dicate that the presently favored model for the earth's magnetic field as an axial dipole may require review.

The final chapters of this volume are "Paleontology and climate" and "Problems of sediments and soils." In the former, Teichert interjects a timely note of warning by suggesting that distribution patterns of fossils and of sediments can as well represent the circumstances of control as any real pattern. And in the latter, red beds are subjected to yet another review in which Van Houten seems to find little real promise that these sediments can provide unequivocal indications of any special climatic regimen.

Problems in Paleoclimatology suggests that the principal problems of the field are occasioned by emergence from uncomfortable adolescence. This is an emergence in which the whole scientific community may take heart, for it will lead to substantial advances. Certainly, as human population increases, the importance of long range planning will increase and the significance of learning enough to predict and possibly someday to modify the intensity, direction, and rate of climatic change is evident. *Problems in Paleoclimatology* tells us of the ground that we have so far traversed, of the chaos in which we are presently ensnared, and occasionally points hopefully to a direction we may take in order to achieve real advances in our knowledge of climate and climatic change.

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Techniques in Organic Chemistry

Applications of NMR Spectroscopy in Organic Chemistry: Illustrations from the Steroid Field. Norman S. Bhacca and Dudley H. Williams. Holden-Day, San Francisco, 1964. x + 198 pp. Illus. $7.95.

A major reason for the recent rapid development in organic chemistry has been the availability of instrumental techniques for structure determination, analysis, and similar purposes. Twenty years ago commercial ultraviolet spectrometers completely changed the way in which chemists studied unsaturated compounds. Fifteen years ago infrared spectroscopy changed the approach to qualitative functional group analysis, and 10 years ago nuclear magnetic resonance (NMR) spectroscopy made it possible to study the chemical environment of protons in organic compounds.

Several books dealing with NMR spectroscopy have appeared during the last 10 years, but none of them are really satisfactory in guiding the chemist to make maximum use of this technique or in illustrating the wealth of information that may be obtained from a detailed consideration of the spectrum of a given compound. The present volume is successful on both scores, and is recommended for all but the most experienced among NMR spectroscopists.

The authors have chosen to use the spectra of steroids to illustrate the approach that may be used. At first, this may seem strange because the spectra of these compounds are often very complex. However, as the authors point out, the steroids have relatively fixed conformations, permit functional groups to be placed in a variety of positions with respect to a given proton, and are readily available with a variety of substituents. The authors begin with a discussion of the relatively simple bands that result from angular methyl groups and illustrations of the effect of the environment of the methyl groups on its chemical shift. Methylene and olefinic protons, which add the complexity of spin-spin coupling between protons, are considered. The treatment of extra complications that arise from long-range spin-spin coupling precedes an excellent discussion on the use of NMR spectroscopy on the determination of configuration and conformation. The last chapter is concerned with solvent effects.

Throughout, the book contains useful illustrative spectra and many tables that summarize important data concerning chemical shifts, coupling constants, and their relation to structure. This appears to be a very useful, well-organized, and well-written book. It cannot illustrate all of the potential applications of NMR spectroscopy to organic chemistry, but it does well in covering those related to structure determination.

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General Relativity

Introduction to General Relativity. Ronald Adler, Maurice Bazin, and Menahem Schiffer. McGraw-Hill, New York, 1965. xvi + 451 pp. Illus. $12.50.

The Theoretical Significance of Experimental Relativity. R. H. Dicke. Gordon and Breach, New York, 1964. xii + 153 pp. Illus. Paper, $1.95; cloth, $4.95.

For more than 20 years, Bergmann's textbook has remained (in my opinion) the most readable and balanced introduction to general relativity. This has been true partly because the foundations of the subject have changed so little, partly because Bergmann's breadth of view could accommodate the shift of areas of research since 1942. Most recent books have seemed too personal, or too advanced, to be useful as beginner's textbooks for senior or graduate physics students. Owing to its catholic content and its attention to pedagogical details, *Introduction to General Relativity*, by Adler, Bazin, and Schiffer, is, I feel, the likeliest to supersede Bergmann. It is based upon a lecture course given at Stanford University by Schiffer. In addition to standard treatments of Riemannian geometry, the field equations, the Schwarzschild solution, gravitational fields in hydrodynamic and electromagnetic media, and implications for cosmology, there are excellent accounts of recent work on the Cauchy problem and Rainich theory. I should also mention the admirably clear chapters on conservation laws and the linearized equations.

It is a pity that the authors were reluctant to use 20th-century mathematics. It would be helpful to be told just what tangent spaces or differential forms are, because such terms are occasionally used here. Curiously, they offer as explanation their desire not to prejudge future theoretical developments. The authors also confess misgivings (and well they might!) about the inclusion of the old Lenz derivation of the Schwarzschild solution out of flat space and the equivalence principle. Apart from these minor objections, I found this book a pleasure to read, and one that can be recommended as a textbook for use in a lecture course or by those who wish to study on their own.

The Theoretical Significance of Ex-

perimental Relativity is a printed version of the author's lectures at the 1963 Les Houches summer school, supplemented by reprints of a dozen articles by the author and his collaborators. Several ideas link the notes and appendices, and reveal the extent of the author's preoccupation with gravitation during the past several years. He (i) follows Mach and postulates gravitational fields accounting for inertial forces in a less passive way than does general relativity; (ii) investigates other covariant theories satisfying (i); (iii) advocates accurate null experiments to reject some of the many candidates admitted by (ii); (iv) believes that among cosmic "experiments" being performed, astronomers may see some which he would like to be attempting in his own laboratory; (v) stresses the importance of additional clues that are lying about the Earth and solar system; (vi) criticizes the three tests of general relativity. Red-shift experiments do not test Einstein's field equations. Many distrust the measurements of light deflection by the Sun. Now the author makes the alarming suggestion that we cannot exclude effects like solar oblateness on Mercury's perihelion motion. He has impressive experiments in train to test some of his suggestions, most notably a refined Eötvös experiment.

The very form of this group of writings precludes much organization. Neither is the layout very clear nor the typography free from error. Nevertheless, this is a most welcome provisional collection of provocative ideas.

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Geological Society of America Charts

Physiographic Diagram of the Indian Ocean: The Red Sea, the South China Sea, the Sulu Sea, and the Celebes Sea. Bruce C. Heezen and Marie Tharp. Geological Society of America, New York, 1964. $2.

This large (4 by 5 feet) and excellent physiographic diagram of the entire Indian Ocean is the third in a series of charts prepared by Heezen and Tharp. (The two previously published diagrams deal with the North Atlantic and South Atlantic areas.) The diagram is accompanied by a brief descriptive text and figures that show (i) sounding lines of bathymetric data used in compilation of physiography; (ii) physiographic provinces, including continental margins, ocean-basin floors, plateaus and aseismic ridges, midoceanic ridges, and fracture zones; and (iii) a generalized bathymetric sketch based on 500 meter isobaths.

Of necessity considerable subjective interpretation is incorporated in such a hachured diagram, compared to a contoured bathymetric chart, but happily this is the work of professional marine geologists. Most of the sounding data were collected in connection with the International Indian Ocean Expedition, so the chart has been made possible by broad international cooperation, including the soundings of the U.S.S.R.'s ships *Vitiaz* and *Ob.* Agencies from participating countries have been given due credit for contributed sounding data. The authors promise the eventual preparation of a full scientific text in the form of a monograph to accompany the physiographic diagram.

The diagram opens to view, for the first time, the general geomorphology of a region almost as extensive as the combined area of the North and South Atlantic Oceans. The midocean ridge, so prominent in the Atlantic Ocean, continues through the Indian Ocean where it takes the form of an inverted Y, but it is no longer a geometrically median ridge. Numerous fracture zones are delineated, often generating transcurrent offsets of the topography.

Large, isolated blocks of presumed sialic rock are delineated and have been termed "microcontinents" by Heezen and Tharp. Remarkably straight north-south lineaments are perhaps the most striking feature of the diagram and should precipitate great speculation or, hopefully, working hypotheses for the interpretation of the geologic history of this little-known area. Advocates of continental drift will find comfort in the strong geomorphic suggestion that the Indian subcontinent moved northward as much as 50 degrees, as had been suggested previously by paleomagnetic data.

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The Tropical Atmosphere

Cloud Structure and Distributions over the Tropical Pacific Ocean. Joanne S. Malkus and Herbert Riehl. University of California Press, Berkeley, 1964. x + 229 pp. Illus. $7.50.

The tropical atmosphere is a region of great importance to the understanding of our weather. Half the atmosphere is situated between 30°N and 30°S latitude, and within this region large transformations of energy (for example, absorption of radiation, evaporation, and vertical convection) occur which are certain to influence the large-scale behavior of the whole atmosphere in important ways. The tropical atmosphere also exhibits fascinating and unique phenomena of more specific scientific interest—the hurricane, the equatorial convergence zone, and the 26-month cycle of equatorial stratospheric winds. Yet the tropical atmosphere remains a *terra incognita* from which travelers return with tales that are fragmentary and sometimes conflicting.

We owe our limited knowledge of the tropical atmosphere, to a considerable degree, to the analyses and interpretations of tropical observations which Joanne S. Malkus (Simpson) and Herbert Riehl have made during the past two decades. Malkus has specialized in tropical cloud phenomena of mesoscale (~ 10 km) while Riehl has specialized in synoptic-scale (~ 1000 km) phenomena; they are therefore uniquely equipped by experience and interest to collaborate in a descriptive investigation of the relations between meso- and synoptic-scale phenomena. *Cloud Structure and Distributions over the Tropical Pacific Ocean* describes the results of three aircraft flights over the tropical Pacific, made in July and August 1957, on which cloud photographs were taken at 1-second intervals at heights of 7000 to 9000 feet. The flights covered a total period of about 80 hours. These data are supplemented by surface observations from ships and meteorological stations and by a very few upper-air observations. The bulk of the book is devoted to a systematic analysis of each flight: included are synoptic charts of streamlines, wind shear, pressure, and precipitable moisture, soundings of temperature and wind velocity in the upper air, a few pictures, and flight cross sections showing prevailing cloud distributions.