inc., New York City, 1948. \$6.50.

The organization of an industrial research laboratory is an unknown field to many sciences. While physicists probably feel that the best type of scientific organization is to have no organization (just as the "best" type of printed form is a blank sheet of paper), such ideas do not work out in practice, for wherever people work together some forms are necessary and some social conventions must be set up if friction is to be avoided. The present volume attempts to tell in some detail how various aspects of running a research organization have been faced in a number of cases. The thirty-three contributors represent many of America's better known companies: carpets, rubber, soap, radio, antibiotics, textiles, aeronautics, oil, refrigerators, flour, minerals, cartridges, chemicals, and vacuum cleaners are all represented and with this diversity of interests one finds, as one should expect to, a diversity of problems. In most cases these problems are merely stated and left unsolved, but quite often the solution which fits one set of circumstances may not fit another.

In such a volume, containing as it does the work of so large a number of men, there is bound to be some unevenness of style and content. There also appears a certain amount of reiteration which makes for dullness. But then one would scarcely expect to read so general a work from cover to cover. It is rather a sort of manual to

which one has to return, each time with a specific problem in mind.

One of the most interesting aspects of the book lies in the inherent disclosure that difficulties in running a laboratory seem to arise less often from the technical problems involved than from the personnel problems involved. Thus the evidence indicates that the fitting of a research group into a sales or production organization is not an easy task. For example the chapters on Selecting Projects for Research and Evaluating the Results of Research clearly show the effects of necessary compromise between the several groups. It is safe to assume that most companies have experienced similar problems.

The book contains chapters (among others) on the philosophy and objectives of research, the research director's job, research budgets and reports, characteristics of the research man as well as his procurement and selection, salary policies, personnel policies, design of a research laboratory, tools and helpers, the translation of research into new products, the evaluation of research, patent policy and patent pools (the article on the latter makes an interesting case for a highly debatable subject), public relations, and research in Europe. While most of the book is of high quality such a chapter as that on Research in America and Europe is so short as to be both superficial and misleading.

The book contains a bibliography of some seven hundred references as well as such addenda as sample personnel and patent forms. Written by men working directly on the fields concerned, the work is certainly a comprehensive endeavor. It is unfortunate for physicists (inasmuch as they must become more interested in such topics) that this first attempt is so overwritten and repetitious.

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Greek Science

A SOURCE BOOK IN GREEK SCIENCE. By Morris R. Cohen and I. E. Darkin. McGraw-Hill Book Company, Inc. New York, 1948. 579 pp. \$9.00.

This book is part of the series, "Source Books in the History of the Sciences," published under the auspices of several scientific societies under the general editorial supervision of Gregory D. Walcott, Edwin G. Conklin and Harlow Shapley. Source books in astronomy, mathematics, physics and geology have already appeared. After the death of Professor Cohen in January, 1947, Professor Darkin of the College of the City of New York, who had collaborated with Cohen on the selection and translation of the material, took the final editorial responsibility. The result of the conscientious and discriminating work of the two scholars is this exceptionally useful anthology. It contains English translations of the most interesting contributions of the Greeks and Romans on mathematics, astronomy, mathematical geography, physics, chemistry, geology, meteorology, biology, medicine and physiological psychology.

This book will be welcomed by all who want to study the ideas of the classical authors on science and are not

able, or have no patience, to read the original Greek or Latin texts, many of which are not even easily available. The publication will counteract the tendency to quote from second hand sources, the cause of so many serious misunderstandings. The present collection, with its broad pattern of subjects, should appeal—in the words of the editors—to those thoughtful readers who wish to achieve some understanding not only of the foundations of modern science, but of a vital element in our humanistic tradition as well.

There we find together, in rich variety, some of the most important sections of the works of Euclid, Archimedes, Pappus, Ptolemy, Hero, Aristotle, Vitruvius, Lucretius, Pliny, Theophrastus, Celsus and Hippocrates. Some unusual texts are included, such as a translation of a Leyden papyrus on the imitation of precious metals, and of a Stockholm papyrus on pigments and dyes. The editors have added commentaries, which occasionally amount to independent essays on certain aspects of Greek science. Added are extensive bibliographical references, which show that very little of any importance has escaped the editors (we miss Eva Sachs' book on the five Platonic bodies, E. J. Dijksterhuis' book on the Elements of Euclid, in Dutch, and material in the Russian language). It seems petty to cavil at the choice of material of so excellent and comprehensive a selection, but we believe that the account in Aristotle (Physics VI, 9) of Zeno's four paradoxes might well have been included. On the other hand, we are grateful for the inclusion of several texts on musical theory.

We believe that Professor Darkin can be proud of his labor of love, which has provided English reading people with a book of the greatest use to all who like to understand our classical heritage. There will be many who, like this reviewer, are delighted with this opportunity to enrich their knowledge of Greek science in its many ramifications.

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Books Received

TRANSACTIONS OF THE AMERICAN PHILOSOPHICAL SOCIETY, Vol. 38, Part 3, THE FREEZING OF SUPERCOOLED WATER. By N. Ernest Dorsey. 328 pp. The American Philosophical Society, Philadelphia, Pa., 1948. \$1.75.

ELEMENTS OF ELECTROMAGNETIC WAVES. By Lawrence A. Ware. 203 pp. Pitman Publishing Corporation, New York, 1949.

EINFÜHRUNG IN DIE ATOMPHYSIK. By Wolfgang Finkelburg. 339 pp. Springer-Verlag, Berlin, 1948. DM 28.

THE KELLEY STATISTICAL TABLES. Revised. Truman Lee Kelley. 223 pp. Harvard University Press, Cambridge, Mass., 1948. \$5.00.

THE OPTICAL PRINCIPLES OF THE DIFFRACTION OF X-RAYS. By R. W. James. 623 pp. G. Bell and Sons, Ltd., London, 1948. \$17.50.

PROCEEDINGS OF THE BERKELEY SYMPOSIUM ON MATHEMATICAL STATISTICS AND PROBABILITY. Edited by Jerzy Neyman, University of California Press, Berkeley and Los Angeles, 1949. \$7.50.