point and negligent of the literature as to be all but useless. Even W. M. Wheeler's *Ants: Their Structure, Development, and Behavior* (Columbia University Press), the beautifully written classic of myrmecology, is 57 years out of date.

It is therefore with pleasure and relief that I have read Sudd's *An Introduction to the Behavior of Ants*. Here at last is a clear, adequate account of these insects. The book goes well beyond the scope of its modest title, touching on many engrossing topics in physiology and ecology relevant to the core subject of behavior. In order to cope with the great backlog of literature—over 35,000 titles—Sudd has chosen for citation about 500 articles that are most representative of the field, and he has synthesized with skill the material they contain. The book contains no important new ideas and does not try to probe very deeply into old ones. It is, instead, a sober, didactic account of available information. It faithfully reflects the author's view that the day of the sweeping "supra-organism" analogy is past. "The main efforts of students of ant behavior now are in describing how ants actually behave, and how the behavior of one ant reacts on another ant." His book makes this research goal attractive. It should draw new students to the subject and serve as a stimulus and useful reference work for biologists and psychologists of many persuasions.

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## The Uses of a Concept

**The Concept of Energy**. D. W. THEOBALD. Spon, London; Barnes and Noble, New York, 1966. 208 pp., illus. $7.50.

Energy, a term first used by Thomas Young in 1805 in the Bakerian Lecture to the Royal Society, has become central to a number of scientific theories only distantly related to Newtonian mechanics. An analysis of the function and structure of the energy concept within each of its theoretical contexts and of the analogies that are used to justify the widespread use of this single term should therefore illuminate the general problem of the roles played by scientific concepts in the formulation of our knowledge and help to enhance our understanding of the concept itself. Such an analysis is attempted in *The Concept of Energy*.

Potential readers who are seeking a popularized or simplified discussion of the energy principle and its applications will find nothing of interest to them here. Nor will they find the kind of historically oriented analysis displayed by Max Jammer in his fine series of books on the concepts of mass, space, and force. What they will find is a mathematically sophisticated, philosophically oriented analysis of the concept of energy as it is used in classical mechanics, thermodynamics, theories of the electromagnetic field, relativity theory, and quantum theory. The substance of this analysis is sandwiched between two general philosophical chapters which establish the roles that the author assigns to scientific theories and the concepts that appear within them. Along with Rudolf Carnap and others, Theobald argues that human experience is in large measure determined by the language in which we interpret or express it. The purpose of any theory or conceptual framework is to provide a language which can give meaning and coherence to observations, and the scientist is "like a great poet, the creator of a language which enables us to say new things, and which suggests new things that might be said." The unit of the scientist's creation is the concept, a mental invention devised when current language fails to deal adequately with experience.

I am not sympathetic to Theobald's exclusively linguistic model of scientific theory, nor can I agree with his contention that "the historical and psychological factors which play an important part in the genesis of a theory are largely irrelevant in the context of an analytical discussion." Yet, within his self-imposed limits, I think that he has provided an interesting and perceptive discussion.

The value of the book is marred by a few minor but irksome details. For instance, there are several places in which words have been deleted, tenses of the verb changed in mid-sentence, and parentheses forgotten in mathematical expressions. Furthermore, the figures in the text have not been titled, and at least one figure (2.4) is not referred to explicitly in the text and is not within sight of the textual matter to which it applies. The style is condensed and, in the philosophical chapters, often disturbingly cryptic. But in spite of the distractions, *The Concept of Energy* should be of interest to philosophers of science, philosophically oriented physicists, and anyone who lectures on the concept of energy as it is used in any of the exact sciences.

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## The Chemistry of Silicates

**Silicate Science**. Vol. 4, *Hydrothermal Silicate Systems*. WILHELM EITEL. Academic Press, New York, 1966. 631 pp., illus. $24.

If additional evidence were needed of the recent exponential growth of scientific research, it could be provided by citing Eitel's texts in the field of silicate chemistry. The first, a single volume entitled *The Physical Chemistry of the Silicates*, was published in 1954. In the last three years Eitel has produced the five-volume *Silicate Science*. (In addition to the one under review here, the volumes are 1, *Silicate Structures*; 2, *Glasses, Enamels, Slags*; 3, *Dry Silicate Systems*; and 5, *Ceramics and Hydraulic Binders*.) Additional weight is given to this example when we note that the five new volumes do not constitute revision and updating of the 1954 text but deal almost exclusively with data presented between 1952 and 1962. The use of copious footnotes has permitted inclusion of some references up to 1965.

Although largely an annotated collection of phase-equilibrium data, volume 4 also presents a wide selection of topics ranging from detailed discussions of petrogenesis to diagrams and descriptions of high-pressure apparatus, x-ray diffraction patterns, and crystal-structure diagrams. Almost inevitably with such a wide range of topics and of chemical systems, it is not possible for a single author to make critical judgments and comments on all the material included. In several instances, therefore, comments on a particular system are limited to what resembles a précis of the original author's abstract, accompanied by the most appropriate diagram from the original paper. Such an approach would be disastrous in a textbook, but the disadvantages in this reference book are minimal. The wide range of literature referred to in this volume is extremely impressive. Indeed, perhaps one of the major contributions of all

five volumes may be to bring English-speaking readers up to date on the work of some of their European colleagues. Translations of Russian literature are now fairly readily available and are thus frequently cited, but except for these, reference to the European literature is often completely absent from papers in English.

The present volume is not devoted exclusively to hydrothermal systems but treats carbonate-silicate systems and their relation to problems of carbonatites. A review of high-pressure apparatus is also included, but it is difficult to understand the omission of internally heated vessels used so extensively by Yoder, Burnham, Tuttle, and others when the cold-seal vessels and "Morey bombs" are described in detail. Further criticisms may be made of a style of sentence construction that is often unwieldy and sometimes ambiguous. The text is liberally illustrated, but as with many reference books of this type, most of the figures are too small to serve any practical purpose. Faults, however, are minor in comparison with the overall value of the volume. The author is to be complimented on his most comprehensive and systematic presentation of a large quantity of data. All those associated with any aspects of teaching and research in silicate chemistry will find this and, I am sure, the other four volumes of *Silicate Science* most useful in their work.

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## Water in Solid Form

**Traité de Glaciologie.** LOUIS LLIBOUTRY. Vol. 1, *Glace, Neige, Hydrologie Nivale.* 433 pp., illus. 140 F. Vol. 2, *Glaciers, Variations du Climat, Sols Gelés.* 616 pp., illus. 190 F. Masson, Paris, 1964–65.

Glaciology, defined as the study of snow and ice in all forms, and not simply—as too many still hold—the study of glaciers, has gained considerable momentum in recent years, especially since the commencement of the International Hydrological Decade. Fifty to 80 times more water is stored in solid form than exists in all freshwater bodies. Following on the recognition of the practical importance of snow and ice, glaciology has emerged as an interdisciplinary science which requires an essentially interdepartmental academic training. Consequently the need has arisen for both a basic introductory textbook for the students and a comprehensive, authoritative handbook for the specialist. Lliboutry's massive two-volume work is an admirable effort to provide a handbook. It is well organized and clearly written, and contains many excellent diagrams and photographs.

The author, a geophysicist with a wide range of knowledge and experience, is a professor at the University of Grenoble and director of the laboratory of glaciology at the Centre National de la Recherche Scientifique. In these volumes he reviews, abstracts, and critically discusses an enormous amount of literature, covering not only the easily accessible publications in French, English, and German but also those in Russian, Japanese, and other languages. The sheer task of assembling such a mass of material is formidable. The coverage is up-to-date, reference being made to 1964 and 1965 publications. Each of the 23 well-conceived chapters has its own extensive bibliography. There are, however, instances of criticism of work which is not fully identified in the references, so that it is difficult for the reader to form an independent judgment, and there are a number of minor errors in the references.

The author succeeds in combining theoretical, experimental, and field evidence on a multitude of topics covering the whole field of glaciology. Consideration is given to the physics, mechanics, and petrography of ice; the formation of solid precipitation; snow cover with creep and avalanche problems; snow and ice engineering; heat balance of snow and ice surfaces with associated hydrological and morphological factors; the temperature pattern and heat flow in snow and ice; the characteristics and distribution of glaciers; mass balance; movement; geophysical study techniques; deformation morphology; internal motions and bottom gliding; erosion and deposition of material; glacier fluctuations and the relationship to elimate; the main glaciations with their causes and effects; and frost action in the ground. Though the balance is generally well kept, there are certain cases of over- or under-emphasis; sea ice, for example, deserves a more exhaustive consideration.

The great merit of this treatise, and that which distinguishes it from earlier compendiums, is that it establishes glaciology as the science which treats quantitatively the whole range of processes associated with solid water. The synthesis is contingent upon the continual consideration of physical principles. On occasion the author emphasizes his own opinion on a currently debated problem where it would have been more appropriate simply to report the various ideas as, for example, concerning the sliding of glaciers on their beds. But it is always possible to level some criticisms at a book of such magnitude and diversified scope. These cannot detract from the integral importance of the whole. The *Traité de Glaciologie* is the only comprehensive single work on glaciology, and encompassing, as it does, such a variety of topics from traditionally separated disciplines, it is a landmark in the development of that science.

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## Major French Influence

**The Development of Technical Education in France, 1500–1850.** FREDERICK B. ARTZ. Society for the History of Technology and M.I.T. Press, Cambridge, Mass., 1966. 286 pp. $7.95.

The publication of this volume in 1966 will seem to many an anachronism, since three of the four chapters are essentially unaltered translations of articles written by the author for French historical journals in 1937, 1938, and 1946. As the footnotes reveal all too clearly, Artz has not seriously attempted to bring the results of his research abreast with current knowledge. This is a serious flaw, especially since much has been uncovered that illustrates Artz's themes better and more succinctly, and occasionally contradicts his views. Among the recent works, the most significant is the 700-page volume *Enseignement et diffusion des sciences en France au XVIII^e siècle* (Hermann, Paris, 1964), which covers much of the same ground, but with considerably more evidence taken directly from archival sources. For all practical purposes, one can think of Artz's volume as having been published in 1950.

It is nonetheless very useful. Historical works do not age as quickly as much of scientific research. The book is a mine of bibliographical references to articles in obscure journals, of factual information concerning French educational theories and practices, and,