telling one about the predictive value, as well as qualitative validity, of the theoretical models.

Some readers will also be disappointed by the neglect of numerical models. I largely agree with Csanady that "numerical models come into their own in synthesizing a variety of phenomena, *after* those phenomena have been identified and understood on the basis of simple analytical models," but this attitude tends to downplay the intuition-building role of numerical solutions for problems that are idealized but still analytically intractable.

More seriously, there is no mention, or inadequate treatment, of a number of major recent advances that one would expect to find in a book that aims "to summarize those aspects of coastal ocean dynamics relevant to 'circulation' or long-term motion." Most striking is the lack of any mention of the "H/U^3" criterion for the separation of regions that are well mixed by the tides from those that become stratified in summer. These regions occur quite widely in the world and do affect circulation, particularly at the fronts between mixed and stratified water. They are also of particular importance for a variety of biological processes. Fronts are discussed briefly in the book, but with excessive attention to models of frontal adjustment and insufficient consideration of the mean circulation, or cross-frontal transfers, associated with coastal-upwelling fronts or tidal-mixing fronts.

Csanady also omits any discussion of the mean flows that can be generated by the rectification, over topographic features, of oscillatory tidal currents. These flows may contribute significantly to large-scale current patterns (such as the gyre around Georges Bank) and, over small-scale topography, may be a dominant factor in lateral mixing.

Horizontal dispersion is largely neglected in the book (perhaps justifiably in view of the title). Csanady does discuss some mechanisms, but not convincingly or completely.

For the graduate engineer or meteorologist, at whom the new series Environmental Fluid Mechanics is partly aimed, this book is at once too limited in its perspective and, perhaps, rather too difficult in detail to be a good introduction. The specialist physical oceanographer will find the book to be a valuable summary of many of the key recent advances in dynamical coastal oceanography, particularly those advances associated with Csanady himself, and will be pleased to have it on his or her shelves. A teacher of a graduate course on the physical oceanography of the continental shelf will find much of the book to be very useful but will need to supplement it with a discussion of several other topics and approaches. In other words, this is a valuable book containing science of high quality, but its coverage is not as complete, or uniform, as the title or dust jacket suggest.

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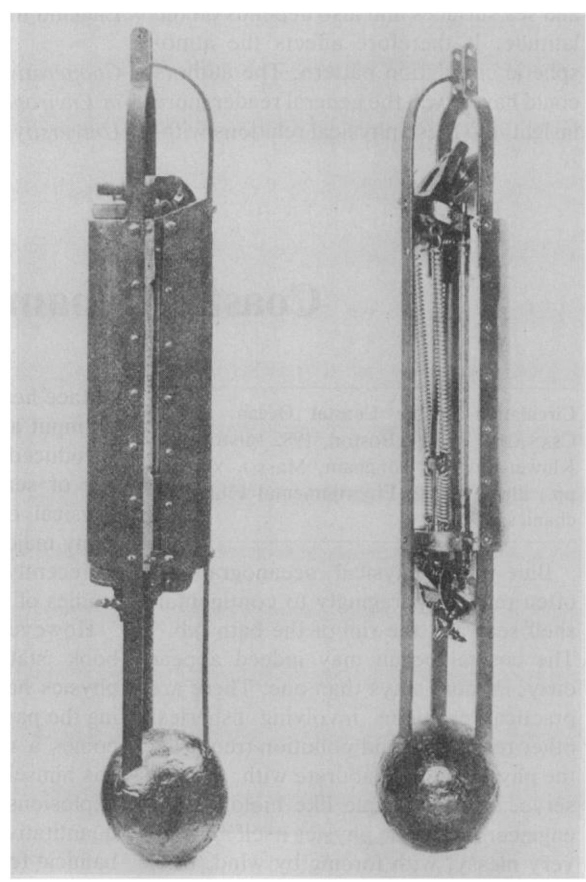
Tools of Oceanography

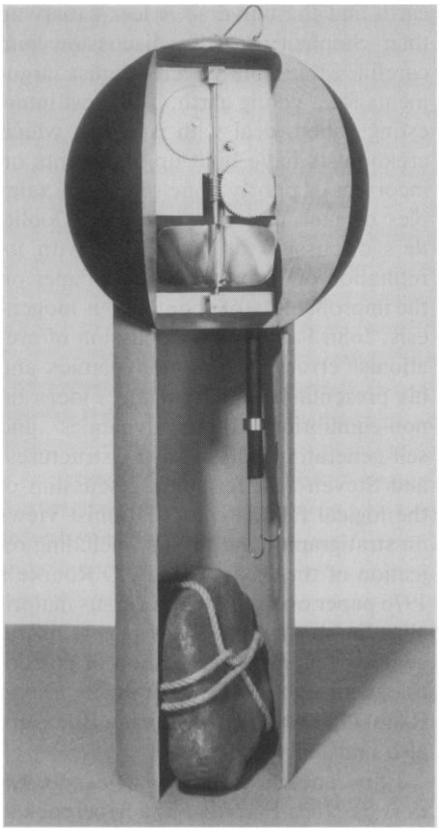
No Sea Too Deep. The History of Oceanographic Instruments. ANITA MCCONNELL. Hilger, Bristol, England, 1983 (U.S. distributor, Heyden, Philadelphia). xii, 162 pp., illus. $49.

The 1960's and 1970's were golden years in our exploration of the oceans, in which a new generation of instruments provided details of the structure and restless motions of the sea that were previously unsuspected. Remote sensing from satellites revealed patterns of eddies arising from convolutions in great current systems such as the Gulf Stream, and continuous echo-sounding of the ocean floor showed structures of rifts and fractures that led to a revolution in our view of global tectonics. This beautifully and extensively illustrated book reminds us of the newness of these techniques and how difficult it was, until quite recently, to take deep soundings of the ocean and to measure the temperature of the water below the top few hundred meters. "The greatest Victorian technology . . . , a telegraph system girdling the world," required trans-oceanic cables and closely spaced soundings with bottom samples along tracks fixed precisely by astronomical observations. The development of mechanical sounders was not at all a trivial task. They had to be lowered from a ship, often in rough seas, at the end of a line 5000 meters or more long and indicate precisely when (and where) they hit the bottom. Enormous pressures made temperature measurements unreliable.

McConnell's book is arranged more or less chronologically, beginning with the devices conceived by Robert Hooke and others in the 17th century and the early deep-sea thermometers and sounders of the 18th. The Arctic expeditions between 1773 and 1828 provided opportunities for oceanographic observations, since among the Arctic islands currents were taken as clues of the existence of the Northwest Passage. The development of more reliable thermometers con-



Martin Knudsen's high-speed bottle for taking water samples from a ship under way. In 1905, to increase the number of observations that could be made in a limited time, Fridtjof Nansen and V. W. Ekman designed an "automatic" insulated water bottle. "Nansen's experiences with this bottle were satisfactory, but [his ship's] winch could not take the quantity of line needed to stream the instrument at its maximum operating depth of 600 m. . . . Knudsen took the design further and in 1909 published details of [the bottle shown here]. With [his] ship travelling at 8 knots he was able to sound to the bottom, an average depth of 80 m, all the way [from Stavanger to Aberdeen] except in the deep trench adjacent to the Norwegian coast." [Reproduced in *No Sea Too Deep* from M. Knudsen, *Cons. Perm. Int. Expl. Mer. Publ. Circ. No. 50* (1909)]



Replica of a sounder introduced by Robert Hooke in 1691. The mechanism in this sounder, one of several designed by Hooke, "resembled a land surveyor's waywiser. . . . A vane was turned by water flow, and the number of its revolutions were counted on a register during the descent. On its ascent, a lid automatically dropped over the mechanism so that it became inoperative. . . . The value of Hooke's work [on oceanographic instruments] lies less in its originality, which he himself disclaimed, than in the detailed descriptions which became widely known through the medium of the *Philosophical Transactions*." [From *No Sea Too Deep*; Crown Copyright, Science Museum, London]

tinued to be of concern throughout the 19th century, even the electrical resistance thermometer being far from satisfactory. Devices for biological sampling are also discussed, as are the first attempts to develop a deep-sea current meter.

This reviewer was a little disappointed that the book does not go beyond the end of the 19th century; the pace then picked up. Nevertheless, it gives a fascinating account of the formidable problems facing oceanographic instrument makers (then and, indeed, now) and the ingenious solutions they devised. It will be read with interest and pleasure by anyone who loves the sea.

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Responses to Creationism

Abusing Science. The Case Against Creationism. PHILIP KITCHER. MIT Press, Cambridge, Mass., 1982. x, 214 pp. $15.

Creation and Evolution. Myth or Reality? NORMAN D. NEWELL. Columbia University Press, New York, 1982. xxxii, 204 pp., illus. $19.95. Convergence.

Science on Trial. The Case for Evolution. DOUGLAS J. FUTUYMA. Pantheon, New York, 1983. xiv, 254 pp., illus. Cloth, $16.50; paper, $6.95.

Scientists Confront Creationism. LAURIE R. GODFREY, Ed. Norton, New York, 1983. xxviii, 324 pp., illus. $19.50.

The Monkey Business. A Scientist Looks at Creationism. NILES ELDREDGE. Washington Square Press (Pocket Books), New York, 1982. 158 pp. Paper, $2.95.

Christianity and the Age of the Earth. DAVIS A. YOUNG. Zondervan, Grand Rapids, Mich., 1982. 188 pp., illus. Paper, $19.95.

The concept of organic evolution has always generated opposition from those who perceive it as an attack on their religious convictions. Scientists have normally avoided confrontation on the issue because they have not been involved in any attack and have felt that the argument was falsely based and unproductive. Recently, however, by forcing a presumably intellectual and theological issue into the political arena, the creationists have at last generated direct responses from several quarters. Federal courts have rejected on constitutional grounds the first two state laws mandating the teaching of creationism in public schools. Scientific societies have held symposia on the issue. And now some of the most respected scholars engaged in the study of evolution have examined the arguments of the more vocal creationists and responded in detail.

The six books under review are a bonanza of good, vigorous scholarship. Proponents of creationism have not been ignored or suppressed by the scientific community as the supporters of von Däniken and Velikovsky claim was the fate of their heroes. Although philosophers of science may be nonplussed with the way one argument or another is constructed in the individual books, no one can quibble with the way each book presents the general differences between evolutionary science and creationist arguments. The concept of evolution is shown to be part of a body of successful scientific study built up from many lines of inquiry and regularly modified as reliable new evidence accumulates. The creationist viewpoint is exposed as a position built on assertions derived from only one of many possible interpretations of one religious document. The five books that deal directly with evolution evaluate the creationist objections to evolution and convincingly reject them as having no legitimate place in the scientific arena, either as alternatives to evolution or as acceptable classroom fare.

Lay persons sometimes view science as a body of demonstrated truths, but this is a misimpression. Philosophers of science tell us that certain proof is virtually impossible. As Kitcher says (p. 32), "Complete certainty is best seen as an ideal toward which we strive and that is rarely, if ever, attained." Therefore, I agree with Futuyma that the ideas of Dorothy Nelkin (discussed on pp. 21–22 of *Science on Trial*) expose the central difference between evolutionary science and creationism: namely, whether we require evidence for beliefs or whether we accept beliefs without evidence. Beliefs, not proofs, are the issue. Both tenets of religion and widely accepted scientific theories are beliefs. However, scientific beliefs require evidence of some sort before they can claim to be convincing, whereas religious beliefs are frequently held without substantiating evidence. Indeed, that is one of the qualities that justifies the term faith. In science we must maintain that distinction, or we will have no reason beyond their direct emotional appeal for choosing among the multitude of ideas.

All the books point out that scientific theories, including our current views of evolution, are not sacred writ but are based on observations we regard as evidence. Scientific theories unite the various observations we make in a coherent fashion and are the most useful explanations we know for natural phenomena. They are open to correction, improvement, or modification by new, more effective ideas that unite a wider spectrum of observations or resolve previously observed conflicts. All the books reveal that creationists do not accept any of these approaches in forming their ideas. Their beliefs are based on a priori