although the volume does not contain a paper by him. His outspoken challenge of the ease with which invertebrate neuropharmacology can be extrapolated to vertebrate neuropharmacology is a useful reminder to invertebrate neuropharmacologists that they still bear the burden (fairly or not) of having to justify the relevance of what they do. A careful reading of the discussions makes it clear that in the early stages of research it can be a nontrivial endeavor to distinguish general principles from species specific information.

The volume belongs in all university and research libraries and in the personal libraries of all insect neurophysiologists. Whether it will convince many vertebrate neuropharmacologists of the necessity of paying significantly more attention to insect neuropharmacology remains to be seen.

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Biological Rhythmicity

The Clocks That Time Us. Physiology of the Circadian Timing System. MARTIN C. MOORE-EDE, FRANK M. SULZMAN, and CHARLES A. FULLER. Harvard University Press, Cambridge, Mass., 1982. xvi, 448 pp., illus. $25. A Commonwealth Fund Book.

The "clocks" that are the focus of this book are those endogenous oscillators that are responsible for the generation of circadian (that is, about 24-hour) rhythms in humans and other mammals. It has only been in the last 25 to 30 years that more than just a handful of scientists have begun to seriously study circadian rhythms in plants and animals. The pioneering efforts of Jürgen Aschoff, Erwin Bünning, Colin Pittendrigh, and Curt Richter opened up a new scientific discipline that today enlists the efforts of hundreds of life scientists. Despite the rapid growth of this new area of biology, many life scientists are unaware of even the most fundamental properties of biological rhythms. As the authors point out, circadian oscillations in biological variables have simply represented the "noise" in baseline data for many investigators. Yet it is now apparent that just about every physiological variable shows some circadian fluctuation in humans as well as in other animals. *The Clocks That Time Us* is aimed at biologists and clinicians who are not directly concerned with biological rhythms but for whom a basic understanding of the circadian organization is critical for the design of experiments as well as the interpretation of data.

The book begins by outlining the history of interest in biological rhythms. Also in the opening chapter is a general introduction on the nature of endogenous circadian rhythms and how data on rhythmicity are collected and interpreted. The second chapter discusses the general features of circadian systems. During most of the modern era of the study of biological rhythms, the circadian system has been treated as a black box, studied by following the movement of the hands of the clock (that is, by monitoring some measurable circadian rhythm such as feeding, sleep, body temperature, or locomotor activity) under a variety of external environmental conditions. Any attempt to explain the physiological basis of circadian oscillations, whether at a systems, cellular, or molecular level, must take into consideration the fundamental properties of free-running or entrained circadian rhythms as discovered by such research, and Moore-Ede *et al.* lucidly explain many of these properties.

In chapters 3 through 5 the authors detail what is known about the endogenous nature of the clock system that regulates a multitude of circadian rhythms. It is now recognized that multicellular organisms utilize a number of circadian oscillators. A major concern of research today is the hierarchical nature and the interaction of these various oscillators and how they remain synchronized with one another as well as with the external environment. In mammals, and possibly other vertebrates, one "pacemaker" that drives many circadian rhythms appears to reside within the suprachiasmatic nuclei of the anterior hypothalamus. Moore-Ede *et al.* do an excellent job of reviewing the anatomy and function of these structures as related to the circadian organization.

The longest and most original chapter in this book (chapter 5) discusses how central circadian pacemakers time many bodily functions, including sleep, feeding, drinking, thermoregulation, excretion, reproduction, and endocrine activity. Though many circadian biologists are interested either in the location and structure of central circadian pacemakers or in the time course of various rhythmic variables, few attempts have been made to provide a complete picture of the physiological events that must accompany the transfer of information from a central circadian oscillator in the brain to an end organ or tissue. Moore-Ede *et al.* clearly outline how the circadian organization influences a variety of different physiological systems.

In the sixth chapter the authors present a mathematical model of human circadian rhythms that was recently developed by them and Kronauer. Whether or not this model will provide any new insight into the physiology of human circadian systems will depend on future studies. Its inclusion seems inappropriate in a general overview of the field.

The final chapter of the book is devoted to the medical implications of circadian rhythmicity. Although the data on humans are still fragmentary, it now appears that the most effective diagnosis and treatment of many illnesses depend on a working knowledge of the circadian organization of the patient. In addition, the etiology of many physical and mental disorders may involve disruption of normal circadian rhythmicity. Nevertheless, few attempts have been made to use the recently gained knowledge of biological rhythms for the benefit of human health. One objective of this book is to motivate physicians at least to begin to consider circadian rhythmicity in their practices. In an attempt to catch the ear of the medical community, the authors are at times guilty of sensationalism, an all too common practice of scientists who are trying to make their ideas known to a broader constituency. For example, when discussing the fact that the men who operate nuclear submarines in the U.S. Navy are on an abnormal 18-hour day-night cycle, Moore-Ede *et al.* write, "There should be some global concern about the health and performance of these men, since they are the ones with their fingers directly on the nuclear button!" (p. 337). Critical readers of this book do not need these histrionics to convince them of the importance of a normally functioning circadian system for human health. The authors have already laid a scholarly foundation for the medical implications of circadian rhythmicity.

In the preface of their book the authors raise the question "How could research on the clocks that time our sleep and wakefulness, our metabolic, endocrine, and neural functions be so easily ignored?" At least part of the answer lies in the fact that an easily readable book on biological rhythms in mammals and their implications for human health has not been available. Moore-Ede, Sulzman, and Fuller have provided such a book.

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