Like the first report, the second report does not reveal all its technical details, and there will no doubt be criticism of these when they are revealed. There is real danger that computer modelers develop a "mystique" which makes the operation hard to criticize in detail. A dictionary of assumptions and parameters would be highly desirable. Nevertheless, the presentation is masterly. It consists of a general text interspersed with "briefs" which develop some, but not all, of the more technical details. It will be a rare person who is not moved as well as stimulated by this document. One hopes that these modern works will indeed have the same effect as Jonah's prophecies. It will be recalled that Nineveh did repent and was not destroyed even though this made Jonah furious. This is a slim thread on which to hang a hope for the future, but perhaps it is all the thread we have.

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Oceans of the Geological Past

Studies in Paleo-Oceanography. Papers from a symposium, Houston, Texas, Mar. 1971. WILLIAM W. HAY, Ed. Society of Economic Paleontologists and Mineralogists, Tulsa, Okla., 1974. iv, 218 pp., illus. $11; to members, $9. SEPM Special Publication No. 20.

As the first book to use "paleo-oceanography" in its title, this volume extends to ancient oceans the broad acceptance by chemists, geologists, biologists, and physicists that the study of the marine realm is more than the sum of the individual parts. The emphasis on ancient oceans per se is, in addition, in sharp contrast to the time-honored geologic interest in rocks and indicates yet another change in the traditional topics of geology departments.

Two types of results are being published for these ancient bodies of water: descriptive statements of the sequence of events as oceans appeared, disappeared, and reappeared, in which the particulars of special history are of prime importance; and causal analysis of ocean behavior (using the averaging effects of geological time), in which stochastic processes within narrow equilibrium limits are the chief guiding principles. Paleooceanography (a form preferable to the tentative-looking "paleo-oceanography" and in accordance with the usage of Kay [1945] and von Arx [1959]) is in the growth phase of descriptive work, as the appearance of 27 volumes from the JOIDES Deep Sea Drilling Project in only five years makes very clear. Simultaneously, models are being developed which are independent of time and place and which look at events in ecologic (or laboratory) time and apply the results over evolutionary (geologic) time.

One can divide paleooceanography into seven major topics, each one of which is covered to some extent in the ten chapters of this book. None of the seven is given even, thorough coverage, however, and in truth the book is chiefly notable for its chapters on chemical aspects of sediments and oceans, past and present.

Concerning the *paleogeography* of ocean basins, Berggren and Hollister use paleogeographic reconstructions on a Lambert equal-area projection centered at 30°N,20°W, as prepared by Phillips and Forsyth (*Bulletin of the Geological Society of America* **83**, 1579 [1972]) for the North and South Atlantic since the breakup of Pangea in the Mesozoic. Ramsay presents Atlantic physiography for the Eocene, Oligocene, and Miocene but uses the reconstructions and modified Mercator projection of Francheteau (unpublished). *Paleobathymetry*, for which there is a voluminous literature, is barely touched upon. However, if one follows Worsley, a previously suggested criterion, the carbonate compensation depth, has migrated from depths of 5 to 6 kilometers to the surface, and then back, in the 20-million-year period from the Late Cretaceous to the Late Paleocene.

In *water studies*, Berggren and Hollister present inferred circulation patterns through the history of the Atlantic, and show the origin of Atlantic Ocean currents. Data on *paleotemperature* are also summarized for Mesozoic and younger oceans by Berggren and Hollister, who emphasize the conclusion of Emiliani that deep water of the world oceans cooled from about 14°C in the Cretaceous to its present 2°C, as a result of chilling of source waters at high latitudes. Ramsay presents a summary curve of temperatures of surface waters in temperate latitudes for the world ocean since the Jurassic.

Paleochemistry of oceanic sediments is the chief subject of the book. With characteristic lucidity, Berner discusses the solubility of calcium carbonate in seawater, using data from both descriptive chemical oceanography and laboratory experiments. He contrasts the expected effects of special historical factors, namely crossing of boundaries between water masses, with results obtained by equilibrium chemical approaches involving dissolution kinetics and surface chemistry, and considers the equilibrium approach of main importance. The origin of the compensation level on the western flank of the East Pacific Rise is treated by Broecker and Broecker, who find the kinetic and historical factors inextricably interwoven at this locality. Ramsay, in discussing the distribution of calcium carbonate in deep-sea sediments, attributes the chief causal influence to ocean productivity, which, in turn, is believed to be regulated by temperature changes in surface waters. He also presents postulated distributions of red clay, pure siliceous ooze, and carbonate ooze for the Atlantic during the Eocene, Oligocene, and Miocene. Heath, in a very wide-ranging and excellent paper, presents all aspects of the silica cycle and emphasizes regulation by plants. He concludes that deposition of silica by inorganic precipitation appears "virtually impossible since the late Mesozoic and unlikely since the Precambrian."

In the present ocean, perhaps 1500 pre-Quaternary sediment cores have now been obtained, and Saito, Burckle, and Hays show the position, depth, and age of 900 of these which are housed at the Lamont-Doherty Geological Observatory (see also the listing by Funnell of 500 cores obtained before August 1967 in *The Micropalaeontology of Oceans*, B. M. Funnell and W. R. Riedel, Eds., Cambridge University Press, 1971, pp. 507–534). Saito *et al.* conclude that over much of the Pacific the accumulation rates are less than 1.2 centimeters per thousand years for the Pleistocene, with the narrower Atlantic Ocean having rates two to four times higher.

Three chapters treat ocean chemistry through geologic time. Chemical considerations allow one to predict phases that would precipitate if the ocean varied widely from its present chemical composition. Holland examines these limitations on ocean chemistry and draws specific conclusions about ranges permissible in present and past seawater (the topic is further developed by him in *Geochimica et Cosmochimica Acta* **36**, 637 [1972]). Mackenzie and co-workers (Garrels in one case, Lafon

in the other) develop explicit equilibrium models for the early evolution of the oceans and by examining postdepositional changes in sedimentary rocks illustrate probable long-term controls of ocean chemistry. Thermochemical data were used to predict the sequence of weathering of the "average igneous rock," and the process was modeled by computer simulation. The results indicate that a very rapid degassing with equally rapid assumption of chemical equilibrium at a composition close to the present composition of seawater is a distinct possibility. Subsequent recycling through geologic time merely stirs the system.

With respect to *paleoclimatology*, the possible influence of Pleistocene changes is mentioned by various authors. In *paleobiology*, Berggren and Hollister present a fauna-by-fauna account of the changes in the biotic provinces that existed during the evolution of the Atlantic Ocean. And the chief point of Worsley's chapter is to explain the Cretaceous extinctions as due to the rapid migration of the carbonate compensation depth.

As is typical of SEPM special publications, no index is provided, and the papers appear about 3 years after they were given in a symposium. All in all, however, this is a very useful series of "studies" which will encourage the development of paleooceanography as a recognized discipline in university curricula.

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A History of Probability

Probability Theory. A Historical Sketch. L. E. MAISTROV. Translated from the Russian edition (Moscow, 1967) and edited by Samuel Kotz. Academic Press, New York, 1974. xiv, 282 pp., illus. $22.50. Probability and Mathematical Statistics, vol. 23.

The history of the history of probability is curiously simple. There is only one major work; Todhunter's detailed *History of the Mathematical Theory of Probability* appeared in 1865 and is still in print. Todhunter reports everything then known, devoting a 150-page review to the giant of that time, Laplace. Maistrov's new account, while only a historical sketch, effectively fills some of the gaps in Todhunter's book and works at bringing us up to date.

Maistrov's book divides roughly into three sections, the first being a workmanlike overview of the early period from prehistory to Laplace. The author thinks that the classical approach linking probability and gambling "neglects the whole prehistory of the subject." His argument is unconvincing, since gambling predates other aspects of prehistory, and, furthermore, he gives no reasonable alternative explanations of the origins of probability beyond brief mentions of census and insurance. Important sources not considered at all are the mentions of probability in Jewish writing about A.D. 200 (discussed, for example, by N. Rabinovitch, *Probability and Statistical Inference in Ancient and Medieval Jewish Literature*, University of Toronto Press, 1973) and the randomization in early religious rituals (discussed by F. N. David, *Games, Gods and Gambling*, Griffin, 1962, and by F. Van Der Blij, *Scripta Math.* **28**, 1 [1967]).

Maistrov makes a novel contribution in his tabulation of several hundred throws of each of over a dozen very old dice. An analysis of the data I have made for this review shows that ancient dice are very far from being uniform. Most of the bias can be explained if the dice are assumed to be rectangular solids instead of cubical.

Maistrov carefully presents Bernoulli's original proof of the law of large numbers and most of Bayes's paper, but otherwise his examples complement those in Todhunter's work. For instance, he pulls together little-known aspects of Galileo's thoughts on errors in measurement in astronomy and gives Buffon's motivation for studying geometrical probability.

As the translator points out in footnotes, the author perpetuates an old myth concerning the Demoivre-Laplace theorem. This theorem places the normal curve of error in its position of prominence as the limiting distribution of sums of random quantities. We are told several times that Demoivre obtained the limiting distribution for tosses of a fair coin with probability of heads $p = \frac{1}{2}$ and that "later, Laplace extended Demoivre's theorem to arbitrary values of $p \neq 0, 1$." Actually, the case of general p was dealt with by Demoivre in the third edition of *The Doctrine of Chances*.

Laplace deserves to have his name linked with the theorem for a different reason. He first understood the normal curve in the way we do today as a continuous probability distribution with wide applications. Laplace proved that the sum of independent but not necessarily identically distributed random quantities can be renormalized to converge to a normal distribution. Demoivre nowhere writes as if he considered the normal curve as a probability distribution. He derived it as a numerical approximation for the problem of independent repetitions of an experiment with a yes or no outcome.

In the middle section, Maistrov pays homage to Gauss, who is barely mention by Todhunter, and gives some details of his work on least squares. It is strange that no one has yet presented a thorough analysis of Gauss's contribution to probability and statistics.

The author writes with new authority in his discussion of probability in Russia. He discusses the introduction of probability in the Russian universities (around 1830) and gives examples of very early course curricula. The probabilistic work of Revkovskii, Davidov, Lobachevskii, Zernov, Bunyakovskii, and Ostrogradskii will be new to most readers. Both Chebyshev and Markov are treated in detail; we learn not only about Markov chains but also about Markov's detailed statistical analysis of the poem "Eugene Onegin."

The last part of the book deals with modern probability. The author limits the scope of his inquiry to a single topic: the problems of the axiomatic foundation of probability. Thus, with the exception of a short, confused section on sums of independent random variables, there is no mention of the great probabilists of the 20th century, such as Cramér, Feller, Gnedenko, Lévy, or Wiener.

The author seems not to recognize subjective probability in this survey. This leads him to almost ridicule statements of Condorcet, Laplace, Borel, Poincaré, and others that have clear, well-defined meanings in the modern subjective framework.

The translator has preserved the readable style of the original, corrected numerous mistakes, and provided many useful comments, definitions, and new references.

The older literature of probability contains much that is new from the perspective of a research worker in probability or statistics. Sections of books by Bernoulli, Demoivre, and