between theory and experiment does not necessarily mean that the theory is correct. Similarly, the sequence in which the products are formed does not unambiguously define the reactions by which they are formed. A more critical appraisal of a good deal of the work covered in this book would have been welcome. The recurring suggestion that peroxy radicals can undergo a metal-surface-catalyzed unimolecular decomposition to form an aldehyde or ketone and an alkoxy radical seems unlikely to me. Even at the comparatively low temperatures which are employed the lifetimes of the individual peroxy radicals are too short for any significant fraction of them to come in contact with the surface during a liquid-phase oxidation. The experimental data can be more plausibly explained in terms of the well-documented homogeneous β-scission of alkoxy radicals.

The translation is excellent, but there are several printing errors. The text is clear and liberally supplied with figures and tables. The authors have produced a comprehensive study of the theory, technique, and technology of a rapidly growing field of chemistry, and the book is recommended to all those interested in this field.

K. U. INGOLD
Division of Applied Chemistry, National Research Council, Ottawa, Ontario, Canada

The State of a Science

Changing Identity of Graduate Earth Science Education. Proceedings of a conference held in Atlanta, Ga., January 1965. CHARLES E. WEAVER, Ed. Georgia Institute of Technology, Atlanta, 1967. 184 pp. Paper. Available free from the editor.

Faced with the problem of starting a graduate program in the earth sciences, the administration of the Georgia Institute of Technology sought guidance in a conference. The 31 participants included representatives from large and small, private and state universities and colleges, the U.S. Geological Survey, and the National Science Foundation, which sponsored the meeting. This volume is a partially edited transcript of the proceedings.

I can do no better in summarizing the outcome of the conference than an unidentified participant who concluded: "I have been an observer here for two days. I have heard an analysis of what is wrong with geology rather than a real changing identity of graduate earth science education."

At the risk of taking some remarks out of context, I quote from Charles E. Weaver's foreword, which has many of the characteristics of a postmortem: "In some instances there is little relation between the titles and the actual talks. The discussions ranged far and wide and though few, if any, problems were 'solved,' many were defined and evaluated. . . . Unfortunately, relatively little thought was given to the long-range effects of some of the changes that are taking place. . . . Many will conclude that the ideas and problems presented at this conference are not representative of the whole field of graduate earth science education. This is probably true."

In spite of half a dozen sound and well-prepared presentations, the conference obviously provided a minimum of guidance for an institution about to embark on a program of graduate instruction. I have just initiated a graduate program at the University of Pennsylvania, but I did not discover the dichotomy that several of the conferees stressed between so-called "classical" and "modern" geology or earth science. Geology is still the study of the earth, whether its followers call their specialties geophysics, geochemistry, or paleoecology. The major function of geochronology is that of refining correlation and extending it from the interpretative stratigraphic correlation of sediments to the more precise dating and differentiation of other petrologic types. It is a new and exciting adjunct to historical geology.

The conferees emphasized the need for a great deal of pregraduate training in mathematics, physics, and chemistry, but what is new about this? In 1946, I berated listeners at a meeting of section E of the AAAS with an address pointedly entitled "Geomorphology—The Inexact Science." The need and the potential of mathematics, physics, and chemistry were as evident then as they are now, and had the profession as a whole been alive to the fact 20 years ago, departments of geology (or earth science)—and conferees on graduate education—would not be bemoaning the dearth of undergraduates, or the loss of the best students to other disciplines.

What is new is the instrumentation from the fields of physics, engineering, chemistry, and geology itself that provides opportunities to probe more profoundly into the physics and chemistry of the earth and thereby learn with some precision how our planet fits into the solar system, how it has evolved, and how we can live on it and with it as a dynamic body. If there is a schism, it is between the new methodology and the background training that is being provided for those who will have to comprehend the significance of tools that are still being devised. The embryonic stage in which the profession finds itself is evident from the diametrically opposed views geophysicists draw from the same sets of physical facts—witness heat flow, remanent magnetism, convection, continental drift.

I heartily agree with Weaver that "We are on the threshold of an explosive growth in the Earth Sciences," and the conferees at Atlanta were—and are—enthusiastic participants in the advancement of the field. One of the gems contributed to the meeting came from Julius R. Goldsmith, of the University of Chicago, who observed that there is a marked difference, in graduate programs, between crystallization and petrification. If Georgia Tech manages to avoid the latter, success in its graduate venture will be assured.

HOWARD A. MEYERHOFF
3625 South Florence Place, Tulsa, Oklahoma

Stars and Substances

Nuclear Astrophysics. WILLIAM A. FOWLER. American Philosophical Society, Philadelphia, 1967. 127 pp., illus. $3. Jayne Memorial Lectures, 1965.

In this slender masterpiece, based on a series of four Jayne lectures, Fowler ranges over a wide variety of fascinating topics that include element synthesis in the proto-universe and in the stars, age dating of the universe by nuclear clocks, supermassive stars, and the enigmatic nature of quasars. The presentation is extremely lucid, following in the grand tradition of Eddington, Jeans, and Hoyle. Characterized by vivid and nonmathematical description, this volume will appeal thoroughly to the layman. By the perspective that it affords and by the state-

ment of a personal philosophy that it represents, it will appeal to the specialist in astrophysics as well. Amply sprinkled throughout the book are skeleton diagrams of nuclear transformation chains and photographs of spectacular stars, stellar regions, and galaxies, all of which contribute to the reader's understanding and enjoyment. The author's insistence on laboratory measurements as a foundation for nuclear astrophysics and his obvious delight in the interpretation of astronomical observations are apparent throughout. It is easy to see why he has, for over a decade, been a leader in the field.

One particular passage in the book deserves to be ranged alongside that classic quotation from John Donne that sets the theme for Hemingway's *For Whom the Bell Tolls*. After carefully tracing the sequences of nuclear transformations and element synthesis that occur in stars as they evolve from the hydrogen-burning main-sequence and red-giant stages through helium-burning stages and beyond, Fowler concludes: " . . . all the elements heavier than helium, and perhaps the helium too, have been synthesized in stars . . . your bodies consist for the most part of these heavier elements. Thus . . . you and your neighbor and I, each one of us and all of us, are truly and literally a little bit of stardust." Statements such as this convey to the layman how it is that men can dedicate their lives to research in astrophysics.

ICKO IBEN, JR.
Department of Physics, Massachusetts Institute of Technology, Cambridge

Growth Symposium

Major Problems in Developmental Biology. The 25th symposium of the Society for Developmental Biology, Haverford, Pa., June 1966. MICHAEL LOCKE, Ed. Academic Press, New York, 1967. 420 pp., illus. $16.

This volume, the latest of the "Growth Symposia," marks the silver jubilee of this splendid series. It provides an occasion for a backward look, and in the opening paper Jane Oppenheimer recounts the origins and something of the achievements of the symposia, putting them into a background of contemporary discoveries. It provides an occasion, too, for a wider span of topics than has recently been usual. A substantial sample of those major problems of animal development which seem due soon for solution come up for discussion under various guises.

Preeminent among these is the determination of tissue types. Molecular genetics has blown the fog away from this towering problem and suddenly it seems to be approachable. The developmental biologist, since he is in no danger of distracting the biochemist from the search for gene repressors (given a stimulating discussion here by Koshland and Kirtley), can with a clear conscience continue his harping on some of the complexities of the business. Of these the involvement of cell heredity, or at least cell population heredity, is one of the most interesting. It has seldom been more beautifully displayed than in the work of Hadorn, which he discusses here, on the prolonged replication in culture of the state of determination in *Drosophila* imaginal disks. Cell heredity is of course part of the cancer problem too. Malignant transformation has attractions as at least an analogue of differentiation, and vice versa, and it is interesting that more than a tenth of the book is concerned with the cancer cell, in papers by Ebert and Kaighn and by Rubin. It is refreshing to have Rubin's uninhibited airing of the idea that the cell surface may be an organ of heredity.

Twenty-five years ago the inside of a cell was such a mystery that the only approachable problems of determination seemed to be those concerned with the signals between embryonic cells that switched determination on. Whether these are really a softer option seems doubtful now. We are faced with problems whose outlines we cannot even make out when we read of the laying down of the intricate patterns of differentiation described here by Ursprung and by Waddington; or, in Jacobson's article, of the onset of the polarities of embryonic rudiments, a problem which the modern highly refined analysis of retinal development revives from earlier days.

The Growth Symposia have always put botanical and zoological contributions side by side, and in this volume there is a most lucid account by Lang of the (to a zoologist) usually impossibly confusing subject of plant hormones. But one has the impression that the two cultures are still apart, even though they share, with stimulating variations, the problems of determination. Perhaps it is because they have less in common when it comes to morphogenetic mechanisms. Morphogenetic cell death, here discussed by Saunders and Fallon, and especially morphogenetic cell movement, given a masterly review by Trinkaus, are predominantly animal mechanisms. Indeed, the pride of the animal kingdom, the ordered complexity of its nervous systems, depends largely on the extreme subtlety of the behavior of moving axon tips during development. There is no more striking example of this than the regeneration of the anamniote optic nerve that Jacobson describes. But though animals by their exploitation of cell movement may have gained a nervous system, the vegetable world has not had to pay the corresponding penalty of cancer.

One cannot leave this volume without recording the great debt of gratitude that the community of developmental biologists owes to those who have organized the Growth Symposia; for a quarter of a century they have spent much imagination and skill in our service.

MICHAEL ABERCROMBIE
Department of Zoology, University College, London, England

Sulfur Chemistry

The Chemistry of Organic Sulfur Compounds. Vol. 2. NORMAN KHARASCH and CAL Y. MEYERS, Eds. Pergamon, New York, 1966. 473 pp., illus. $21.

The second volume of this work consists of 15 chapters, most of which seem to have been written shortly after publication of the first volume in 1961. To bridge this time gap, some of the authors contribute short addenda to the appendix, and the editors themselves list in the appendix reviews of organic sulfur chemistry and provide a collection of brief summaries of selected primary publications from the period 1961–1965. Regrettably the material of the appendix (30 pages) is not indexed.

The most comprehensive and generally useful discussions are those on Polyfluoroalkyl Derivatives (R. E. Banks and R. N. Haszeldine), The Chemistry of the 1,2-Dithiole Ring (N. Lozac'h and J. Vialle), Mechanisms of Raney Nickel Desulfurization (W. A. Bonner and R. A. Grimm), Oxidation of Disulfides, with Special Reference to Cystine (W. E. Savige and J. A. Maclaren),