of comet orbits, asteroid rotations, collapsing galaxies, and craterlets on the moon.

Sky and Telescope, a journal with high standards of editorial competence and a wide coverage of astronomy, is attractive to laymen and amateur and professional astronomers alike. Papers from 13,000 pages of it and its predecessors (dating from 1931) were expertly selected by Thornton Page and Lou Williams Page, the editors of **The Origin of the Solar System: Genesis of the Sun and Planets, and Life on Other Worlds** (Macmillan, New York, 1966. 350 pp., $7.95), in order to present this account, which is necessarily speculative at times, of our increasing understanding of the origins of the earth and the solar system. The Pages have provided continuity by inserting numerous appropriate commentaries, especially necessary in a book of this type and on this subject, where many of the contributions are "dated" and need to be put into proper perspective. The book will be enjoyed by all those who enjoy reading *Sky and Telescope*.

Selections of special interest are "How did it all begin," by Henry Norris Russell; "The solar energy spectrum" by Harriet Malitson; "Finding the age of the earth," by Otto Struve; "Barnard's star as an astrometric binary," by Peter van de Kamp; "The origin of comets," by Otto Struve; "Some astronomical aspects of life in the universe," by Su-Shu Huang; and "How can we detect radio transmissions from distant planets?", by Frank Drake.

This last contribution concerns Project Ozma, the controversial observational program of listening for radio signals from possible intelligent life outside the solar system. It seems to me that this program may well have been based on a fundamental misconception. *If* there is such life "nearby" (and one should remember here that only one possible planet has been tentatively located outside of the solar system), it would be almost completely improbable that its level of technology would be within 50 years of ours; it may be at a pre-Stone Age level, or it may be highly developed beyond our wildest imaginings. If the latter, such intelligence would have radio reception and transmission facilities not just billions of times more powerful than ours, but something really "out of this world." Some of our own transmissions, made during the past half century, are spreading out through space and should eventually reach such life—if it is there—and be readily detected and interpreted—there. An answering transmission would be so powerful that it would be readily received without special preparations, and so intelligently put together that its source would be obvious. Perhaps we should just sit down and wait. And perhaps we shouldn't answer!

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Biochemical Engineering

Suichi Aiba (Institute of Applied Microbiology, University of Tokyo) was joined by A. E. Humphrey, a visiting American engineer, and Nancy F. Millis, a visiting Australian microbiologist, in writing **Biochemical Engineering** (University of Tokyo Press, Tokyo; Academic Press, New York, 1965. 339 pp., $15). That the authorship should span three continents is appropriate because the subject draws on the separate disciplines of biology, chemistry, and physics which, like the world, are being drawn closer together. Books like this one can help knit the sciences through practical engineering problems.

The authors properly define biochemical engineering as "concerned with economic processing of materials of biological character or origin to serve useful purposes." Then they promptly narrow the scope of the book to fermentation engineering—that is, the application of chemical engineering to the industrial use of microorganisms. It is the only thorough book on the subject now available, and I believe it will be widely used as a reference source and text book.

In the first chapters, which describe microorganisms and their fermentation pathways, particular attention is given to practical application. These chapters are so valuable that one wishes Miss Millis had participated in the writing of the rest of the book, which suffers from disregard of the underlying biology or biochemistry. On the whole, the subjects treated are the right ones: kinetic patterns of growth and product formation, aeration and agitation, sterilization, special equipment, and control devices. The approach is also correct in that it provides an analytical rather than a descriptive account of the fermentation process. Frequent references to data in the current literature and the citing of worked-out numerical examples aid the reader. A logical innovation is the early discussion of continuous fermentation, even though the technique is not used much in industry.

It is stated in the preface that no mathematical understanding beyond calculus is required, but microbiologists will be confused by engineering quantities (eddy diffusivity, for example) that are not adequately explained in physical terms. Although it is stated that modern theories of mass transfer, which are briefly described, are useful for solving aeration problems, the authors do not provide additional discussion. Even engineers will feel that the mathematical manipulations are often cumbersome. For example, a rather involved discussion of the cumulative age of cells in continuous culture leaves the reader unsure about whether they are older or younger than indicated by their mean retention time in the fermentor. The treatment of batch sterilization of media is unnecessarily elaborate. A practising engineer would either make a linear approximation to the proposed exponential and hyperbolic heating curves, or he would realize that his knowledge of heat transfer coefficients was inadequate and do a graphical integration of measured heating and cooling curves. Neither approach is mathematically very elegant.

The strong point of the book, then, is that it provides a starting point, not that it is a complete designer's manual or student's text. Many new ideas are presented and there are some data from the Japanese literature about which we in the West are too often ignorant. Thus, in many ways it is a pioneering effort.

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"Tree Grasses"

This handsome volume, **The Bamboos: A Fresh Perspective** (Harvard University Press, Cambridge, Mass., 1966. 362 pp., $10) by F. A. McClure, contains a wealth of information, much of it new, that has been distilled from a lifetime of experience in the study of bamboos. Probably no botanist, past or present, has had so intimate an acquaintance with these "tree grasses," in all parts of the world in which they grow, as the author of