

### Bumblebees

By Dr. John B. Free and Dr. Colin G. Butler. With two appendices by Dr. Ian H. H. Yarrow. (The New Naturalist: a Survey of British Natural History.) Pp. xiv + 208 + 25 plates. (London: William Collins, Sons and Co., Ltd., 1959.) 25s. net.

**I**N their preface the editors express the hope that this book will widely encourage naturalists to take up the study of bumblebees, and it is indeed a stimulating work. Much information is given in an easily understood form, and possible answers to problems as yet unsolved are suggested. This eagerness to press forward on to untried ground does, however, occasionally lead the authors into making assumptions which are not entirely justified by the available experimental results. Certain over-simplifications also occur in places, as, for example, on p. 66 in the description of an experiment by Dr. Free, which was designed to test whether bumblebees entering a strange colony can be recognized by their scent alone. Reference to the original paper shows that the results were less clear-cut than stated here. Nevertheless, in assessing the overall scope and value of the book these criticisms prove to be relatively unimportant.

The development of colonies from their inception in the spring until the final hibernation of the mated young queens is described and, as in other chapters, the descriptions are illustrated by numerous original photographs. Among other topics discussed are the division of labour, collection of food, recognition of intruders in the nest, and predators and parasites. Not only are the biology and behaviour of bumblebees considered, however, for there is also an interesting chapter on their economic importance, in which their value as pollinators of crops and in plant-breeding is reviewed; various suggestions are also put forward for increasing their numbers in farming areas.

Two appendixes by the authors on methods of collecting and rearing colonies contain much useful practical information, while a further two appendixes by Dr. Ian Yarrow give a simple key to the British species of *Bombus* and *Psithyrus* and details of their distribution.

M. DELIA ALLEN

### Foundations of Set Theory

By Prof. Abraham A. Fraenkel and Prof. Yehoshua Bar-Hillel. (Studies in Logic and the Foundations of Mathematics.) Pp. x + 415. (Amsterdam: North-Holland Publishing Company, 1958.) 42 guilders; 84s.

### Axiomatic Set Theory

By Prof. Paul Bernays. With a Historical Introduction by Prof. Abraham A. Fraenkel. (Studies in Logic and the Foundations of Mathematics.) Pp. vii + 226. (Amsterdam: North-Holland Publishing Company, 1958.) 45s.

**T**HESE two books are the latest in the series of Studies in Logic and the Foundations of Mathematics, produced by the North-Holland Publishing Co. The first opens with a short chapter on the paradoxes of set theory and then proceeds to the axiomatic foundations, including the axiom of choice; the axiom systems of von Neumann, and of Bernays and Gödel are discussed. There is a chapter on type-theoretical approaches, containing developments by Quine, Wang, Lorenzen and others, and an interesting section on set theories based on non-standard logics. Here, in particular, is a discussion of the rather obscure ideas of the Polish logicians,

Leśniewski and Chwistek. About seventy pages are devoted to intuitionistic conceptions of mathematics, and the bulk of the discussion concerns, of course, the ideas of Brouwer. The final chapter is concerned with metamathematics and semantics. The bibliography, extending to fifty pages, covers comprehensively the years 1947-56, and will probably become the standard for this period.

"Axiomatic Set Theory" is, apart from the introduction by Fraenkel, largely a presentation of a modified form of the material published by Bernays over the years 1937-54 in the *Journal of Symbolic Logic*. It is a formal development and is carried out in detail in its applications to analysis, including the theory of real numbers, and to cardinal arithmetic. The book is, as the author says, "designed for a reader who has some acquaintance with problems of axiomatics and with standard methods of mathematical logic".

To the 'working mathematician' these two volumes will indicate something of the great amount of effort which, in recent decades, has been expended in the field of symbolic logic and the foundations of mathematics. The situation is still very fluid, and it appears that "the third foundational crisis that mathematics is still undergoing" is far from becoming a thing of the past.

L. S. GODDARD

### Elementary Statistical Physics

By Prof. C. Kittel. Pp. ix + 228. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1958.) 64s. net.

**T**HIS book contains a short but concentrated treatment of a wide field of theoretical physics. Part 1 (116 pages) deals with classical and quantum statistical mechanics and its relation to thermodynamics; Part 2 (52 pages) with fluctuations, random processes in general (including the Wiener-Khinchine theorem), Brownian motion, noise and irreversible processes; and Part 3 (46 pages) with detailed balance, kinetic and transport theory. The three parts are divided into a total of 45 sections, many of which are preceded by references to standard works and recent papers.

The exposition is usually clear and as simple as the topic permits, though there is an exception on p. 19 where the law of increasing entropy is discussed before the entropy of a non-equilibrium state is defined. The amount of application to particular problems is inevitably small in relation to basic theory. Assemblies of non-interacting particles only are considered, except for an example on a linear ferromagnet in the section on the density matrix and an appendix proving the virial theorem of Clausius. However, where possible, the author discusses both knotty points and recent developments; as examples may be mentioned sections on the thermodynamics of magnetization and negative temperatures, respectively. Problems are given, but some of these seem to be intended more as invitations to follow up the references than as exercises on the text. For example, after no more formal definition of a Markoff process than the statement that the two-event probability function  $p_2$  "contains all the information we need" the student is asked to prove the Smoluchowski (Chapman-Kolmogoroff) equation.

The book may be recommended for readers who wish to find out about some of the great variety of problems and methods in modern statistical physics.

G. M. BELL