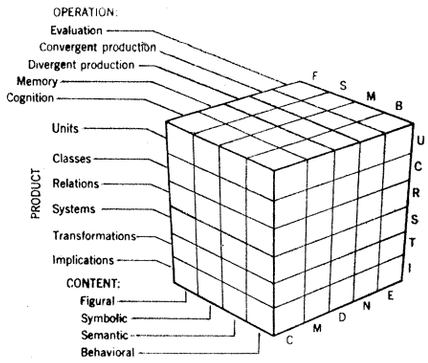
garding each of the 120 components as different ways to process information. New inputs, for example, are processed via 24 cognitive abilities, such as the cognition of semantic units (as in vocabulary tests), the cognition of figural units, and the cognition of figural transformations (both spatial-visualization factors). Information already in storage, but capable of being retrieved, is processed via the 24 memory mechanisms. The production of new information—what we think of as creativity—occurs via the 24 "divergent" information operations, whereas those problem-solving tasks which logically lead to only one possible solution are reached via the proper combination of "convergent" operations.

The remainder of the book (about two-fifths) is devoted to relating Guilford's theory to relevant theoretical aspects of learning, perception, cognition, and creativity, as well as an examination of the major determinants of intelligence (heredity, brain mechanisms, social and cultural variables, and intellectual factors as a function of age). The essence of Guilford's message to mainstream (especially behavioristic) learning theorists is that the association principle, which they wish to apply to all learning, is relevant to only one of Guilford's six kinds of intellectual products ("implications"). His main message to theorists in other related domains is that they have also oversimplified, particularly in failing to deal with the multiplicity of processes, whether they be perceptual, learning, creative, or cognitive in nature. He backs this up with various specific examples, such as, in an analysis of human serial learning, by showing the differential involvement of cognitive and coordination factors in the development of psychomotor skills, and by elaboration of the 24-cell matrix of divergent production abilities which are so important in creativity.

Guilford's book is important. Why? Because it is a synthesis of some 60 years of effort to understand the nature of intelligence; because it provides a basic taxonomy for thousands of previously unrelated empirical studies; in short, because it provides a degree of order where there was chaos. It is, in fact, the most penetrating and comprehensive summary of the factorial attack on the problem of intelligence, and it will probably take its place in history as a 20th-century classic. What's wrong with it? Nothing really, other than the usual incompleteness which is characteristic of any scientific theory. Its most



Guilford's structure-of-intellect model, with three parameters. Other parameters may be added. [From *The Nature of Human Intelligence*]

obvious incompleteness stems from its static quality—its inability to deal with the dynamics of intellect. In short, Guilford's SI model is what it purports to be, a statement of the *structure* of intelligence, a statement which roughs out a basic taxonomy of what we are up against if we wish to understand the full complexity of how man processes that which is discriminable. Details of functional significance, dynamics, brain correlates, and the biochemical and experimental manipulation of each of the 120 processes—all this can follow. Guilford, in fact, does a scholarly job of bringing together the available empirical evidence regarding the biological and cultural correlates of factors, but the story is just too incomplete to add up to much. We get various exciting leads, however, such as (i) the various agnosias and aphasias as the most suggestive findings for correlating intellectual factors with brain functions; (ii) definitive evidence that the genotype makes a difference; (iii) definitive evidence that cultural deprivation and enrichment also make a difference; and (iv) differential life-span growth and decline curves for a large number of factors.

There are serious technical issues, however, such as Guilford's obvious bias in favor of an orthogonal model over the less restrictive oblique model, the mere adoption of information theory *terms* rather than a tight, systematic, information theory *analysis*, and the problems of factor matching and factor invariance. Guilford is aware of these problems, but he is not able to offer convincing solutions to them. It is highly probable that the orthogonal-oblique issue will eventually be settled on empirical grounds, and that a more analytic wedding of information theory and factor theory is just a matter of time. Factorial invariance, however, is much more intractable. In spite of some dozen mathematical solutions in the literature of the past decade, it may well be that the general case, involving different subjects and different (that is, nonoverlapping) measures, is unsolvable in principle. In my opinion this issue is crucial, although not devastating. It does mean, however, that Guilford's SI model (and anybody else's model) is presently based on qualitative or subjective judgments of factor identification. A quantitative index of factor similarity, based on identification of a given factor by multiple studies rather than by rotating two test batteries into a common space, is what is required to alleviate the present difficulty.

In this book we see one of the reasons why Guilford enjoys his reputation as one of the most distinguished psychological scientists of our time; for in his work he manifests a rare combination of qualities—namely, the nonmethodolatrous but sophisticated utilization of quantitative analysis under the control and direction of a broad and deep scholarliness which brings together all (or most) of the relevant empirical work. Is this not what science is about? And has anyone else brought forward a more viable theoretical structure which will account for intelligence?

JOSEPH R. ROYCE
Center for Advanced Study in Theoretical Psychology, University of Alberta, Edmonton

Works of a Statistician

Collected Papers. Contributions to Mathematical Statistics. S. S. WILKS. T. W. Anderson, Ed. Wiley, New York, 1967. xxxiv + 693 pp., illus. $12.50. Wiley Series in Probability and Mathematical Statistics.

S. S. Wilks (1906–1964) went to Princeton in 1933 as an instructor in mathematics and continued there, ultimately as a professor in the Department of Mathematics and as director of the Section of Mathematical Statistics, until his death. He was internationally known and respected as research worker, teacher, author of textbooks, editor, and, especially during and after World War II, as a propagator of statistical and mathematical ideas over a wide field, particularly in the U.S. government service. A good number of the most distinguished mathematical statisticians in the United States were research students under his direction.

The present volume, edited by T. W. Anderson and sponsored by the Institute of Mathematical Statistics, is a fine record of Wilks's work. It begins with a quite detailed biography and critique of his research. There follow 48 papers reproduced photographically from the original journals.

The 18 papers from the period 1931–1938 are theoretical contributions to statistics. The later papers are more varied. Some are mathematical, whereas others are concerned with applications of statistics, for example, to geology, to public opinion polls, and to the age distribution and mortality of resident members of the American Philosophical Society; this last study was commissioned to guide the policy of election. Yet other papers illustrate Wilks's concern with the broad problems of mathematical education.

There have been very big developments in mathematical statistics since the time when the main body of Wilks's theoretical work was done. It is a major tribute to the content and presentation of his work that the early papers remain interesting and relevant.

In addition to the widely known and commonly referred to papers, which nevertheless it is good to have collected together, there are a number of papers not previously readily accessible. It is likely that students, teachers, and research workers with an interest in statistics, theoretical or applied, will find something unfamiliar and of value in the volume, and it deserves to be widely available.

D. R. Cox

Department of Mathematics, Imperial College, London

Medical Entomology

Ectoparasites of Panama. RUPERT L. WENZEL and VERNON J. TIPTON, Eds. Field Museum of Natural History, Chicago, 1966. xii + 861 pp., illus. $25.

The variety and number of recently recognized arthropod-borne pathogenic agents afflicting man and other vertebrates can scarcely be encompassed by any single specialist. Moreover, newly discovered complex vector and reservoir chains and interplays of hosts, parasites, and ecological elements in pathogen-transmission patterns cause numerous textbook examples of arthropod-borne disease epidemiology to be suspect or incorrect. Disease investigation in many regions of the world is hampered by insufficiency of knowledge of hosts and parasites. Rarely in developing areas do workers in the diverse disciplines involved in epidemiological investigations have available, even in scattered form, faunal information as useful as that consolidated into this book, to which 20 recognized specialists have contributed important information on 360 ectoparasite species and over 200 mammalian host species found in Panama. The contents of the book demonstrate what an enormous amount of field collecting, data recording, and laboratory study is necessary for a preliminary biomedical understanding of even such a limited tropical area.

In the introduction, the environment and history of medical entomology in Panama are reviewed. A gazetteer of collecting localities is followed by a foldout map showing altitudinal contours and key localities.

Five chapters are devoted to some 42 genera (5 new) and 95 species (34 new) of mites. Laelapine mites, which "may fill key roles in epidemiological patterns that for the moment are confusing," include 8 genera and 19 species known to infest 33 mammalian species. Where only a single dermanyssid mite had previously been reported, 41 taxons infesting about 45 host species are recorded. Eight of 15 bat-infesting spinturncid mite species are described as new; all are first records for Panama. Chiggers numbering 76 species in 29 genera (16 new species and 5 new genera) were collected from some 5000 hosts representing about 70 mammalian, 50 avian, and a few reptilian species.

Of 47 tick species in 10 genera, 12 were previously unreported from Panama. Extensive host lists and comments on apparent host, altitudinal, and climatic preferences are included. Fifty-four instances of human infestation by 11 tick species are recorded. Epidemiological features of even such obvious tick-borne diseases as Rocky Mountain spotted fever, piroplasmosis, and relapsing fever remain to be studied in Panama.

A checklist of the 21 species of highly host-specific mallophagan lice known from Panamanian mammals, and of 17 other species that may eventually be found there, is included. Eighteen species of anopluran lice double the number previously recorded for Panama.

A new parasitic beetle in the family Staphylindae is described and another is recorded from Panama together with a new species from southern Mexico. These strange parasites of cricetine rodents represent primitive Andean elements in highlands of southern Mexico and Central America.

The text on fleas, which describes 37 species and subspecies, including 6 new species and 7 initially recorded from Panama, is followed by 40 fine plates. The tabulation is especially useful for host infestation percentage and male and female infestation of each host species in lowland, intermediate, and highland zones.

Three chapters are devoted to dipterous parasites. A short checklist of Hippoboscidae notes 6 species from birds and 2 from mammals. The nycteribiid bat flies treated consist of 5 previously unrecorded and 2 new species. A 270-page treatment of the streblid bat flies is based on several thousand carefully annotated Panamanian collections from more than 50 host species that provided over 10,000 streblid specimens, many with a high degree of host specificity, belonging to 66 species, 44 of them new. Certain other neotropical species are treated to enhance the overall taxonomic picture. Following a thorough account of techniques of streblid collection and specimen preparation are a section on morphology and some biological notes. The extensive systematic review and concluding discussion of host-streblid relationships are a significant contribution.

The chapter entitled "Some relationships between mammal hosts and their ectoparasites" is based on such extensive experience that it is must reading for all investigators concerned with host-parasite associations. An essay entitled "Mice, land bridges, and Latin American faunal interchange" presents a large volume and variety of information pertaining to the ancient and more recent factors affecting the composition and distribution of the Panamanian mammal fauna in relation to that of North and South America. Both of these chapters take issue with prevailing views on the role of the Panama water gap and the land bridge in the dispersal of mammals, especially the cricetine rodents, into South America. An annotated checklist of mammals is followed by an appendix in which host species are listed together with the species of their ectoparasites.

Carefully constructed keys are provided for Panamanian species and genera of ectoparasites dealt with in the book except for those that are only enumerated in checklists. Details of collecting data and disposition of type materials, acknowledgments, and the like are especially well handled. The quality of