could enter into chemical combinations in the same way as other matter. Hales himself never envisaged that there might be more than one "air" involved, and hence in his experiments he was content merely to measure the volume of air absorbed or released, without testing for differences in chemical behavior; indeed, had he noticed any such differences he would have attributed them not to real differences between the "airs" involved but to different impurities floating in a single undifferentiated elastic medium. Even so, his work had a profound influence on the succeeding generation of chemists. It led directly to a more detailed study of the chemistry of gases and thence to the crucial advances in chemical understanding that we normally associate with the name of Lavoisier.

In his own day, Hales was at least as well known for his philanthropic endeavors as for his science. He was an influential opponent of the notorious gin trade and played a significant part in having it brought under legislative control. He was an active member of the Society for Promoting Christian Knowledge and one of the trustees of the charitable trust that established the colony of Georgia in North America as a refuge for England's poor. He also sought to apply his scientific knowledge to alleviate suffering. He devised an effective ventilator for ships and an improved method for distilling seawater. In addition, his chemical investigations led him to a long but ultimately unsuccessful search for a satisfactory solvent for those painful sources of human affliction, kidney and bladder stones. Late in life, he played a leading role in the establishment of an important new London institution, the Society for the Encouragement of Arts, Manufactures and Commerce.

These various facets of Hales's career are described in detail in this new biography, in which Schofield provides the chapters on Hales's science and its influence and his inventions and Allan those of a more orthodox biographical kind. In addition to its 140 pages of text, the book includes a full calendar of Hales's correspondence and writings and a complete bibliography of his published works. It is the more welcome because the only other book-length biography, by A. E. Clark-Kennedy, though reprinted some years ago, is still not widely accessible. Furthermore, Schofield in particular has profited from the progress that has been made since Clark-Kennedy's day in our understanding of the way science evolved during the 18th century. His closing chapter on Hales's scientific reputation and influence is the most important in the book and represents a substantial advance on Clark-Kennedy's work. Disappointingly, however, even here the book develops few new or more general perspectives on Hales's work or career, apart from something of an attempt by Schofield to fit Hales into the general mechanism-versus-materialism classificatory scheme for 18th-century British science that he has proposed elsewhere.

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Solid State Physics

The Lattice Dynamics and Statics of Alkali Halide Crystals. JOHN R. HARDY and ARNOLD M. KARO. Plenum, New York, 1979. x, 314 pp., illus. $32.50.

In 1959 John Hardy wrote the first paper on the "deformation-dipole" model at approximately the same time that William Cochran published his investigation of phonons in a crystal (germanium) using the "shell" model of Dick and Overhauser (1958). The models are similar, since both consider the effect of displacement-induced dipolar forces resulting from the deformation of the electronic charge density in a lattice wave. This was the most important step in bringing the theory of lattice dynamics into quantitative contact with experimental data, in particular with neutron inelastic scattering results obtained by Brockhouse and other groups after 1958. In the subsequent two decades there was a fruitful period during which the essential features of lattice forces and related properties in many crystals were clarified. An important part of this clarification may be attributed to the use of what are nowadays called "dipolar models."

In the present book Hardy and Karo offer a comprehensive study of the static and dynamic properties of alkali halides. Discussion of the deformation-dipole model may be regarded as the "hard core" of the book, although many other features are discussed. After an introduction and a review of dipolar models, there is a detailed and useful presentation of dipolar coupling coefficients, Debye-Waller factors, and specific-heat data. After that, the experimental phonon dispersion curves of alkali halides are compared, in detail, with the rigid-ion model, the polarization model, and two versions of the deformation-dipole model. The treatment up to this point contains many impressive examples of agreement between experimental data and the deformation-dipole model, and the presentation of different deformation-dipole models is often very detailed. On the other hand, other interesting and successful approaches are not treated.

The last third of the book contains an interpretation of two-phonon infrared and Raman spectra of alkali halides as well as a short account of impurity dynamics and statics in alkali halides. Many useful references to the relevant literature and to the explicit use of dipolar models in actual calculations are given. The comparison of the models with experimental data and the consideration of the results of other groups are less satisfactory. There is no discussion of the microscopic theory or of models that try to establish explicit connections between the electronic band structure and properties of phonons. The authors state that both of these topics are beyond the scope of the book.

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Achievements in Astronomy

Oort and the Universe. A Sketch of Oort's Research and Person. Liber Amicorum Presented to Jan Hendrik Oort on the Occasion of His 80th Birthday, 28 April 1980. HUGO VAN WOERDEN, WILLEM N. BROUW, and HENK C. VAN DE HULST, Eds. Reidel, Boston, 1980 (distributor, Kluwer Boston, Hingham, Mass.). viii, 210 pp., illus. Cloth, $29; paper, $12.95.

Jan Hendrik Oort is, by common consent, the most influential astronomer of the present century. Born on 28 April 1900, Oort has made sustained and fundamental contributions to astronomy for some 60 years, and his major accomplishments during the past six decades are landmarks in the continuing development of astronomy. They include his discovery of galactic rotation in 1927, followed by his discussion of the galactic dynamics in the vicinity of the sun, his determination of the force field perpendicular to the galactic plane in 1932, his role in van de Hulst's prediction of the 21-centimeter line of hydrogen, his discussions relating to the formation and growth of interstellar grains during World War II, his first delineation of the spiral arms in the Milky Way system

from the 21-centimeter line in 1951 and in 1954, his part in establishing the synchrotron nature of the emission in the continuum of the Crab Nebulae, his discovery of the high-velocity clouds in the central regions of our galaxy during the late '50's, and his continued participation in the work of the great radio-observatories of Holland. All these and much more testify to Oort's unique place in the astronomy of this century.

Oort's contributions to astronomy are enhanced by his inspiration and guidance of successive generations of astronomers who have gone to Leiden to learn from him. Besides, he has played a major role in international organizations such as the International Astronomical Union: Oort was the General Secretary of the International Astronomical Union for some 13 years (1935–1948) and President for three years (1958–1961). He was also the initiator and guiding spirit in the building of the radio astronomical observatories at Dwingeloo and Westerbork and in later years also of the European Southern Observatory.

This handsome volume describes all of these accomplishments and gives a picture—often intimate—of the manner of man Oort is. The reviewer was particularly impressed by the papers by Blaauw, by van der Laan, and by Margaret and Geoffrey Burbidge describing the many phases of Oort's scientific contributions. Papers by Christiansen and by Allen and Ekers describe in considerable detail Oort's contribution to radio astronomy and his part in the building of the great radio-observatories in Holland. And there are several papers devoted to recollections and remembrances which provide a charming picture of Oort's humaneness and of his relations with his students and his colleagues. It is clear from these tributes that his associates value his personal friendship almost as much as his scientific contributions.

I have not had the good fortune to have been associated with Oort in any substantial way, but I do recall his visiting the Yerkes Observatory of the University of Chicago, as a guest of his friend, the late Gerard Kuiper, in 1959. During an hour's discussion I had with Oort, he described with great enthusiasm his then recent discovery of the nature of the high-velocity clouds in the center of the galaxy. But toward the end, with his natural politeness, he asked me of my own interests. When I mentioned to him the results of some laboratory experiments in hydromagnetics that had just been completed by one of my associates, Oort asked me, "But when are you going to come to grips with the real problems of astronomy?" The real problems of astronomy have always been Oort's abiding concern.

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Biogeochemistry

Environmental Chemistry of the Elements. H. J. M. BOWEN. Academic Press. New York, 1979. xvi, 334 pp., illus. $43.50. Revision of *Trace Elements in Biochemistry* (1966).

How much copper is there in kale? Can fungi live without zinc? What is the titanium content of the average human diet? What elements tend to accumulate in cultivated soil? What is the metabolic role of molybdenum? For the answers to questions like these, consult this compilation of the basic data of biogeochemistry.

In chapter 6, "The elemental composition of living matter," we learn that kale contains 4.9 milligrams of copper per kilogram of dry matter. Chapter 8, "Essentiality, deficiencies and toxicities of the elements," tells us that fungi require zinc for healthy growth, as do bacteria, blue-green algae, green algae, and seed plants. Table 8.7 lists elements in human diets; these include titanium at the rate of 0.8 milligram per day. Chapter 12, "Environmental effects of human activities," includes an illuminating discussion of the geochemical budgets of typical soils. Arsenic, cadmium, fluorine, iron, lead, selenium, and vanadium are the elements that appear to be accumulating in moderately contaminated, cultivated soils. Chapter 9, "Chemical forms and functions of the elements," reveals that molybdenum is a constituent of several oxidases, a dehydrogenase, and the nitrogenase enzyme system.

The last chapter, "Elements in the geosphere and the biosphere," presents a summary of biogeochemical data, arranged alphabetically by element, for all of the elements in the periodic table up to curium. Data for a typical element occupy half a page and include: abundances and half-lives of naturally occurring stable and radioactive isotopes; average concentrations in various types of rock as well as fresh water, sea water, and air; common minerals; concentrations in various classes of organisms, as well as information on essentiality, toxicity, and accumulator species; natural organic compounds and biochemical functions; and a list of recent review articles. This compilation of data is compact but easy to understand.

Perhaps a third of the rest of the book is occupied by detailed tabulations of data, and the text is equally rich in hard fact. There is little interpretation, explanation, or speculation, and perhaps this is a weakness. This is a book about the where and the what of biogeochemistry, not the why and the how. The tables provide ready answers to specific questions, but more extensive use of graphs might have made it easier to perceive patterns in the chemical interaction of organisms and their environment.

This interaction offers many opportunities for interesting and important research. Biogeochemical knowledge contributes to the realistic assessment of the hazards of pollution, improved potential for sustainable exploitation of earth's living resources, and a clearer understanding of factors that have affected the course of biological evolution. Bowen has advanced biogeochemistry both with his *Trace Elements in Biochemistry* (Academic Press, 1966) and with this expanded and up-to-date volume.

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Books Received

Acute Toxicity in Theory and Practice. With Special Reference to the Toxicology of Pesticides. V. K. Brown. Wiley-Interscience. New York, 1980. x, 160 pp., illus. $28. Monographs in Toxicology.

Adaptation to Thermal Environment. Man and His Productive Animals. Laurence E. Mount. University Park Press, Baltimore, 1980. xiv, 334 pp., illus. Paper, $27.50. A Series of Student Texts in Contemporary Biology.

Advances in Aquatic Microbiology. Vol. 2. M. R. Droop and H. W. Jannasch, Eds. Academic Press, New York, 1980. xii, 356 pp., illus. $46.

Basic Chemistry. General, Organic, Biological. Denis M. Callewaert and Julien Genyea. Worth, New York, 1980. xxiv, 838 pp., illus. $19.95.

Basic Pharmacology for Health Occupations. Henry Hitner and Barbara T. Nagle. Bobbs-Merrill, Indianapolis, Ind., 1980. viii, 272 pp., illus. Paper, $12.95.

Beginning Algebra for College Students. Karl J. Smith and Patrick J. Boyle. Brooks/Cole, Monterey, Calif., ed. 2, 1980. xiv, 448 pp., illus. $15.95.

Biochemical Characterization of Lymphokines. Proceedings of a workshop, Ermatingen, Switzerland, May 1979. Alain L. de Weck, Flemming Kristensen, and Maurice Landy, Eds. Academic Press, New York, 1980. xxxii, 622 pp., illus. $39.50.