Astronomers at Mount Wilson Observatory, 1910. *Facing left*, J. C. Kapteyn; *in light suit*, Karl Schwarzschild; *at extreme right*, V. M. Slipher. [Yerkes Observatory]

ature and has opened up a new pathway to understanding how science changes.

Paul carefully defines "statistical cosmology" to describe the activities of those who constructed either empirical or mathematical models of the structure, form, and content of the visible stellar system. Both types of modeling efforts were based on statistical studies of the observed spatial and luminosity distributions of the stars. The empirical school, led by Jacobus Kapteyn, relied on numerical techniques to determine the number density of stars in space and how they distributed themselves in luminosity, whereas the mathematical school, led by Hugo von Seeliger, built theoretical models using the frequency distribution laws of Maxwell and Boltzmann and tested them against the observations.

Paul distinguishes statistical cosmologists from those who merely catalogued data about the stars and focuses primarily on the Dutchman Kapteyn and how his numerical techniques, especially his method of determining the mean parallaxes of groups of stars, led to his discovery of star streaming at the turn of the century and how he eventually developed the idea of a finite Sun-centered system that has been called the "Kapteyn Universe." Paul contrasts Kapteyn's empirical style with that of the Munich mathematical theorist Seeliger, who during the same period developed elaborate models of the stellar universe based upon complex luminosity and density functions, but who found a universe similar to the Kapteyn Universe. Paul then identifies how these two lines of inquiry were elaborated but ultimately failed to account for various observed dynamical features of the visible stellar universe. Finally, Paul recounts how the young Mount Wilson astronomer Harlow Shapley, cast in an entirely different mold from Kapteyn or Seeliger, showed that their concept of the stellar universe had to be profoundly modified, and in so doing helped to usher in the decline of statistical cosmology.

Along the way, Paul demonstrates in helpful detail how Kapteyn marshaled a large fraction of the world's observatories to engage in a coordinated "plan of selected areas" to gather the data necessary for building and then distinguishing among possible statistical models of the stellar universe. His discussion here will be highly valuable to those who wish to comprehend the ultimate complexion of astronomy in 20th-century America and how it differed from, yet depended upon, astronomy on the Continent.

Although Paul attempts to explore the degree to which statistical techniques were accepted by astronomers generally as the path to cosmological modeling, he succeeds in showing only how the modelers themselves regarded statistical methods, since he confines his attention to those people who were engaged in constructing the models and explicitly neglects others, primarily in the United States, who limited themselves to collecting and cataloguing the masses of data that were required. By inference and by omission he demonstrates indeed that Americans were not prominent in statistical astronomy. This is an important point and should be developed. Consideration of how Americans reacted to the use of statistical techniques during this period would help us appreciate why some of them sought out alternative methodologies.

In general, however, Paul succeeds admirably in his basic goal of showing how this episode changed the practice of much of stellar astronomy, as well as the concept of the size and extent of our galaxy. The book contains a few unfortunate blunders (though none undermine its main arguments), and the writing is at times turgid and redundant. But the book was written more for the specialist historian and journeyman astronomer than for the casual reader. It is a very welcome contribution to the literature made all the more poignant since Paul, a valued colleague in the historical profession, died soon after its publication.

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Oil Damage

Marine Mammals and the *Exxon Valdez*. THOMAS R. LOUGHLIN, Ed. Academic Press, San Diego, CA, 1994. xx, 395 pp., illus. $49.95 or £38.

Probably the single most publicized human-caused environmental disaster in United States history is the March 1989 *Exxon Valdez* oil spill. Both the efforts to clean up the spill and the efforts to assess its impact were unprecedented, and the final cost to the Exxon Corporation will exceed $10 billion.

Beginning within days after the spill and continuing through 1993, a series of studies were designed and executed to determine the extent and magnitude of the effects of the spill on marine mammals, particularly sea otters. Many of these studies have been compiled into the present 21-chapter, semi-technical book. Much of the information discussed in the book has been presented elsewhere, but the book is a convenient compendium with excellent overviews and summary conclusions.

"A formerly oiled harbor seal pup being fed at a rehabilitation center in Homer, Alaska, May 1989." [From S. T. Zimmerman *et al.*'s chapter in *Marine Mammals and the Exxon Valdez*]

About a third of the book is devoted to studies that quantify population-level impacts, with much of the remainder focusing on behavioral, pathologic, or toxicologic studies designed to understand how petroleum hydrocarbons negatively affect free-ranging marine mammals. In an overview, Ballachey *et al.* note that the "studies [were] driven largely by impending litigation against the Exxon corporation"; thus the researchers concentrated "on estimating acute mortality and documenting continuing damages." Overall, as is pointed out in the final chapter, "The reader . . . will sense the frustration of researchers attempting to sat-

Vignettes: Psychometric Needs

Those who work in the field say that asking governments and technologists to take care of natural resources is just like asking the fox to guard the chicken-coop; politicians reply that trusting biologists and Indians to preserve the natural populations they are studying and using is no better; both have a part of the truth, because there are people on all sides interested only in their own "progress" and not in humanity's future. Someone needs to invent a "motivometer" in order to discover and unite the honest and altruistic idealists on both sides.

—*Hamilton A. Tyler, Keith S. Brown Jr.*, and *Kent H. Wilson*, in *Swallowtail Butterflies of the Americas: A Study in Biological Dynamics, Ecological Diversity, Biosystematics, and Conservation* (Scientific Publishers)

They will be telling us some day of the WEIGHT of the MOON, even to *drams, scruples*, and *grains*—nay, *to the very fraction of a grain*!—I wish there were infallible experiments to ascertain the *quantum* of *brains* each man possesses, and every man's *integrity* and *candour*:—This is a *desideratum* in science which is most of all wanted.

—*Robert Harrington*, in *The Death-Warrant of the French Theory of Chemistry* (1804), as quoted by Jan Golinski in *The Values of Precision* (M. Norton Wise, Ed.; Princeton University Press)

isfy scientific inquiry in a sometimes chaotic environment with competing priorities and limited resources."

As a compilation of what over 23 million dollars and thousands of hours of effort by some of our nation's best-trained marine biologists and veterinarians can buy, what does the book tell us was learned? Remarkably little for some species (including most cetaceans), but a significant amount for others, particularly sea otters and harbor seals. In some chapters, the conclusions reached seem feeble, given the data. This may in part reflect concern about litigation, but in most cases the equivocalness of authors can be attributed to the logistical constraints of sampling wide-ranging animals in a large, remote area; to the inadequacy of baseline data; to a lack of preplanning; and to the fact that most marine mammals apparently sink after dying. Despite these difficulties, data presented in several chapters provide empirical support for previously unconfirmed hypotheses and show that researchers obtained significant new information. The observational and anecdotal information presented demonstrates that most marine mammals do not avoid oil and that shoreline cleanup does not prevent pinnipeds from becoming oiled; forensic and behavioral evidence demonstrates that hypothermia is the critical factor leading to death in sea otters. In chapter 13, Williams *et al.* conclude that if nonendangered pinnipeds are oiled with weathered or the nonvolatile fractions of crude oil, it may be best to leave them alone rather than subject them to the stress of capture, cleaning, and rehabilitation. However, nearly all authors addressing the issue concede that little is known about the long-term or chronic impact of oiling on mammals, and the effect on marine mammals may be further compounded by their long migrations, prolonged fasting, and the physiology of diving. Finally, it is apparent from the data presented in this book that the acute toxicity of newly spilled oil begins to affect animals severely within hours of a spill and that scientific protocols must be already in place if we hope to document these effects.

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