Oxide Formation

High-Temperature Oxidation of Metals. PER KOFSTAD. Wiley, New York, 1966. 354 pp., illus. $13.50.

As Kofstad points out in his preface, this book is not intended as an exhaustive, critical review of the literature of the high-temperature oxidation of metals. Indeed, only the results for the oxidation of the six refractory metals titanium, zirconium, hafnium, tantalum, niobium, and tungsten are covered in detail, a choice no doubt reflecting both the current upsurge of technological interest in these metals and the author's own extensive investigations of their oxidation properties. Aside from the convenient summary of the oxidation data for these six metals, the considerable value of this book lies in its clear discussion of the principles and techniques of high-temperature oxidation research.

The section on experimental methods contains much useful information. A brief summary of current theories of low-temperature oxidation is given, but the major portion of the theoretical section is given over to a discussion of the Wagner theory of oxidation. There is an extensive treatment of the kinetic approach to the analysis of oxidation mechanisms. The chapter on diffusion in oxides, while not mathematically complete, is particularly welcome because of the distinction drawn between the contributions of the enthalpies of defect formation and those of defect motion to the activation energy for diffusion. The potential importance, especially at low temperatures, of grain-boundary and short circuit diffusion is also pointed out.

The sections on experimental results emphasize the factors which complicate oxidation mechanisms—for example, the effects of stress development in both oxide and substrate during oxidation, the consequences of oxygen solution in metals, and the importance of oxide morphology. The overall picture of high-temperature oxidation which emerges is that of a highly complex process on which a variety of experimental techniques must be brought to bear if it is to be understood. That contribution alone would be enough to make this book a valuable addition to the literature of the oxidation of metals.

JOHN V. CATHCART
Metals and Ceramics Division,
Oak Ridge National Laboratory,
Oak Ridge, Tennessee

IBP Symposium: Environmental Photosynthesis

Primary Productivity in Aquatic Environments. Proceedings of an International Biological Programme symposium, Pallanza, Italy, April–May 1965. C. R. GOLDMAN, Ed. University of California Press, Berkeley, 1966. 464 pp., illus. $7.

Eddying between the streams of photosynthetic physiology and biogeochemical systems ecology is a field of science that relates the role of light and chemical inflows as controlling agents in photosynthesis to the distribution of these agents in lakes and oceans in order to predict the rate of production of organic matter. This rich flowering of 27 papers showing causal relations and predictive procedures attests to the success of the International Biological Programme when it concentrates on a single theme.

The symposium shows a split of faith not at all hidden by the alternation of papers of opposite view. To some of the authors the performance characteristics of species in laboratory isolation provides the means of predicting what happens in the group system, the latter being the sum of the actions of the species. Soeder, for example, regards phytoplankton as "a mixture of many pure cultures" each in a stage of development like that exhibited by his synchronous cultures. Those of the opposite faith see the group processes as dependent on limiting rates of flow between species, a property of the group system and physical circulations not predictable from a study of the parts. Thus Steele documents the regenerating animal components as critical system factors; Hobbie and Wright show that the performance of bacterial-algal mixtures differs from that of the separate cultures.

Duursma regards organic-matter release from plants as a second trophic level, implying a necessary tenfold loss of fuel. It is less confusing to regard organic releases as a flow from a sequence of biochemical compartments prior to respiration, and thus as an output of the first trophic level. Fogg and Watt's report of an acceleration of glycollate release when light intensity is increased suggests a safety-valve release from the primary photosynthetic drive, hardly a secondary-trophic-level phenomenon.

As in the work reported at the limnological congress at Wisconsin, the carbon-14 method continues to be used to give results approximately an order of magnitude too low in benthic and pond environments, probably because of the improper use of the tracer method in which long finite increments are used for instantaneous processes without using compartmental modeling, a procedure used in other sciences for years. These ecologists will have to learn some systems kinetics or see their science captured by those who do. Some papers do deal with systems analysis as a means of predicting group performance. The one by Beyers on a photosynthesis-respiration loop system-control model has somehow been put in the section on photosynthesis and adaptation of algae. Yet the editor's own good paper in the limiting-factor section has hyperbolic uptake graphs for molybdenum that seem to be explained by that same charge-discharge system model.

Papers providing new understanding of bacterial roles include Sorokin's report of experimental stimulation of animal growths on food chains from bacterial blooms by the addition of chemosynthetic, gaseous substrates of hydrogen and methane. However, Sorokin confuses trophic concepts by calling the organic consumption steps primary production (this being firmly defined as the conversion of light energy into chemical potential energy).

The papers show many vital truths emerging, with clarification of issues indicating a live science in progress. From Yentsch we have clarification of a mystery through documentation that the large chlorophyll-like substances found below the lighted zone in the sea are without their magnesium (pheophytin) and are mostly nonfunctional whereas chlorophyll that is still in operating condition there is potentially as efficient as that at the surface. The well-presented account of the production limnology of Africa's Lake Victoria by Talling is probably headed for textbook use. The tropical production far exceeded that of the English Lake Windermere. There is a fine review of diurnal methods for primary production in streams by Owens, with proper attention given to new means for making the atmospheric aeration correction. Jorgensen and Steemann-Nielsen use photosynthesis-light curve analysis to infer that more enzymes are adapted when the cells are at work at low temperatures.

This reviewer's challenge to some sci-

entific issues and approaches is actually a high compliment to the success of the volume. A graduate student preparing for an oral examination in ecology might do well to know the streams of effort and their issues of excitement and controversy as represented in this volume. If the European IBP effort is producing this kind of focus by concentrating on basic productivity as a theme, perhaps the broader, ill-defined, and do-nothing program of the U.S. should be narrowed to conform to the European pattern.

H. T. ODUM
University of North Carolina, Chapel Hill

Kepleriana

Kepler's Somnium. The Dream, or Posthumous Work on Lunar Astronomy. Translation (from the 1634 edition) and commentary by EDWARD ROSEN. University of Wisconsin Press, Madison, 1967. 279 pp., illus. $8.75.

Kepler's *Dream* is a curiously interesting tract on two accounts. First, its fantasy framework of a voyage to the moon makes it a pioneering and wondrously prescient piece of science fiction. Second, its perceptive description of celestial motions as seen from the moon produces an ingenious polemic on behalf of the Copernican system. The work takes the form of an interview with a knowledgeable "daemon," who explains how a man can be transported to the moon:

> In every instance the take-off hits him as a severe shock. . . . For this reason at the onset he must be lulled to sleep immediately with narcotics and opiates. His limbs must be arranged in such a way that . . . the shock will be distributed among his individual limbs. . . . After the first stage of the trip is finished, the passage becomes easier . . . so that finally the bodily mass proceeds toward its destination of its own accord.

In a note Kepler explains how to calculate this point at which the gravitational attractions of the earth and moon balance out; his incorrect answer reveals his theory of a gravity proportional to distance. Kepler goes on to describe the inhabitants of the moon and their adaptations to their peculiar environment.

Kepler first put forth his idea of a "lunar astronomy" in a student dissertation at the University of Tübingen around 1593 but did not write it out in its final form (including the dream sequence) until 1609. For years after that the work lay unpublished. Kepler was Imperial Mathematician in Prague, and his attention was occupied with his *Dioptrice* and *Epitome of Copernican Astronomy*. Not until 1621 did Kepler again return to the *Dream*; during the next nine years he extended it with the addition of 223 notes. Consequently in the finished work we see preserved two different stages of Kepler's scientific thought.

The *Dream* itself is very short, scarcely 19 pages in this edition. Kepler's notes, supplemented by 399 scholarly and exceedingly helpful footnotes by Rosen, run to 128 pages. Happily, the frequent complaints against previous translators that marred Rosen's notes to his translation of Kepler's *Conversation with Galileo's Sidereal Messenger* are entirely absent here. Even Marjorie Hope Nicolson, with whom Rosen disagrees about the interaction between Kepler and John Donne, comes off without attack; her punishment, apparently, is being omitted from an otherwise complete index.

Thirteen appendices, ranging from biographical notes on Jacob Bartsch (who became Kepler's son-in-law) and Ludwig Kepler to "the cold of Quivira," bring us a compendium of interesting Kepleriana, illuminated by those delightful flashes of erudition that we have come to expect from Rosen. Appendix 1, on Kepler's concept of inertia, is particularly suggestive. Kepler introduced the term *inertia* into the physical sciences. Although Newton scarcely mentions Kepler in his *Principia,* the idea of inertia is fundamental in his theory, and he may have been more indebted to Kepler than he was willing to admit.

Rosen's translation of the *Somnium* is the second to appear within the last few years. Patricia Frueh Kirkwood's very acceptable version was issued in 1965, accompanied by an enthusiastic interpretation by John Lear. When we consider the paucity of works by Kepler available in English translation, this duplication of effort is regrettable. In any event, Rosen's edition is much to be preferred, both because of his unquestionable mastery of scientific Latin and for his authoritative annotations.

OWEN GINGERICH
Smithsonian Astrophysical Observatory, Cambridge, Massachusetts

Atomism in the 1860's

The Atomic Debates. Brodie and the Rejection of the Atomic Theory. W. H. BROCK, Ed. Leicester University Press, Leicester, England, 1967. 196 pp., illus. 35s.

As the history of science becomes a more professional and specialized discipline, so the number of monographs devoted to minor characters and abstruse controversies begins to increase. In this latest study Sir Benjamin Brodie is the character, and his "calculus of chemical operations" the focus for the "atomic debates" of the 1860's.

Thanks to the editorial persistence of W. H. Brock we are now presented with three essays which seek to explore the context and significance of Brodie's long-forgotten work. The first essay (by Brock and D. M. Knight) sets the background of 19th-century scepticism about chemical atoms. The second (by D. M. Dallas) outlines the calculus itself, and the third reproduces a variety of correspondence relating to it, from such eminent men of science as Crum Brown, Odling, and Williamson. It is this third section which is in many ways most fascinating, not only for the glimpse it gives into the private attitudes toward atomism of an important group of mid-Victorian scientists, but also for the atmosphere of leisured grace it portrays. A far cry from today's world of "big science," massive research contracts, and multimillion-dollar atom-smashing machines!

Somewhat unfortunately, the authors have chosen to stress the fact that Brodie's calculus was a "form of *operationalism* which preceded and anticipated Bridgman's use of the term by some sixty years." While this may be true, the importance of Brodie's work does not lie in any anticipation of such a now-dated fashion as operationalism. Indeed, the writers seem uncertain as to quite how significant were the "atomic debates" that they report. This present volume, in raising more problems than it solves, highlights the need for further research on the uneasy marriage between practical success and theoretical doubts, so typical of the 19th-century career of chemical atomic theory.

ARNOLD THACKRAY
Churchill College, Cambridge, England