Prof. Carter does not discuss that difficult question in any detail. Indeed, he seems to raise it only to illustrate the complexity of all these issues and how readily they may incline to decisions which are self-frustrating or defeating. It is only too easy to take decisions for one purpose only to find that they have created conditions which destroy the incentives it is sought to provide. We must indeed recognize the existence of these economic problems and give them the study and attention they need; but it cannot be too carefully kept in mind that nothing is easier than to plan out of existence the conditions in which high, and especially creative, ability functions most effectively and efficiently.

PHASES IN EVOLUTION

Grossabläufe der Stammesgeschichte

Erscheinungen und Probleme. Von Prof. Arno Hermann Müller. Pp. vii+116. (Jena: Gustav Fischer Verlag, 1961.) 18.20 D.M.

THE work under review is a revised edition of one originally published in 1955; some of its subject-matter and diagrams have also been incorporated in Vol. 1 of its author's *Lehrbuch der Paläozoologie* (1957). Its purpose is to study the fluctuating fortunes, during their long geological histories, of those major animal groups of which abundant fossil remains are preserved, and to draw such general conclusions as seem possible. The author uses as data the number of genera recorded in successive subdivisions of the geological column, each representing some 15–18 million years. He is not the first palaeontologist to have taken up this line of investigation, for an account of very similar work by a group of United States authors has appeared in the *Journal of Paleontology*, 26 (1952). For presentation of the facts he relies mainly on symmetrical diagrams in which the number of genera, grouped according to their time-ranges in differently shaded areas, is plotted horizontally across a median axis representing geological time.

The obvious objection to the choice of genera as the basis of the study is that of differing taxonomic standards among workers who have specialized (as most modern palaeontologists tend to do) in fossils belonging to particular families or geological formations; for irresponsible genus splitting might well become interpreted as evidence of unusually intense evolutionary diversification. By taking his data from treatises in which the material has already been digested according to more or less uniform standards the author has probably avoided this pitfall to some extent. In discussing the trilobites he gives two diagrams, based respectively on modern works in which 996 and 1,395 genera are recognized, and he shows that both present the same general picture. In the case of Mollusca other than Cephalopoda his information does not appear to be derived from up-to-date sources. Thus on p. 94 the number of known gastropod genera is given as about 700, whereas in the Wenz-Zilch treatise on this class (1938–60) in the *Handbuch der Paläozoologie* the number of shell-bearing genera recognized is 3,400; the figure 296 given for known genera of Bivalvia (Lamellibranchia) is similarly disproportionately low.

It is probable (although some authors deny it) that the concept of a species is less subjective than that of a genus, so that a census of species would have been a more satisfactory basis for the present study. According to a recent estimate, however, among invertebrates alone the total number of extinct species with hard parts capable of becoming fossilized has been 7–8 millions; and, even though (according to estimates from other sources) those so far described number only from one-hundredth to one-twentieth of the whole, it would clearly have been beyond the capacity of a single worker to assemble the necessary data about them. A count of genera was the only practicable approach to the investigation. One thing is clear; the number of genera and species living at any period does not necessarily bear any relation to the total of adult individuals belonging to a group or give any indication of its relative competitive success. The former is incalculable, the latter unassessable.

In the work under review the diagrams already mentioned show a succession of bulges and contractions; not one is a steadily broadening triangle, although there is some approach to this with the Gastropoda and Bivalvia. A marked bulge corresponds to what the author terms a "Virenzphase", a phase of profuse mutational changes. The most abrupt and intense of such phases are the 'explosive' or 'eruptive bursts' of United States and British writers. According to the author, three types of evolutionary history are distinguishable. In the "regressive" type (Trilobita, Graptolithina, Nautiloidea) there is a series of "Virenzphasen" decreasing in intensity and duration and leading eventually to extinction. In the "progressive" type there is a succession of such phases increasing in intensity and duration, although ultimately the group may fail to survive a subsequent phase of shrinkage and crisis. (For example, during the two intervals, at the close of the Permian and of the Triassic periods respectively, between their three "Virenzphasen" the Ammonoidea almost died out, but two or three genera just managed to survive in each case; a third crisis at the end of the Cretaceous, however, sealed the fate of the whole order.) In the third type of evolutionary history, the "intermediate" type (Brachiopoda, Amphibia), there is a series of complex "Virenzphasen" each consisting of a relatively weak initial phase, an intense main phase, and a weak late phase.

Applying these results to groups now living, the author considers the Nautiloidea, reduced to a single genus following what he believes to be the final phase of a history of the "regressive" type, to be probably well on the way to extinction. The Echinoidea and Reptilia, however, although now on the decline, would appear to have further "Virenzphasen" ahead. The Brachiopoda may pass through a weak phase of increase before their final extinction. The Mammalia are now passing through the main phase of a "progressive" series; at least, they were doing so before the advent of man.

Chapters are devoted to a survey of knowledge of pre-Cambrian life (illustrations of recent finds in South Australia are reproduced in some of the plates) and to a discussion of the various factors which may have combined to determine the history of life through the ages. A study of the diagrams in this book suggests to me that the author's three-fold classification is an over-simplification. The future, in fact, seems to be entirely unpredictable. L. R. Cox