evolution. But he has still produced a very valuable book for professionals and students wishing an introduction to the evidence, ideas, and literature on the early history of animal life or seeking inspiration for new areas of research at the bottom of the metazoan fossil record.

J. JOHN SEPKOSKI, JR.
Department of the Geophysical Sciences, University of Chicago, Chicago, Illinois 60637

A Cetacean Species

The Gray Whale. *Eschrichtius robustus*. MARY LOU JONES, STEVEN L. SWARTZ, and STEPHEN LEATHERWOOD, Eds. Illustrations by Pieter Arend Folkens. Academic Press, Orlando, Fla., 1984. xxiv, 600 pp. $75.

The phenomenal upsurge in marine mammal research during the past decade is well exemplified by this volume that treats one of the most intensively studied species of great whale. Conveniently brought together are the results of 25 independent studies by 38 investigators (one Japanese, five Soviet, seven Canadian, and 25 American). The chapters are arranged under four general headings.

In the first section (Evolution, Fossils, and Subfossil Remains), L. G. Barnes and S. A. McLeod attempt for the first time to apply phylogenetic systematics to the baleen whales (suborder Mysticeti). They reaffirm the mysticete affinities of the problematic toothed *Aetiocetus* of the Oligocene (the allegedly related *Mirocetus* and *Ferecetotherium* are not mentioned). They also demonstrate that the traditional family Cetotheriidae is a non-monophyletic assemblage of early (Oligocene to Pliocene) baleen whales. The living mysticetes fall into four well-marked families: Balaenidae (right whales), Neobalaenidae (the pygmy right whale), Eschrichtiidae (the gray whale), and Balaenopteridae (rorquals). The polarity of the character-states that distinguish these taxa is discussed in detail. The distribution of apomorphic states reveals no unequivocal phylogenetic pattern. The authors criticize earlier ideas about the relationships among the mysticetes but do not try to resolve the phylogeny of either the living or the fossil taxa.

Although now living only in the North Pacific, the gray whale has long been known from subfossil remains in Europe. J. G. Mead and E. D. Mitchell now report 10 finds of gray whale bones from western North Atlantic beaches between Long Island and Florida. Carbon-14 dating reveals that the most recent specimen died in the late 16th or early 17th century. These discoveries lend some plausibility to the contention that the enigmatic "scrag whale" of New England colonial times was the gray whale.

The second section (Historical Relationships and Exploitation) covers the aboriginal, old-style, and modern fisheries for gray whales. The six chapters here bring together much previously untapped archival material that will interest historians and anthropologists as well as cetologists. I. I. Krupnick's account of aboriginal whaling in Siberia and H. Omura's account of early Japanese whaling summarize information from published and unpublished sources that are otherwise practically inaccessible to Western researchers.

Part 3 (Demography, Distribution, and Migration) includes nine chapters, all of which deal with the eastern North Pacific ("California") population (the western or "Korean" population appears to be close to extinction). Because of their narrow coastal migration corridor and their circumscribed inshore winter range, gray whales are one of the easiest wildlife species to count. They have been systematically censused many times from vessels, aircraft, and shore, and the data have been subjected to elaborate mathematical analyses. Having been responsible for much of this research, I have been disillusioned to find that population estimates based on surveys of the winter grounds and those based on migration counts differ by a factor of two. There is an even greater discrepancy between estimates of calf production. Many possible biases in these estimates are discussed by S. B. Reilly. Jones and Swartz's five-year study at Laguna San Ignacio and J. D. Darling's 10-year study at Vancouver Island, based on observations and photographs of individually recognizable animals, indicate one of the most promising directions for research on cetacean population ecology.

In the last section (Biology and Behavior), A. V. Yablokov, L. S. Bogoslovskaya, and S. A. Blokhin report studies on age, growth, reproduction, stomach contents, and parasites of gray whales killed in the Siberian subsistence fishery; their data corroborate and extend previous research conducted in California. Other authors have investigated feeding, sound production, diving patterns, and movements. The variety of new techniques they have used suggests some of the potential for future field studies of live whales. Side-scan sonar allowed M. Nerini to observe the impact of feeding whales on the benthic communities of the Bering Sea. Hydrophones revealed to M. E. Dahlheim, H. D. Fisher, and J. D. Schempp the diversified acoustic behavior of a species that less than 20 years ago was called "the quiet gray whale." Radio-tagging enabled J. T. Harvey and B. R. Mate to track a migrating whale for 6680 kilometers from Baja California to Unimak Pass, Alaska.

The editors have made it easy for readers to find their way among the wealth of new information. The table of contents and the running heads include both the titles and the primary headings of each chapter. At the head of each chapter is a complete outline of the contents. There is an adequate subject index, but names of organisms and authors are slighted.

DALE W. RICE
National Oceanic and Atmospheric Administration, National Marine Mammal Laboratory, Seattle, Washington 98115

Meteoric Processes

Physics of Meteoric Phenomena. V. A. BRONSHTEN. Reidel, Boston, 1983 (distributor, Kluwer Boston, Hingham, Mass.). xviii, 357 pp., illus. $74. Geophysics and Astrophysics Monographs. Translated from the Russian edition (Moscow, 1981).

It has been over 25 years since the appearance of the classic theoretical monographs by B. Yu. Levin and the late E. J. Öpik on the phenomena that accompany the entry of meteoric bodies into the atmosphere of a planet. In *Physics of Meteoric Phenomena*, V. A. Bronshten has succeeded admirably in synthesizing and summarizing work done in this field since then. The topics covered will be of interest to workers in plasma physics, aerodynamics, radiation gas dynamics, meteoritics, meteor astronomy, and space science as well as to those concerned with middle and upper atmospheric physics, chemistry, and spectroscopy.

The author uses the model of simple ablation theory in a hydrostatic isothermal atmosphere as the context in which to view meteoric phenomena. What little is known regarding fragmentation and its eventual inclusion in a realistic way in the modeling process is considered in the last chapter of the book with an update in the last appendix of the English edition.

The book begins with a treatment of

the simple physical theory of meteors. It is followed by a chapter on initial heating phenomena and the details of the progressive interaction between air molecules and the meteoroid as the momentum and energy exchange varies from a free molecular (Newtonian) to a near-continuum type of flow. A chapter on ablation processes considers both experimental results and theoretical modeling assuming near-equilibrium flows. It also contains good discussions of meteoroid energetics and of the morphology of meteoritic ablation processes. A chapter on the luminosity and spectra of meteoroids discusses experimental results concerning differential luminous efficiency and compares the chemical abundances of meteorites and those deduced for meteoroids from spectral analysis. A chapter on ionization discusses the formation and development of the head echo and wake ionization and their relation to meteor radar systems and the subsequent decay processes. There is a chapter on the determination of the dynamic and photometric meteoroid masses and the deduction of bulk density from these and related quantities. This chapter analyzes fireball observations, including the recovered and photographed Pribram, Lost City, and Innisfree meteorites, and draws conclusions regarding the types of meteoroids entering the atmosphere.

There are four appendixes in the English edition. Two consider recent detailed models of the fireball-atmosphere interaction which corroborate the heat transfer coefficients deduced by observation, experiment, and theory earlier in the book, one covers "electrophonic" ("or ethaerial") sounds, and one summarizes recent work on analytical modeling of the onset of fragmentation due to uniaxial compressive failure of the meteoroid.

The choice of subject matter and depth of treatment are moderately subjective. There is no discussion of rates of meteoroid influx, cratering processes, the propagation and decay of shock and sound waves, or comparable effects in other planetary atmospheres. There is almost no mention of the techniques of instrumental or data analysis by means of which many of the theoretical conclusions can be inferred from the observations. It is somewhat surprising that "electrophonic" sound, which has not yet been observed instrumentally, is treated whereas "ordinary" nonlinear, weakly nonlinear, and linearized acoustic-gravity waves from fireballs are not discussed. It is also surprising that Bronshten has not attempted to define his realm of interest more precisely for extremely large masses, $\gtrsim 10^{17}$ grams.

An introduction, however rudimentary, to radiation gas dynamics and its methods as they apply to meteoric phenomena would have been useful to the reader in assessing the limitations of the simple ablation theory in continuum flow even in the absence of gross fragmentation. I cannot generally agree with Bronshten's conclusions concerning the bulk densities of meteoroids. As has been shown by Ceplecha and McCrosky and later by Wetherill and ReVelle, a substantial fraction (up to a third) of the observed fireballs have bulk densities comparable to those of ordinary chondrites. Clearly more work needs to be done on this subject, especially for friable meteoroids.

These differences aside, Bronshten has assembled, synthesized, and critically commented upon an enormous amount of literature, much of it written by Soviet and Eastern Bloc scientists during the period from about 1960 to 1980 (though comparatively little Western literature more recent than 1977 is included). Renewed interest in permanent earth-orbiting vehicles such as the NASA Space Station project requires that scientists and engineers from many disciplines gain modern perspective on the meteoroid population and its interaction with the earth's atmosphere. *Physics of Meteoric Phenomena* will provide an impetus for discoveries in this field.

DOUGLAS O. REVELLE
Universities Space Research Association, NASA Marshall Spaceflight Center, Huntsville, Alabama 35812

Origins of Modern Astronomy

The History of Astronomy from Herschel to Hertzsprung. DIETER B. HERRMANN. Cambridge University Press, New York, 1984. x, 220 pp., illus. $24.95. Translated from the German edition (1973) and revised by Kevin Krisciunas.

This broad-brush review of the origins of modern astronomy presents the contributions of 19th- and early 20th-century German astronomers from a point of view intimately associated with Eastern Bloc political philosophy. Herrmann treats all aspects of modern astronomy, as practiced both in Europe and America, from this point of view, but provides more than sufficient objective historical narrative to make the book of great value, if read with perspective.

Herrmann, director of the Archenhold Observatory in Berlin-Treptow, is well known to historians of astronomy as a prolific researcher and interpreter of the development of modern astronomy and astrophysics, as well as of the history of German astronomy. He has collected here much of his own research on the founders of German astrophysics, patterns of growth of astrophysical enterprises (observatories, journals, and data), and comparative studies of national styles in astrophysical research in the late 19th century. Krisciunas, an astronomer with an avid interest in history, has provided a straightforward translation that preserves the general flavor of Herrmann's style, as well as his sometimes obtrusive Marxist rhetoric.

The book covers a wide range of topics, including the modern transition from a static to a dynamic and evolutionary cosmology; the growth of astrophysical observing techniques as related to problems in photometry, photography, and spectroscopy; the subsequent increase of astrophysical data, who generated them and why; and the application of modern physics to the study of stellar systems, stellar structure, and stellar evolution. Any of these topics would be difficult to squeeze into 200 pages of text. Herrmann has in general done a good job of distilling the story even further, but as a result of the compression the information content, historical depth, and treatment of complex issues are not completely satisfying. The role of solar studies as a driver of stellar astrophysics is not emphasized; for example, the treatment of the importance of Saha's ionization theory to modern studies of stellar atmospheres and interiors is brief and superficial. We learn only that the theory is important, not why, or how it was derived. In the discussion of the origins of the Hertzsprung-Russell diagram, the critical influence of Antonia Maury's complex spectral classification system upon Hertzsprung is not identified. The application of modern physics to astronomy is not analyzed to the point where one might understand how and why it took place, what the problems were (there were many), and how they were overcome. Although Eddington's use of radiative equilibrium to study stellar interiors is discussed, the fact that it was a significant departure from earlier theories that used only convective transport is not made clear.

In sum, a work on this scale should have been a primary introduction to the history of modern astronomy, but this one presupposes too much. Still, for those with some knowledge of the subject, it will provide useful factual back-