entist, believes that the most significant means by which the United States could prepare itself to render scientific aid to new nations would be to set up advisory groups "dedicated to a continuing major effort to understand scientific revolutions as social phenomena." In other words, the key to effective technical aid is the study of social history. Haskins is right. It is to be hoped that his book will be read on both sides of the Atlantic.

Antisymmetry

Colored Symmetry. A series of publications from the Institute of Crystallography, Academy of Sciences, U.S.S.R., 1951–1958. A. V. Shubnikov, N. V. Belov, and others. Translated from the Russian by Jack Itzkoff and Jack Gollob. William T. Holser, Ed. Pergamon, London; Macmillan, New York, 1964. xxvi + 263 pp. Illus. $9.75.

The title of this book is misleading, for the volume is not concerned with the color of symmetry but with the symmetry that relates colored bits of patterns. A better short title would be "Color Symmetry." Actually, most of the subject matter is even more restricted, for only the last 19 of some 247 pages are devoted to general color symmetry, the remainder being limited to the symmetry that can be represented by two colors—that is, the symmetry of dichromatic patterns of various sorts. This symmetry, commonly called antisymmetry or black-white symmetry, is more elegantly expressed as the symmetry that can be displayed by real functions.

This book is, in brief, a translation of several major Russian contributions to antisymmetry, plus 19 pages also translated from Russian work on more general color symmetry. William T. Holser, the editor, has made the collection as uniform as possible without actually rewriting it.

The book is in two parts. Part I is a translation of A. V. Shubnikov's book, *Symmetry and Antisymmetry of Finite Figures*. Part II is a collection of six papers by N. V. Belov and various coauthors: the first four papers treat periodic antisymmetry groups in various dimensions; the others are on two- and three-dimensional color patterns. There is an 11-page bibliography on symmetry in which each citation includes the title. The list is valuable, although there are some obvious omissions—for example, all Barlow's works. But the list of Russian citations appears exhaustive.

Work in symmetry, one of those subjects which appeared to be closed, opened up again a dozen years ago when attention was drawn to the notion and uses of antisymmetry. Actually, antisymmetry was noted by a few workers as early as 1930 as the result of a publication by Heesch. I became acquainted with it, however, through the publications of Woods, who was interested in the "counterchange" symmetry seen in textile patterns. At that time I regarded the concept as unnecessary because this kind of symmetry was readily accounted for by considering the diperiodic patterns to exist in three dimensions. Woods was the real pioneer of antisymmetry, but his work is overlooked by present-day writers.

In 1951, some 16 years after the work by Woods was published, Shubnikov published (in Russian) his book, *Symmetry and Antisymmetry of Finite Figures*, in which he dealt with the antisymmetry of nonperiodic patterns —that is, with the antisymmetry of point groups. But the recognition of antisymmetry began in the western world with the publication a year later, in *Acta Crystallographia*, of Cochran's paper, "The symmetry of real periodic two-dimensional functions"; Cochran's paper aroused interest because everyone had considered crystallographic symmetry as relating actual objects, such as atoms, in a pattern, and atoms were represented by positive electron density. But it had just been shown that, if a Fourier synthesis were made by using as Fourier coefficients the amplitudes derived from an upper-level x-ray photograph, a new synthesis called a "generalized projection" of the electron density (or the Patterson density) resulted; this showed negative regions symmetrically related to positive regions. This development led Cochran to consider removing the restriction of "positive" from periodic functions and to consider the symmetry of functions which could assume both positive and negative (that is, real) values. Cochran's recognition of these patterns and their obvious application to crystallography is passed over lightly by the Russians, yet it must have been the stimulus which eventually started the Russians on their investigations of periodic patterns involving antisymmetry. Three years elapsed before the publication of their first paper in which Cochran's work was extended. Cochran's symmetries were also being found elsewhere. For example, I found them in partial Fourier syntheses.

A translation of Shubnikov's 1951 book, *The Symmetry and Antisymmetry of Finite Figures*, constitutes the first part of the volume being reviewed here. Shubnikov develops point-group symmetry from the beginning, including both classical symmetries and antisymmetry. A somewhat confusing aspect of his development of point groups is the use of roto-reflections rather than the roto-inversions which are now internationally adopted. But this is not unreasonable in Shubnikov's development; the matrix for a proper rotation requires merely a change of sign of one element to transform it from a rotation to a roto-reflection, and a change in the sign of another element to change from classical symmetry to antisymmetry. Unfortunately, Shubnikov's symbolism for a roto-reflection is the same as the international symbol for a roto-inversion having the same value of n. Confusion would have resulted from this (and from some other features of Shubnikov's notation), if the editor had not added to each symbol the one usually used in international notation.

Shubnikov develops the ways of combining rotations by substituting a pair of reflections for each rotation. A more direct approach, and one that is less confusing to a beginner, is to devise ways of combining rotations without involving nonexistent reflections. Shubnikov derives not only the point group symmetries (classical as well as antisymmetry) consistent with crystallographic symmetries, but also the noncrystallographic point-group symmetries, including those with $n = \infty$. Shubnikov's text is very clearly written, well illustrated, and easy to understand.

Part II, translations of six papers, two papers by Belov and four others by Belov and one or two of his colleagues, is not nearly as easy to read and understand as part I. There are a number of reasons for this: part II consists of several original papers (contrasted with a carefully planned and integrated book); it has too few illustrations; the separate parts appear more or less in the chronological order of the appearance of the original papers—three-dimensional groups (1955); two-dimensional groups (1956); two-dimensional mosaics (1957); one-dimensional groups (1956). Finally, the derivations in part II lack a central unifying theme. The general scheme is to introduce, as they appear to be needed, tricks for deriving antisymmetry groups from classical ones.

I feel that this derivation of antisymmetry groups, while valid, is not the best. Just as every group that has operations of the second sort can be derived from the groups composed only of operations of the first sort, so all antisymmetry groups can be derived from the classical groups by systematically adding to each classical group an antisymmetry operation which transforms the classical group into itself. Derivation of the antisymmetry groups in this way would give a simple routine, and might also lead to a simpler symbolism for antisymmetry groups. But this is work for the future.

Meanwhile, all who are interested in symmetry, especially crystallographers, are not only indebted to the authors of the original papers, but to the publishers, the translators, and the editor, for making this part of the original literature on antisymmetry available. Many of us would like to have translations of some of the other original works on symmetry—especially Federov's fundamental work, Shubnikov's other works, and possibly the works of Herman, Weber, Motzok, Heesch, and Ginzburg.

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Chemistry

Chemical Thermodynamics. Basic theory and methods. Irving M. Klotz. Benjamin, New York, revised ed., 1964. xvi + 468 pp. Illus. $9.75.

Introduction to Chemical Thermodynamics. Irving M. Klotz. Benjamin, New York, 1964. xviii + 244 pp. Illus. Paper, $3.95.

Chemical Thermodynamics is intended to be a textbook suitable for senior or first-year graduate courses. In format, it is divided into two parts. The first of these, consisting of chapters 1 to 12, treats the three basic laws of thermodynamics and their application to pure phases. Chemical reactions are treated in great detail, but the discussion is restricted to reactions between pure phases or to reactions between ideal gases. Nonideal gases are discussed, but the calculation of their thermodynamic properties is deferred to the second part of the book, where the concept of fugacity is introduced.

The second part, chapters 13 to 22, is devoted to phases of variable composition. Most of the conventional topics are discussed; among those topics excluded which one might expect to find in a book on chemical thermodynamics are phase equilibria, electrochemical systems, and the thermodynamics of surfaces. These are not completely neglected, however. The Clapeyron equation is derived, and the colligative laws are discussed; on the other hand, the phase rule is not mentioned. Electrochemical cells are discussed in connection with Gibbs function changes, and with the determination of activity coefficients, but no general treatment is given.

The pace is leisurely and the treatment is thorough, especially with respect to the detailed working out of examples. Many examples are worked two, or even three, ways. Average students will find this useful, but such detail will probably bore better students. It is also possible that, with the welter of detail given, the novice may miss the woods for the trees. Nevertheless, to the average student, the pedagogical value of seeing things done several different ways constitutes one of the book's strong points. The discussion of standard states and of extrapolation procedures for determining standard values of thermodynamic functions is well presented.

Teachers who use this book as a textbook will have to supplement the discussion of basic principles. The treatment of temperature is inadequate, and this carries over into the development of the second law, always the most difficult task of any expositor of thermodynamics. Entropy is defined in the usual way—"$dS = DQ_{rev}/T$"—and "T is the absolute temperature at which the heat is absorbed." This precedes the demonstration that there is, in any sense, an "absolute" temperature. The absolute temperature scale is defined earlier in the book, essentially as an ideal gas temperature scale on which the ice point is given a conventional value. But the definition of a temperature scale by means of only one fixed point rests on the validity of the second law. Another less serious point is the implication that an isothermal compression always evolves heat; this implication is made in the discussion of the efficiency of a Carnot cycle with arbitrary working fluid, but is untrue for a substance with a negative coefficient of expansion, such as water below 4°C.

On the whole, however, I believe that the good points outweigh the faults and that the book could be a useful text for an intermediate level thermodynamics course intended for organic chemists and biochemists as well as for physical chemists.

Introduction to Chemical Thermodynamics is an unaltered printing of the first part of *Chemical Thermodynamics*. It therefore has exactly the same faults and good points as the parent volume, but the fact that the contents are restricted to pure phases severely limits the utility of the brief version as a textbook.

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Plant Morphology

Recent Advances in the Embryology of Angiosperms. P. Maheshwari, Ed. International Society of Plant Morphologists, University of Delhi, Delhi, India, 1963. x + 467 pp. Illus.

State of the Art books, usually entitled "Annual Review of . . ." or "Recent Advances in . . ." have become a part of the biological scene. They characterize fields considered active, with a sufficient readership and subscribership to justify publication of hardbound volumes which are, in effect, international symposia. Plant morphologists, currently alarmed about the shrinking proportion that their field occupies in the economy of today's biology, have cause to applaud the appearance of a volume that registers marked productivity and progress in a descriptive discipline. Plant embryology, although not a new science, has in fact been progressing rapidly in recent years, and no small degree of this achievement has emanated from India. In embryology as well as other areas of morphology, American academic institutions have fallen behind, despite the broad spread of interests in which they supposedly pride themselves. Because of and in spite of this tendency, Maheshwari's book should, and probably will, be acquired by many libraries; will it