mammals feeds the temptation to extrapolate beyond what we know. Observations show that many small cetaceans can swim at a speed of 18 to 20 knots. This is more than engineers think they ought to and is known as "Grey's paradox." From this volume one gathers that the animals achieve this speed by a low-drag shape and skin properties that encourage laminar flow. But another alternative, not cited here, is that the porpoise "puts more coal on the fire" and thus has more energy to expend in reaching this speed.

The diving of these animals is equally fascinating, and our understanding of it is equally hazy. We know that whales and seals can dive down several thousand feet. Whales tangle in telegraph cables, and Weddell seals have obligingly carried depth time recorders which they later returned. But the means used by the diving animal to sustain the temporary oxygen deprivation is not clear. We don't know if the lungs are at all functional at a depth corresponding to 100 atmospheres pressure. Thus much of the explanation offered in this book by Kooyman and Andersen is speculative. It may remain so for some time because of the elusive nature of the experimental material. Most of the book is in this vein of intelligent best guesses. There is also a solid contribution of conventional natural history by R. J. Harrison.

Evolution shows some of its most fascinating workings in environments that produce great stress. The sea is surely such a one for mammals. This volume offers a good sampling of current work and thinking on the biology of these animals.

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The History of Fishes

Current Problems of Lower Vertebrate Phylogeny. Proceedings of the fourth Nobel Symposium, Stockholm, 1967. TOR ØRVIG, Ed. Interscience (Wiley), New York; Almqvist and Wiksell, Stockholm, 1968. 540 pp., illus. $35.

In no area of vertebrate paleontology is work more active than in the early history of fishes, and in no area are there more points of controversy. Many of these debatable topics are discussed, pro and con, in the present volume. Although there is no specific statement to this effect, it is obvious that the Nobel Symposium was essentially a gathering to honor Eric Stensiö, whose major works on ostracoderms ushered in the modern period of study of fossil fishes. Stensiö, although nominally retired, is still active, and work at the Stockholm Museum is being carried forward by Jarvik and Ørvig.

Opinions on the relationships and phylogeny of fish groups held by the Stockholm school differ strongly in many regards from those of a majority of workers from other countries. The points of view held by Stensiö and his colleagues on various debatable problems are fully set forth in a paper by Jarvik which concludes this volume. The organizers of the symposium are to be congratulated for their breadth of vision in inviting a broad array of paleoichthyologists of highly varied beliefs, so that all major points at issue could be fully aired.

Marked differences of opinion are present in the consideration of every major fish group, from the jawless ostracoderms and cyclostomes to the "highest" bony fishes. Among ostracoderms, Stensiö demonstrated clearly in his classic work of 1927 that the cephalaspids and anaspids of the Silurian and Devonian are allied to the modern lampreys. He believed, however, that the hag fishes are not at all closely related to the lampreys, but descended from a very different ostracoderm group, the Heterostraci. Many paleontologists have disagreed with this conclusion; Stensiö, however, has adhered to his early belief, and in the present volume argues ingeniously, by hypothetical restorations of the unknown internal structure of heterostracans, in defense of his belief.

Oldest of known jawed vertebrates are the acanthodians. Watson believed them primitive in the absence of bracing of the jaw joint by the hyomandibular. More recent work, however, has shown that this is not the case; in this volume Miles, most recent worker on the group, gives further information concerning these interesting and problematical little fishes. He believes that they have broad phylogenetic relations with the bony fishes. In another symposium paper, however, Nelson discusses the gill-arch structure of the group, and votes for elasmobranch relationship.

Prominent in the Devonian fish world are the Placodermi, curious armored types of which the Arthrodira are the most abundant. Arthrodires are abundant in all Devonian horizons. Stratigraphically, their history has seemed clear. The early forms have large pectoral spines, with but little development of a movable fin behind the spine. In the Middle Devonian, the spines are generally smaller and there is a modestly developed pectoral fin. Toward the end of the period, the spine is much reduced, and even the spinal bone may be lost, and the pectoral fin is broadly expanded. In recent years, however, Stensiö has advocated a theory of arthrodire evolution, flatly opposed to the stratigraphic evidence and to the beliefs of most workers, to the effect that the most primitive arthrodires are the broad-finned late Devonian types lacking the spinal bone entirely, and that the earlier, spine-bearing arthrodires are specialized. This topic is not treated in detail in the symposium volume, but Heintz points out that at least two familiar forms which Stensiö has included in his supposed primitive group of "Aspinothoracidi" do possess spinal elements; Stensiö admits that at least some revision of his classification is called for.

Of the living cartilaginous jawed fishes, it is quite possible that the elasmobranchs are of placoderm origin, but there is no positive evidence. Many workers are of the opinion that the chimaeras (Holocephali) are definitely of placoderm ancestry. There are, however, two contrasting theories as to the path of descent. One, suggested long ago and most recently advocated by Ørvig, is that the connecting limbs are the ptyctodonts, late Devonian placoderms with powerful jaws. A second theory, recently proposed by Patterson, is that the transitional forms lie among the bradyodonts, the "pavement-toothed sharks" of the late Paleozoic. In the present volume, Patterson maintains this thesis, discussing particularly the Permian bradyodont *Menaspis;* Bendix-Almgreen, on the other hand, in a discussion of bradyodonts, expresses skepticism as to their chimaeroid relationships.

Among the higher bony fish groups, the Dipnoi, or lungfishes, are of perpetual interest. In earlier days they were advocated as ancestors of land vertebrates because of their notable similarity to lower tetrapods in mode of development and in many features of their soft anatomy. It is now agreed

that dental and cranial specializations debar the dipnoans from such an ancestral position, but it has been rather generally believed that the dipnoans are allied to the actual tetrapod ancestors, the rhipidistian crossopterygians. However, in recent years a number of workers, interested in cranial differences and not concerned with "soft parts" or embryology, have tended to deny that there is any close relationship between lungfishes and crossopterygians. This is the position taken in symposium papers by Jarvik and Bertmar. However, Denison presents an important piece of evidence to the contrary in a description of the oldest known lungfish, *Uranolophus*, recently discovered in the early Devonian of Wyoming. This form shows remarkable resemblances to crossopterygians. In characters not related to feeding habits, Denison says, "We find so many that approach the Rhipidistia that a close ancestral relationship seems to be clearly indicated."

The work of Goodrich, Watson, and Gregory in the earlier decades of the century clearly demonstrated that the rhipidistian crossopterygians were the group from which land vertebrates arose. In 1942, however, Jarvik, while agreeing that the rhipidistians were the ancestral stock, claimed that tetrapods arose from them in diphyletic fashion. He claimed that one rhipidistian group gave rise to the urodeles, a second group to frogs and all higher tetrapods. Jarvik has continued to advocate this dual origin in a series of papers up to and including a discussion in the present volume. However, with increasing knowledge of crossopterygian structure in recent years, serious doubts have arisen regarding Jarvik's theory. Thomson, in a paper on rhipidistian–amphibian relationships, sums up much of the evidence and concludes that "there is no safe evidence for the view that the Rhipidistia are distinctly separated into two distant lineages or that any particular rhipidistian group is specially characterized by features indicating a unique relationship to any particular group of modern Amphibia."

Above I have discussed only a fraction of the papers contained in this volume—merely those dealing with certain of the more disputed areas in fish evolution. There are numerous other papers—to a total of 28—which are valuable contributions in less controversial fields. Notable, for example, are a reasoned discussion by Moss of the origin of vertebrate calcified tissues and a parallel survey of the dermal skeleton by Ørvig. Altogether, the Stockholm group is to be congratulated on producing, resultant from the symposium, an important volume which will act as a catalytic agent in stimulating research on early vertebrate history for many years to come.

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The Planetary System

Physics of Planets. V. I. MOROZ. Translated from the Russian edition (Moscow, 1967). National Aeronautics and Space Administration, Washington, D.C., 1969 (available as NASA TT F-515 from Clearinghouse for Federal Scientific and Technical Information, Springfield, Va.). vi + 416 pp., illus. Paper, $3.

An Introduction to Planetary Physics. The Terrestrial Planets. WILLIAM M. KAULA. Wiley, New York, 1968. xviii + 492 pp., illus. $14.95. Space Science Text Series.

Their titles suggest a similarity of content, but these books are instead complementary, for Moroz emphasizes the physics of planetary atmospheres and Kaula discusses mainly the solid bodies of the planets and planetary applications of celestial mechanics.

Moroz writes authoritatively on planetary atmospheres, and even in translation the style suggests a splendid original. The treatment of the material is clear, comprehensive, and uncompromising. However, *Physics of Planets* has suffered from the passage of the time needed for translation, for much has happened since the book was written (most references are earlier than 1966); for example, none of the recent planetary probes are mentioned. There are some minor criticisms of the present version. The translation appears not to have been submitted to any competent scientist for correction of terminology and contains some disconcertingly odd words. It is a pity that the binding is so poor; my review copy fell to pieces as soon as it was opened. But the text of Moroz's book offers an excellent critical summary of the available material on the analysis of planetary atmospheres up to the date of writing, and one may look forward to the revised edition, which I understand is being written.

Kaula's book begins with a summary of geochemistry, petrology, geology, gravity, and planetary magetism, and continues with orbit theory in two tightly written and very good chapters on the dynamics of the earth-moon system and of the solar system; the material of these chapters alone could well form the basis of a course on celestial mechanics. Observations of planetary surfaces and the geology of the moon and Mars follow. The final chapter presents a summary of the evidence and current theories of the origin and evolution of the planetary system.

The section on the moon stresses the impact theory of the origin of lunar craters, although the possibility of a volcanic origin is also treated. I question Kaula's statement (p. 328) that "no wrench or strike-slip faults have been found on the moon"; see, for example, plate 19 in G. Fielder's book *Lunar Geology*, which clearly shows relative horizontal displacement of corresponding segments of lunar features, beyond all argument. Other such examples can be readily found from modern lunar photographs. However, for the most part, Kaula's treatment is impartial and the facts are clearly stated. Generally speaking, the book is excellent. Perhaps too much has been attempted in 445 rather small pages, but it is clearly written and is timely because little else has been written for the student planetologist. A book of this sort has been much needed.

Both books have extensive references and subject indices; Kaula's also has an author index. The papers cited in Moroz are more easily available to the Western reader than might appear from the absence of the Western (often the original) publication data. The page references in the index are pages in the Russian edition, although this is not stated; however, the original numbering is given in the page margins.

In summary, these two books are excellent additions to the literature, though the unavoidable omission of the work of the last 2½ years on planetary atmospheres from *Physics of Planets* reduces its value and points once more to the rapid pace of the advance in our knowledge of the planetary system.

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