

place, for example, bone is stated to be the critical organ for inhaled plutonium but this is not the case for insoluble compounds. At another point the wildly erroneous statement is made that "the rate of excretion of any substance from the body is approximately exponential". Here the desirable mathematical model seems to have been substituted for reality.

Apart from these small criticisms the book is entirely satisfactory and can be recommended to those teaching or learning elementary radiological protection theory and practice.

G. W. DOLPHIN

<sup>1</sup> Langham W. H. (ed.), *Radiobiological Factors in Manned Space Flight* (National Academy of Sciences, Washington DC, 1967).

## Temporal Processes

*What is Time?* By G. J. Whitrow. Pp. 191. (Thames and Hudson: London, September 1972.) £2.

VIEWED simply as a popular exposition of a complex and difficult scientific theme, Professor Whitrow's latest book—an expanded version of four BBC Third Programme talks on the nature of time—is a remarkable *tour de force*. Its topics range from the Mayan conception of time to the ideas of Einstein and Minkowski, from water clocks to atomic clocks, from the fossil record to human memory, from biological evolution to cosmic evolution, from ancient religious beliefs to modern philosophical doctrines. Professor Whitrow has managed to combine these and other facets of his vast subject into an integrated whole in which each facet illuminates and is illuminated by the others.

But this book is more than an extraordinarily successful popularization. It is also a perceptive historical account of the biological, social, religious and philosophical influences that have shaped Western ideas about time and temporal processes. Throughout most of human history time has been perceived as being essentially cyclic. In man, as in other organisms, diurnal, monthly and annual rhythms have become internalized through evolution. Moreover, except in highly industrialized societies, everyday life has always been dominated by the cycle of day and night, the ebb and flow of the tides, the progression of the seasons, the life cycles of plants and animals. The cyclic view of time was further reinforced by observations of planetary motions, which were thought—and are still thought by many—to govern the subtler rhythms of men and nations. With the rise of Newtonian mechanics and of the technology that sprang from

it, Newton's view of a universal time, flowing "equably without relation to anything external", gradually displaced the ancient notion of cyclic time. Yet the Newtonian vision of the world differs almost as much from the modern one as from the one it displaced, for Newton believed that the world and its creatures had been shaped and set in motion by the hand of God only a few thousand years earlier. The modern view (still fragmentary and incomplete)—that the physical universe and the biosphere are the results of evolutionary processes—began to take shape only toward the end of the 18th century, and only during the last few decades have we been able to make reliable estimates of the time scales involved. Despite its brevity, Professor Whitrow's account of these developments, illustrated by aptly chosen quotations from literary, philosophical and scientific sources, is clear and well balanced.

On a third level, the book addresses itself to abstract philosophical doctrines. Professor Whitrow's skill in extracting the essence of a philosophical argument and presenting it in clear, simple language is reminiscent of Russell's. His critical technique relies heavily, and to excellent effect, on confronting doctrines in "pure" philosophy with relevant empirical evidence and theories from psychology, biology and the physical sciences. I especially enjoyed (though I was not always in full agreement with) the critique of Kant's views, the comparisons among absolute time, relational time and relativistic time, and the discussion of the transitional nature of time and the failure of current theories to come to grips with it. Professor Whitrow summarizes his own philosophical position in the book's final paragraph: "Although our perception of time has many subjective and even sociological features, it is based on an objective factor that provides an external control for the timing of our physiological processes. This objective factor is what we call physical time. It is an ultimate feature of the universe and its relationship with observers, particularly fundamental observers, which cannot be reduced to anything else. But this does not mean that it exists in its own right: it is an aspect of phenomena. The essence of time is its transitional nature. That this has given rise to so much argument down the centuries is not surprising, for, in the words of Whitehead, 'it is impossible to meditate on time and the mystery of the creative passage of nature without an overwhelming emotion at the limitations of human intelligence'."

Because of its scope, depth, readability and scholarly quality, this book, though intended for the general reader, is also admirably suited to serve as a text for an undergraduate seminar. Its

value in this capacity would be enhanced by the addition of some bibliographical notes and a list of references, which, it is to be hoped, will be added in subsequent editions.

DAVID LAYZER

## Spectroscopy

*Spectroscopy*. Edited by D. A. Ramsay. Consultant editor, A. D. Buckingham. (MTP International Review of Science. Physical Chemistry, Series One, Volume 3.) Pp. 338. (Butterworth: London; University Park: Baltimore, Maryland, 1972.) £10; \$24.50.

THIS volume is one of the first of a new series of comprehensive scientific review volumes produced by the Medical and Technical Publishing Company. Chemistry as a whole is covered in thirty-three volumes; this is volume 3 of the thirteen volumes devoted to physical chemistry. It consists of eight chapters of about forty pages each, these being independent reviews by distinguished contributors of various special fields of current interest.

The book is an undoubted success. All of the authors speak with authority on their subjects, and the subjects have been well chosen, although I am sorry that there is no chapter reviewing some of the more exciting experiments being done currently with lasers, double resonance spectroscopy, and suchlike. The reviews are indeed comprehensive, and in most cases report developments of the past ten years (rather than the last two years) in the field reviewed. Most of the readers will already be spectroscopists of one form or another. The volume has more in common with the series *Advances in Spectroscopy* edited by H. W. Thompson and published by Interscience, which ran to only two volumes (1959 and 1961), than it has with *Annual Reviews of Physical Chemistry* or *Annual Reports of the Chemical Society*. Its closest competitor today might be the appropriate volume of the Chemical Society *Specialist Periodical Reports*. The book is well produced, although it is quite expensive.

It is at present planned to republish the entire series every two years. If this plan is maintained, I think the style of the articles is likely to change from those in the present volume to something more akin to a catalogue of recent progress; I would regret this change, since such articles are less valuable and already exist in various rival publications. Either the subjects reviewed in the next volume should show little overlap with those reviewed here, or an interval of five or six years would be more appropriate if the style of the articles is to be maintained.

IAN M. MILLS