

among the brightest stars so as to give a reasonably good distribution over the sky. In the planisphere prepared by Flight-Lieutenant Chichester, these stars are shown, with sufficient additional bright stars to aid in their identification. The twenty-four principal stars, the altitudes and azimuths of which are tabulated for different hour-angles and declinations in the Air Navigation Tables, are indicated by name, the remaining navigation stars by their numbers in the Air Almanac, while the other stars shown are numbered and their names given in a key. The planisphere shows the air navigation stars visible at any time of the night or year to observers in latitudes 50° N. and 35° S. It should be a great help to air cadets in learning to identify the stars required for navigation.

H. SPENCER JONES.

UTILIZATION OF STATISTICS IN RESEARCH

Statistical Methods for Research Workers

By Prof. R. A. Fisher. (Biological Monographs and Manuals.) Eighth edition, revised and enlarged. Pp. xv+344. (Edinburgh and London: Oliver and Boyd, 1941.) 16s. net.

SINCE its first appearance in 1925 Prof. Fisher's book has become the standard manual of statistical practice for research workers throughout the English-speaking world, and new editions continue to be called for. This eighth edition follows the same lines as its predecessors, which have themselves grown from the first mainly by the insertion of supplementary material throughout the book, not by structural alteration.

One of the signs of the success which the book has enjoyed is a change in methods and emphasis over the last seventeen years which would have justified a rather more drastic revision. The author evidently feels this himself, for in the preface he excuses himself from "The difficult task of a fundamental rearrangement" on the grounds that "it is of real value to understand the problems discussed by earlier writers and to be able to translate them into the system of ideas in which they may be more simply or more comprehensively resolved". Perhaps so, but we may hope that on some future occasion Prof. Fisher will be able to find the time and opportunity to remould the book a little nearer to the heart's desire.

In some respects this is a difficult book, partly because of Fisher's condensed style and partly for a more important reason. The theory of estimation and the exact tests of significance with which it deals are based on ideas and derived by mathematics which are quite outside the ambit of the average research worker in the so-called natural sciences. It would have been impossible to give anything like a complete account of the theory in a monograph restricted to method; and thus the author was practically compelled to the course which he finally adopted, and to describe only the technique of his methods and to exemplify their use. In consequence the reader has to accept important results without proof and often without any hint as to how they were derived or precisely what hypotheses underlie them. If he is

sufficiently interested and has the leisure to look elsewhere for the basis of the authority so much the better; but he will not find it in this book, and it is difficult to see how Fisher could have provided it without expanding a relatively short handbook into a comprehensive treatise.

This raises the question how far the powerful methods of modern statistics can be properly applied without some conception, however general, of their rationale. Its importance is heightened by the fact that the book, though not intended as a course of instruction for statisticians, is often referred to as if it were. Fisher has, in fact, suffered from a want of self-control on the part of some of his disciples, who betray a rapturous and indiscriminating enthusiasm which would be out of place even at a promenade concert. This in turn has excited a certain amount of criticism of the book. Orthodox statistical teachers have expressed doubts whether Fisher's broomstick can safely be entrusted to any apprentice who can memorize an invocatory formula. It is replied that one can use a telescope intelligently without being an optician. It is retorted that only qualified practitioners are allowed to administer powerful drugs. This sort of argument trails indecisively through a good deal of the statistical literature of the past fifteen years, but the whole question is one which might well be seriously discussed. In a large laboratory the difficulty may be overcome by the employment of a statistical specialist, and perhaps as research becomes more centralized the problem of the individual research worker who has to be his own statistician will disappear. But the question how far a knowledge of statistical *theory* is an essential part of the equipment of a research worker remains unanswered; it is a problem which could with advantage be studied by those responsible for the training of such workers.

However that may be, the influence of "Statistical Methods" on scientific method has been profound. To Fisher and his school goes the credit for having brought home to scientific workers two things. One is that the proper use of experimental data is itself a science which can be brought to a high degree of precision, even when the material is imperfect and the sample small. The second is that though in certain sciences and in certain classes of experiment error cannot be reduced, it can be controlled by experimental design. This latter lesson, indeed, has been inculcated by Fisher in a separate book and has not yet been fully learnt by research workers. It is a useful rule that statistical advice should be sought *before the experiment is carried out*. Most statisticians have met the case in which the results of an experiment could have been given a much greater significance, very often without additional trouble or expense, by adequate design at the outset of the inquiry.

Notwithstanding the interest aroused by the newer methods in statistics as applied to experiment, "Statistical Methods" has few competitors. To some extent this is due to the fact that it is largely a record of Fisher's own achievements, but that is not the whole story. The challenge of Fisher's ideas and his long record of success have made this book a sort of symbol of a new statistical creed and a banner around which his followers rally themselves. Research workers will long continue to buy this book, to wrestle with its ideas and to apply its methods to an ever-enlarging field of discovery.

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