an account of the ecological observations of Soviet microbiologists at hundreds of deep-sea stations in the Pacific, Atlantic, Arctic, Antarctic, and Indian oceans, with reports of more detailed work in the Black Sea, the Caspian Sea, the Sea of Okhotsk, the Greenland Sea, and the Norwegian Sea. To this English version, Kriss has added much new material on the distribution of heterotrophic bacteria in the open oceans and some rather fragmentary data on the use of microbiological indicators of deep-sea currents.

Approximately half of the text is devoted to the presentation and discussion of data on the numerical abundance, vertical distribution, varieties or kinds, and calculated biomass of bacteria in various marine environments—mostly water. The characteristics of marine microorganisms are illustrated by 64 microphotographs, 20 drawings, and 4 colored plates. The vertical distribution of bacteria is depicted by nearly 300 line graphs and about 50 histograms.

Twelve pages of text and 14 pages of microphotographs and colored drawings are devoted to the description and distribution of a new class of microorganisms, called Krassilnikoviae, discovered in the sea. Other workers, including Sorokin of the Academy of Sciences of the U.S.S.R., point out the similarity of these cluster-headed filamentous bodies to what Sorokin diagnoses as the colloblasts of ctenophores, but Kriss avers that microorganisms may have been mistaken by histologists for colloblasts.

Unfortunately, the 16-page chapter in which the author describes methods used in deep-sea microbiology is inadequate either for instructing the novice or for permitting the more experienced microbiologist to assess the significance of the results. Somewhat astounding is the author's contention that, "Experience has shown that it is not necessary to use special microbiological samplers (as suggested by various workers) for collecting water samples from the depths of the sea." Most aquatic microbiologists of my acquaintance question both the numbers and kinds of microorganisms found in water samples collected in unsterilized Nansen-type bottles, which Kriss calls bathometers.

The 42-page chapter, "Biochemical activities of marine microorganisms," deals mainly with the microbial transformation of chitin, nitrogen compounds, sulfate, and hydrogen sulfide in the Black Sea. At the end of this chapter is a short section entitled, "Bacteriophages in the depths of the sea," which deals largely with generalities on bacteriophages and observations made in the Black Sea.

There is an index of authors, one of geographical names, another that lists microorganisms, and a general subject index. The latter lists only 31 major topics—a commentary on the limited scope of the book. There are two bibliographies, one which gives 448 Russian titles and another with only 148 non-Russian titles. These numbers may be representative of the relative effort being devoted to marine microbiology in different countries, since more than half of the publications have appeared since 1950.

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Number Theory

Solved and Unsolved Problems in Number Theory. Daniel Shanks. Spartan, Washington, D.C., 1962. x + 230 pp. Illus.

Although, as the author remarks, the title may mislead one who has not read this book, even a superficial glance at the contents will show that the title is justified; the author's primary concern is not to develop a straight-forward theory but to place the present between the past and the future of the subject, to impart its flavor from open question through conjecture to proof, and to develop the tools necessary to this progress.

The first chapter is built around perfect numbers. The author remarks: "the reader may be inclined to think that we have no sincere interest in the perfect numbers, as such, but are merely using them as a vehicle to take us into the fundamentals of number theory. We grant a grain of truth to this allegation —but only a grain." In the first chapter, by following certain leads and coming back to perfect numbers from time to time, the author leads the reader through the quadratic reciprocity law without the idea of a congruence.

In the second chapter, "The underlying structure," congruences are developed and some attention is given to the structure of the multiplicative group of integers prime to m. The third chapter returns to something like the *modus operandi* of the first; it begins with the Pythagorean theorem and the sum of two squares and continues through the Gaussian integers to Fermat's last theorem (some proofs and some conjectures), with something of the use of continued fractions on the way.

There are many unfamiliar applications, and much attention is given to the importance of computation in number theory. The author's general method, especially in the first and third chapters, is to sketch the historical development, state and discuss a series of conjectures and theorems and the heuristic evidence behind them, pick out a key theorem to prove, and then show by diagram and otherwise how the structure fits together. The exercises are not relegated to the ends of the chapters but are given when the author has a question to ask the reader. They are an integral part of the development.

In the absence of a straightforward theory, it is often a little difficult to sift out unproved theorems from proved ones and to find the proof. This is not a book that one can dip into with great facility. It has somewhat the flavor of a guided stroll rather than that of a hike. One looks for signs of those who went before, explores traces of trails that look interesting, and returns to a favored spot for a second more careful look; he does not scorn rugged terrain, nor is he Puritanical enough to avoid the sheltered places. In the end, he is surprised to find how far he has gone and how much he has seen. Another journey is promised in a second volume.

The flavor of number theory and, in fact, of mathematics is in this book—this is its claim to distinction.

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Aquatic Environments

Limnology in North America. David G. Frey, Ed. University of Wisconsin, Madison, 1963. xviii + 734 pp. Illus. $8.50.

The editor, David G. Frey, and the authors are to be congratulated on their contributions to *Limnology in North America*, a book which should fill a long-existent gap on the bookshelves of aquatic scientists.

Although limnology is a relatively young science, rapid advancements and the diverse approaches employed in

limnological studies have resulted in fragmentation that makes it difficult for an investigator to keep abreast with all developments. This volume is an attempt to bring together much scattered information on the historical progression and current status of limnology in the complex and vastly different environments in North America. To accomplish this objective, the continent was divided into a number of regions and at least one active limnologist in each area summarized its limnology. In chapters devoted to such descriptions, 19 geographic areas are discussed: Wisconsin (the Birge-Juday Era and the years 1940 to 1961); Michigan; New England; Illinois; the Middle Atlantic States; the Central States; the South Atlantic States; the Central Gulf States and the Mississippi Embayment; Minnesota and the Dakotas; the Mid-Continent States; the Rocky Mountain States; the Pacific Coast and Great Basin; the American Southwest and Middle America; the West Indies; Western Canada; Ontario and Quebec; the Atlantic Provinces of Canada; the St. Lawrence–Great Lakes; and Alaska, the Yukon, the Northwest Territories, and Greenland.

Several chapters deal with topics that do not fit into the regional approach—the impact of reservoirs, farm ponds, paleolimnology, sanitational limnology, and a history of the American Society of Limnology and Oceanography.

In an appropriate concluding chapter entitled the "Prospect before us," G. E. Hutchinson discusses directions for research which range from paleolimnology to cross-disciplinary studies in biogeochemical processes and relationships. He appeals for imagination in pursuing theoretical interpretations, using mathematical apparatus, models, and information theory, and emphasizes the need for developing more perfect instruments and techniques and for studies on new aspects, such as the challenging study of running waters.

Perhaps the greatest criticism of a work of this scope in which so many authors were involved, will be that, owing to the relative interest of the various contributors, some regions or topics are more intensively explored than others. However, no previous book has sampled the literature on the limnology of North America as extensively as this one does, and the volume should stimulate limnologists to follow-up with publications of their own work.

Limnology in North America should be widely used as a reference source, for it supplies valuable basic and introductory information, concisely presented, on the many facets of aquatic environments; thus, it will free instructors to emphasize recent findings and students to work on special topics.

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Geology

Geologie von Paraguay. Hannfrit Putzer (Beiträge zur Regionalen Geologie der Erde, vol. 2. Alfred Bentz, Ed.). Borntraeger, Berlin, 1962. xii + 183 pp. Illus. DM. 78.

Paraguay, the "Garden of South America," is divided geographically by the Paraguay River into a hilly eastern region that is rich in water and covered with tropical and subtropical forests and a western region, the Chaco Boreal, that is a vast area of lowlands with swamps, savannas, and brush forest.

Three distinct geological units characterize this country: Eastern Paraguay, the western border of the Parana Basin, is made up of Pennsylvanian, lower and middle Permian, and Triassic sediments, together with a few local remnants of beds of Cretaceous age; the north-south trending Central Paraguayan Swell, a continuation of the pre-Cambrian crystalline rocks of the Brazilian Shield, unconformably covered in the north by marine sequences of pre-Cambrian and Cambrian age, in the south by Silurian sandstones, and along the Paraguay River by Triassic beds; and the geosynclinal Chaco Boreal where the basement rocks are overlaid in the northeast with outliers of early Paleozoic carbonate sediments; the center of the geosyncline is filled with a thick series of marine Silurian and lower Devonian rocks that are covered by terrestrial red beds of Triassic age and by semiconsolidated clastic Cenozoic deposits.

About half of Putzer's book is devoted to a detailed description of the stratigraphy of each of the three mentioned geological units; this is followed by short chapters on tectonics, paleogeography, and mineral resources. The country, however, is poor in ores. Shortly after World War II the Union Oil Company of California drilled nine wells without finding deposits of gas and oil suitable for commercial development, but Putzer is of the opinion that the last word has not been said with respect to this matter. If properly mined and exploited, nonmetallic minerals—such as mica, feldspar, talc, kaolin, and bauxite—may become economically important to the country.

Friedrich Bender contributed a chapter on the hydrogeology of the immense Chaco Boreal region (which comprises 60 percent of Paraguay's total area). This chapter, as well as the chapter on soils (by Putzer), should be of great interest to future settlers in Paraguay.

The book, which is based on Putzer's personal experience, incorporates all the pertinent geological facts and observations so far published. A colored geological sketch-map and two plates with fossils from Silurian and Devonian sediments are included. Two earlier compilations [by Horacio Harrington (1956) and Edwin B. Eckel (1959)] also treat this area, but Putzer's well-written and well-printed book is so far the most complete one that deals with all aspects of the geology of this landlocked country in the center of the South American subcontinent. *Geologie von Paraguay* will be of great value to any future geological exploration in Paraguay.

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Chemistry of the Universe

Space Chemistry. Paul W. Merrill. University of Michigan Press, Ann Arbor, 1963. 166 pp. Illus. Cloth, $5; paper, $1.95.

Space Chemistry was designed by the late Paul Merrill as a short book on the present state of knowledge of the chemistry of the universe as well as a discussion of some of the most pressing problems now being investigated. The book, which is intended for general readers, is so full of interesting information and discussion that the strictly general reader may find it a bigger bite than he can comfortably chew. On the other hand, the scientific reader who is not intimately connected with the field (and I include myself in this group) will find it most valuable and enjoyable. The emphasis is placed on understanding the synthesis of astronomy, chemistry, and physics in research on the nature and evolution of the universe. Dr. Merrill's distinguished career literally grew up with the development of modern spectros-