Book Reviews

Selected Papers in Statistics and Probability by Abraham Wald. T. W. Anderson *et al.*, Eds. Published for the Institute of Mathematical Statistics by Stanford University Press, Stanford, California, 1957. ix + 702 pp. $10.

The development of a scientific discipline goes on at an uneven rate. Frequently, whole decades go by without major scientific advances; they are given simply to meticulous efforts aimed at perfecting the domain already covered. Then the monotony of this day-to-day routine is broken by the appearance of an individual of real talent. His papers reveal new ideas, formulate new problems, and break new ground. Occasionally, an old idea is rediscovered—perhaps one formulated long ago by another man of great talent and then overlooked by his contemporaries and forgotten. This old idea appears in a new light and becomes a basis for a new theory.

An incident of this kind recently occurred in the history of statistics. It was connected with the appearance on the scene of Abraham Wald. Born in Rumania and educated in Vienna, Abraham Wald came to Columbia University in 1938. Up to that time his interests had been directed toward various sections of pure mathematics. However, in 1937 he made a brilliant contribution to the foundations of the theory of probability. While in New York, Wald began to study the theory of statistics and, already in 1939, published one of his most important papers on the subject. Many other papers followed, quite a number of them written jointly with Wald's followers and students. This brilliant career was suddenly interrupted in the fall of 1950 when Wald, and his wife, perished in an airplane accident during a lecture tour in India. The statistical community in this country and abroad was deeply shocked and saddened. The present volume, which contains a collection of Wald's papers especially selected by a committee of the Institute of Mathematical Statistics, reflects the warm feelings of the statistical fraternity.

The achievements of Wald are many, and they are all brilliant. Because of the limitations imposed by the framework of the present review, only two major points can be mentioned. One of these consists in the rediscovery of a very fruitful idea conceived at the end of the 18th century by Laplace, then briefly developed by Gauss and then, largely, forgotten.

As is well known, the general problem of mathematical statistics is to develop methods of using the results of observations subject to chance in order to draw conclusions regarding the chance mechanism that produces the observations. Laplace noticed that, in applying any such method, the statistician is very much in the position of playing a game of chance: if the chance mechanism produces "favorable" values of the observable variables, his conclusions will be right: on the other hand, if the chance variation provides him with "unfavorable" values of whatever he observes, his conclusions will be wrong. How wrong his conclusions will be also depends on chance. The possibility of the statistician's choosing among many possible methods of drawing conclusions corresponds, in a sense, to the possibility of a gambler's having something to say about the rules of the game he is about to play. In these circumstances, Laplace imagined that, with every decision made by the statistician as a result of dealing with some observations, there is connected a "loss" and that the greater the statistician's error, the greater the loss. From here on, there was just one step to the formulation of the basic problem of choice among the possible statistical procedures: select the one that minimizes the expected loss resulting from wrong judgments. Gauss' method of least squares is based on this same principle, except that Gauss' loss function is defined to be proportional to the square of the error committed. Curiously, while the method and, particularly, the machinery of least squares are generally remembered and widely used, the principle on which this method is based—that is, the idea of the loss function—was largely forgotten. Wald's work brought it back, and now it is being broadly developed. The novel developments are concerned with methods of drawing decisions which, in a sense, are optimum not for any particular loss functions, such as those contemplated by Laplace or Gauss, but for broadly defined classes of loss functions.

The second major achievement of Wald consists in the integration of the theory of statistics (theory of decisions based on observations subject to chance variation) with the theory of experimentation, to form what may be called the theory of experimental strategy. The honor of having initiated the theory of experimentation belongs to another outstanding contemporary statistician, R. A. Fisher. However, much as science owes Fisher, particularly for his ideas of randomization, the problems of experimentation considered by Fisher are concerned with the design of isolated experiments and may be termed the tactics of experimental work. Contrary to this, Wald's theory deals not with single experiments but with their totality in a given domain of study. In addition, using his ideas about sequential procedures, combined with the idea of the loss function for faulty judgments, Wald laid the foundations of an all-enveloping, unified theory of experimentation and statistical decision-making. This unified theory contemplates the possible cessation of experiments at each step and the adoption of a terminal decision regarding "the state of the universe" or continuation of experimentation with a novel setup.

These general ideas, combined with many brilliant particular developments, are reflected in *Selected Papers in Statistics and Probability by Abraham Wald.* It must have an honored place on the shelf of every scientific library and on the desks of most serious research workers.

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The Water Relations of Terrestrial Arthropods. Cambridge Monographs in Experimental Biology, No. 5. E. B. Edney. Cambridge University Press, New York, 1957. 109 pp. Illus. $3.

The special difficulties encountered by terrestrial arthropods, because of their small size, in obtaining and keeping a sufficient supply of water have attracted the attention of many workers during the past quarter-century. In this small volume, E. B. Edney, who was, until 1955, reader in entomology at the University of Birmingham and who is now professor of zoology at the University College of Rhodesia and Nyasaland, reviews critically the literature in this extremely active field. The book will be of particular interest to insect physiologists, but comparative physiologists, ecologists, and biologists in general will welcome it. There are nearly 250 refer-

ences and, of these, more than 200 were published in the period 1930–55.

The subjects covered in the six chapters include transpiration and cuticle structure, excretion and osmoregulation, gain of water, and water and body temperature. Despite the limitation suggested by the title, material on aquatic insects is also discussed. Edney's treatment of these subjects is concise and clear, and his criticisms of methods and conclusions—including some of his own—are illuminating. Transpiration, for example, has turned out to be a far more complex process than it was, until recently, believed to be. The many questions which Edney raises should stimulate new and better work in the field.

A search for factual errors in those aspects of the subject with which the reviewer is personally familiar has yielded only one sentence which might be questioned. On page 71 it is stated, "The evidence so far considered shows that in most eggs which absorb water this is restricted to a given period of development—it may be before diapause as in *Melanoplus,* or after, as in *Austroicetes.*" This statement holds for *Melanoplus bivittatus,* as Salt's work has shown, but is not true for *Melanoplus differentialis,* where water is taken up by the eggs both before and after diapause. The fact that two species of the same genus of grasshoppers behave so differently in this respect illustrates both the variety which may be encountered in closely related organisms and the risk of making generalizations even for a genus. Since there are more than 150 species of *Melanoplus* in North America, a considerable number of surprises, no doubt, still await those who investigate the water relations of their eggs.

Edney's compact and well-organized volume is a valuable addition to the series of monographs presently being published by the Cambridge University Press. All who are concerned with the important part played by water in biological processes will be interested in this book.

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Nonparametric Statistics for the Behavioral Sciences. Sidney Siegel. McGraw-Hill, New York, 1956. 312 pp. $6.50.

Prior to the publication of *Nonparametric Statistics for the Behavioral Sciences,* isolated descriptions of nonparametric statistical tests and the necessary accompanying tables were inconveniently scattered throughout a highly varied literature. Sidney Siegel has performed a great service for behavioral scientists by cataloging, in a single volume, most of the available nonparametric procedures, along with tables of critical values. As a reference work, this book is not only convenient but almost indispensable. As an elementary textbook, it combines simplicity and systematic organization with many instructive illustrations, but there is, intentionally, very little presentation of the rationale and derivation of the techniques.

The book is organized around experimental designs; this makes it possible for a research worker to locate an appropriate procedure without knowing the associated significance tests by name. Each technique is described in terms of function, method, and, when relevant information is available, power and power-efficiency. Examples of each method follow a uniform format: null hypothesis, statistical test, significance level, sampling distribution, rejection region, and decision. Instead of producing annoying redundancies, this consistent treatment serves to clarify distinctive properties of the various tests and tends to pinpoint the differential advantages of alternative procedures.

The book also contains a section on measurement, in which the author takes a firm but polemical stand on scaling requirements. He makes a puristic but somewhat overstated case for the widespread application of nonparametric statistics by dismissing interval scales as rare phenomena in the behavioral sciences and then forbidding, for ordinal data, the operations of arithmetic necessary for computing means and standard deviations. However, even though ordinal scales are not completely isomorphic with the real number system, they do reflect certain numerical characteristics, and the sum of a random sample of ordinal numbers possesses statistical properties upon which significance tests may be based. Interpretations of arithmetic operations performed upon noninterval scales are by no means trivial, as pointed out by Lord in his discussion of nominal numbers and Chebyshëv's inequality [F. M. Lord, *Am. Psychologist* **8**, 750 (1953)].

Most nonparametric tests require only ranking information, and some are applicable even to nominal classes. One strong justification that is offered for their use in the social sciences is the difficulty experienced in meeting, for behavioral data, the interval scaling requirements attributed to parametric statistics. However, this issue is complicated by the problem of dimensionality in measurement, which is not mentioned in the present volume. Some of the nonparametric techniques that require ordinal data are illustrated with the California F Scale of Authoritarianism, which is a set of heterogeneous, multidimensional attitude statements. In a multidimensional domain such as authoritarianism, even unique ordinal properties are questionable, and, unfortunately, practical solutions for dimensionality are available only for interval numbers. However, nonparametric statistics are also recommended because of their distribution-free character, ease of computation, and the generality that is obtained by not making numerous and stringent assumptions about parameters. Because of these important properties, nonparametric techniques are widely applicable, and the present volume constitutes an excellent, nontechnical handbook for their use.

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Advances in Cancer Research. vol. 4. Jesse P. Greenstein and Alexander Haddow, Eds. Academic Press, New York, 1956. 416 pp. Illus. $10.

The fourth volume of *Advances in Cancer Research* continues to maintain the high scholarship, completeness, and critical evaluation of the preceding reviews. Three of the eight papers deal with chemotherapy. The first chapter, by Sidney Farber and his associates, on "Advances in chemotherapy of cancer in man," is a remarkably up-to-date analysis which, with Stock's review in volume 2, forms a rather complete summary of the whole of this active area of current research on cancer. Galton's presentation, on "The use of myleran and similar agents in chronic leukemias," not only meets the requirements of the title but contains a discussion of clinical assessment, by a mature investigator, that is worthy of consideration by the younger clinicians now entering this field. Goldin, in a review entitled "The employment of methods of inhibition analysis in the normal and tumor-bearing mammalian organism," effectively demonstrates the valuable additional data that can be derived from carefully designed dose-response laboratory studies in which the drug, the host, and the tumor are considered as an interrelated system.

The very selective review on "Some recent work on tumor immunity," by Gorer, is a reflection of the revival of interest in this approach to cancer. The author is very helpful in orienting the reader to the relevant aspects of modern immunology, but this specialty has acquired a language of its own which will be a source of ever-increasing despair to the general biologist.

Grobstein's consideration of "Inductive tissue interaction in development" is an engrossing account of the recent