the private colleges and private universities which results in the focus of so much attention upon the federal government as a source of financial support. Few state governments appropriate funds for other than the current operations of state-government-sponsored and local-government-sponsored institutions of higher education.

Although he holds his baccalaureate from a private, liberal arts college—his doctorate is from a state university—Chambers is critical of private institutions for their attitude toward the public institutions, and especially for the belief that low tuition charges at public colleges and universities have caused their financial difficulties. He urges private colleges and universities to emphasize their unique attributes and not to worry about competing with the public institutions.

Second, Chambers is an advocate of low tuition for the public colleges and universities. He insists that higher education is principally a benefit to the whole society, not just to the individual who attends and graduates, and so he argues that higher education is an "ideal object of productive public investment." Although he seems to have no objection to federal and state programs of student assistance, these are no substitute in his view for low tuition charges at the public institutions.

In the third place, Chambers argues forcibly against student loans, tax deductions and tax credits for higher-educational expenses, and such proposals as that of the Zacharias Panel of the President's Science Advisory Committee. He notes that the benefits of such proposals may fall primarily to higher-income families, that "back-door" expenditures by the federal government are still expenditures, and that loan arrangements might indenture a student for life.

Finally, I must note that Chambers has no love for statewide "coordination" in higher education. He favors constitutional autonomy for public colleges and universities, institutional competition for funds, development by each institution of any academic program it wishes to undertake, and such voluntary cooperation as public institutions may care to enter into one with another. He recognizes the coordinating authority of governor and state legislature, but sees no good argument for placing any administrator between individual institutions and the policy-making organs of state government.

As usual, administrators, government officials, and faculty members (I would like to include students as well) interested in the financial operations of higher education will be interested in what Chambers has to say, whether or not they agree with all his points of view.

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Vertebrate Biology

Animal Function. Principles and Adaptations. MALCOLM S. GORDON, in collaboration with GEORGE A. BARTHOLOMEW, ALAN D. GRINNELL, C. BARKER JØRGENSEN, and FRED N. WHITE. Macmillan, New York; Collier-Macmillan, London, 1968. xvi + 560 pp., illus. $12.95. Macmillan Core Series in Biology.

One needs only to read the introductory chapter to realize that *Animal Function* is not just another physiology textbook, but one that fills the major need for an ecological approach to physiology with emphasis on the organ, organ-system, and whole-animal levels of organization. Some of the important tenets of this approach are that no logical basis exists for the claim that understanding of the nature of life is more fundamental at one level of organization than any other, that traditional divisions in biology, such as morphology, physiology, behavior, and ecology, disappear in the attempt to comprehend fully the nature of the living world, and that the concepts of evolutionary biology (in its broadest sense) are indispensable to all phases of this approach. The authors conclude their general comments with the statement (p. 2), "The living world is an object of study of a complexity and diversity not even remotely approached by the subject matter of any other field of science. . . . To most fully appreciate the nature of the living world, one must approach it with an open mind and a broad perspective. We hope this book will aid students to make such an approach—and, perhaps, eventually to contribute to what we might call the new natural history." This goal is substantially and elegantly furthered by the material covered and mode of presentation in the rest of the book. Of particular significance is that many of the questions about the adaptation and modification of features in vertebrate phylogeny that might be raised from a morphological point of view are discussed by the authors of *Animal Function* from a physiological viewpoint. That the same questions about vertebrate features arise in different fields of biology suggests that the new natural history may soon become a reality.

The scope of *Animal Function* is restricted essentially to vertebrates and to selected phases of their physiology. The topics covered can be grouped under three main headings: (i) how animals obtain and make available the energy necessary for all activities and how most of this energy is utilized for movement by muscle contraction; (ii) the maintenance of an internal environment by the mechanisms of respiration, circulation, water and solute metabolism, and body temperature and energy metabolism; and (iii) how animals obtain, integrate, and respond to information about the world outside and inside themselves. The decision to select certain topics has resulted in the omission of or in inadequate treatment of many topics of current interest, such as circadian rhythms, yearly cycles, migration, orientation, and navigation.

A serious omission lies in the lack of definition and discussion of many concepts such as "function," "adaptation," and "teleological grounds," which are essential to the goals of this book. Moreover, the general excellence of the text is marred by several weaknesses of organization. No unified discussion exists of general topics such as countercurrent mechanisms, relative size (especially the volume/area relationship), type of epithelium as related to type of transport of materials across it, and physiological adaptation (somatic modifications following environmental changes). Some of these topics are covered, but references to them are scattered throughout the book, and an understanding of their general aspects is therefore not readily obtainable. Some difficulty exists in finding answers to, or even suggestions and references to pertinent literature on, many questions about vertebrate features. As a means of ascertaining the depth of coverage I formulated a number of comparative questions about vertebrate features covered in this book. Typical questions concerned the modifications between crossopterygian fishes and their tetrapod descendants, in hemoglobin and its ability to transport oxygen, or modifications in fetal hemoglobins in those nonmammalian vertebrates that bear live young, or the relationship between blood pres-

sure in the large veins and large lymphatic vessels and the flow of blood into the heart. Although the test questions may be quite similar to one another, reflecting a point of view different from those of the authors and hence unfair, I am still disappointed with the degree of difficulty experienced in obtaining information pertaining to these matters.

These shortcomings are minor when compared with the overall excellence of *Animal Function*, which I can recommend without hesitation to all vertebrate biologists as a general source and as a supplementary text for courses in vertebrate morphology, phylogeny, and general natural history in addition to its natural role in physiology courses.

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Planck's Thought

Max Planck als Philosoph. HERMANN KRETZSCHMAR. Reinhardt, Munich, 1967. 115 pp. Paper, DM 11.

I was never able, though I was in occasional contact with Planck during my years spent at Berlin University as a student and later as an assistant, to regard him as a philosopher. Of course, he had read Kant, also Schopenhauer and Nietzsche, and was well acquainted with the dogmatic positivism of Mach. In contrast to Mach, Planck believed in a *really real* world; he was a naive realist. But so were and are many physicists, chemists, biologists. True, Planck meditated, especially at the sunset of his life, on metaphysical issues such as free will versus determinism, causality, the all-embracing role of the principle of least action, and the need for a unitary or unified physical picture of the universe. And analytic philosophers—such as Russell, Ryle, Popper, Carnap—are indebted to him for his discovery that there are "phantom problems" in many sciences, such as the body-mind antithesis, the dilemma of freedom of will versus causality, and the vitalism-mechanism controversy. Where the "professional" philosopher had often uttered nonsense, Planck applied unambiguous, rational criteria based upon objective, nonpersonalized knowledge. But it was to the foundations of physics, rather than to philosophy of science in general or to philosophy proper, that Planck made his (indeed substantial) contributions.

The book under review attempts to deal with Planck's so-called philosophic insights. But the most essential aspects have been omitted, and less important ones are stressed or misinterpreted. The biographical data presented do not include any information not already well known to the educated physicist. Moreover, Planck's views and his major discoveries are evidently not understood by the author, who quotes generously, but out of context.

It has been demonstrated by Max Born, von Laue, Yourgrau and Mandelstam, and many other authors that Planck's appraisal of variational principles, that is, of the exact mathematical methods applicable to the principle of least action, is wrong. Schrödinger, Russell *et al.* also refused to share Planck's and de Sitter's almost naive faith in the privileged status of the least-action principle. Nowhere does Kretzschmar suggest that Planck may have committed such blunders. Planck's dogmatic commitment to strict causality (in the spirit of Einstein's often-cited belief) is presented without critical comment.

Nor does Kretzschmar discuss Planck's abstruse conception of the nature of fundamental constants in physics. The quantum of action, h, is depicted by Kretzschmar too as a "novel mysterious messenger from the real world." It is impermissible, in my view, to treat physical entities and concepts in this manner. It is crassly unwarranted to compare a few arbitrarily selected ideas of Lenin with Planck's views on the same topics. Toward the end of this painfully inadequate book Planck is dubbed a successor of Leibniz. Planck's h is considered to be the logical (or physical) development of Leibniz's monad. A plethora of similar bold claims are thrown at the reader without substantiation.

Still, perhaps one should not condemn an author who tried to do the impossible, namely, to transform Planck, one of the greatest physicists of all time, into a profound philosopher. It seems that the time is ripe for someone to present us with a sound, critical, and perspicacious account of Planck's significant contributions to the very foundations of physics.

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Oxford Doctor

Thomas Willis, 1621–1675. Doctor and Scientist. HANSREUDI ISLER. Translated by the author from the German edition (Stuttgart, 1965). Hafner, New York, 1968. xiv + 235 pp., illus. $6.

Anyone interested in the origins of scientific societies will enjoy this well-written biography of one of the founders of the Royal Society of London. The author first produced this work in German, and now gives us a first-class English version. Erwin H. Ackerknecht writes the introduction. Willis' circle included Wren, Boyle, Lower, Petty, Hooke, and others of that remarkable group in Oxford and London whose "Invisible College" developed into a great scientific society.

Willis emerges from this study as a father of endocrinology, epidemiology, microbiology, neurology, and psychology. His Hippocratic approach to disease led him to some shrewd clinical concepts, but more importantly to broad scientific generalizations in what we would today call biochemistry and in comparative behavioral studies and comparative anatomy. Extensive quotations and some paraphrases allow Willis to speak to the reader.

The four years (1642–1646) which William Harvey spent in Oxford, as warden of Merton College, coincided with the years during which Willis studied medicine there. Thus Willis absorbed the great Harveian truths at first hand. As a clinician he wrote on fevers, including malaria and "that Peruvian bark" quinine, on typhus in Oxford, hypoproteinemia in dropsy, cerebral localization, the meningeal origin of headache, "contagion" modified by passage through various hosts, secondary sexual characteristics, and the depressor nerve to the heart. His *Cerebri Anatome* was the outcome of a concerted research project involving Wren, Lower, and Millington, and was favorably reviewed in the first scientific periodical, *Journal des Scavans,* in 1665. *Pathologiae Cerebri* was, in 1667, the first book by Willis to be reviewed in the *Philosophical Transactions* of the Royal Society.

Isler has left all scientists in his debt for this masterly study of a slightly neglected doctor-scientist of Oxford's golden age.

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