being devoted to a general treatment of morphology, cytology, genetics, nutrition, behaviour and so on. Sometimes indeed it seems that protozoology is really a non-subject, a miscellaneous assortment of different types of study on an extraordinarily diverse collection of organisms.

The excellent section on genetics, for example, is based mainly on studies with *Chlamydomonas* and *Paramecium* and includes a great variety of topics. The only feature which stands out is the relatively large amount of attention given to non-Mendelian heredity, involving chloroplasts, mitochondria, kappa particles and other odds and ends. A particularly detailed account of work on Foraminifera is given, reflecting the special interests of the author. On the other hand, important parasitic protozoa, such as the malaria parasites, trypanosomes, *Leishmania* and so on, seem to get rather less attention than they deserve.

The book is extremely well printed and beautifully illustrated, and can be thoroughly recommended to those who can afford it. English-speaking readers must be grateful to the author for writing the book in their language, (earlier versions were in German), though some, may find themselves, as I was, at times irritated and even baffled by some linguistic idiosyncrasies. On such occasions a little knowledge of German still helps.

G. H. Beale

Atmospheres of planets

Physics of Planetary Ionospheres. By Siegfried J. Bauer: Pp. viii+230. (Physics and Chemistry in Space: vol. 6.) (Springer-Verlag: Berlin and New York, 1973.) 78 DM; $35.10.

Dr Bauer has worked in the field of planetary ionospheres for more than fifteen years. Working at the NASA Goddard Space Flight Center he has been closely associated with many of the recent developments in the subject.

His book, intended as an introduction, develops logically from a discussion of neutral atmospheres, ionising radiations, chemical processes and plasma transport. In this respect it follows the pattern of many recent books on ionospheric physics. It differs from these in that at each stage it extends the discussion to the planets, particularly Mars, Jupiter and Venus. The space devoted to the other planets seems to be related (quite reasonably) to the thickness of their atmospheres.

In later chapters Dr Bauer discusses models of planetary ionospheres, wave propagation and experimental techniques. The treatment of the last two subjects is rather synoptic and the student may find it necessary to consult the many references for enlightenment. The last chapter gives details of the observations of planetary ionospheres and includes electron density profiles for Mars and Venus measured by the Mariner spacecraft. It is perhaps surprising that only nine pages are devoted to the discussion of these interesting results.

This book has many excellent qualities: the diagrams, tables and general layout are attractive and there is a comprehensive list of up to date references. The author is familiar with the Russian literature and his explanation of some of the Russian terminology will be useful to many. It has become standard practice in the United Kingdom to use SI units in scientific texts. Dr Bauer uses a mixture of c.g.s. and practical units but I found this no great disadvantage.

The author intended his book "to be an introduction to the subject for a new generation of space scientists and a compendium for the old". In my view he has been largely successful. But even at today's prices fifteen pounds is inordinately expensive for a book of 230 pages.

A. R. W. Hughes

Atomic time

The Measurement of Frequency and Time Interval. By L. Essen. Pp. v+55. (National Physical Laboratory: Teddington, December, 1973.) £1.

The rapid development of increasingly precise methods for the generation of specific (atomic) frequencies and their measurement has had a resounding impact on a vast range of theoretical disciplines and practical applications. Accurate control of frequency is a fundamental requirement of radio and it makes possible, for example, the Doppler measurement of rate of change of distance required in navigation and space research. Since 1967 the SI unit of time has been defined in terms of the frequency of a particular transition of the caesium atom, thus giving rise to the integrated reference time scale of International Atomic Time (TAI), obtained by the continuous summation of time intervals deduced from measures of frequency. Coordinated Universal Time (UTC), an approximation to UT1 (or GMT) and which differs from TAI by an integral number of seconds, is now the basis for civil time in most of the world; it provides direct synchronisation to about a millisecond, but individual atomic clocks may be compared with much higher precisions (tens of nanoseconds) making possible, for example, the almost direct verification of the predicted relativistic dependence of clock rate on speed and gravitational potential. A rather more practical application is Loran C for navigation.

This monograph, written by the acknowledged pioneer in the field, describes the basic principles and practical applications of the use of atomic transitions (or spectral lines) as standards of frequency. The treatment is simple and straightforward; the descriptions of the methods used at the National Physical Laboratory, given with explanatory diagrams and photographs, are exceptionally clear even to a layman in the field. Determinations of precision and stability are fully covered. Understandably the main emphasis is on the caesium definitive standard, but Dr Essen also covers working standards (commercial standards, which are portable, are now available with precisions of the order of 1 part in 10^{11}), standard frequency radio transmissions, and the techniques of the comparison of frequencies. His final chapter is devoted to the design and performance of resonance (particularly cavity resonator) frequency meters. It thus provides invaluable background information for the many concerned with the applications of these fascinating developments. But it seems that much of the text was written in 1972 so that those more directly interested in the latest work, especially at laboratories other than NPL, should refer to the technical journals.

Dr Essen devotes one short chapter to atomic and astronomical time, and refers briefly to the modified form of UTC introduced as from January 1, 1972. Although he refrains from saying so, it must now be generally agreed that the adoption in 1956 of the ephemeris second as the SI unit of time was a grave mistake: the astronomers were over-optimistic as regards the practical and theoretical difficulties of its determination, whereas the physicists were not agreed as to which of several possible atomic transitions should be used as the standard. Apart from confusion and change, the second of Ephemeris Time (introduced purely as a theoretical astronomical time scale) is not an approximation to the current value of the second of UT (which varies with the speed of rotation of the Earth), so that the preservation of its value in the 1967 unit results in an unnecessarily large rate of departure of IAT from UT. This has perhaps led Dr Essen to imply that the introduction of leap-seconds into UTC on the preferred dates of 30 June and 31 December would enable the modified time signals to be maintained within ± 0.7 s of UT1—so drastically contradicted on January 1, 1973.

In spite of this misunderstanding (due mainly to the shortcomings of CCIR Report 517) Dr Essen has a right to be proud of his contributions and of his readable and informative monograph.

D. H. Sadler