of biology transformed by his quantitative biochemical studies of stereospecific binding of radiolabeled morphine analogs. Is this the whole story? Compare it with the versions told in Cozzens's book or in the contemporary press (including the pages of *Science*) or with the ongoing description by Candace Pert (Snyder's former graduate student) of her role in the discovery of the opiate receptor (evidenced in 1989 *Current Contents*).

Against this background Snyder's portrayal of the events is too simple and just does not ring true. Nowhere in his description is there evidence pointing to a continuing heated debate in which colleagues and former students publicly dispute Snyder's claims of discovery.

Snyder is at his best when describing the experimental basis of the transformation of neurobiology from a descriptive to a molecular science. The reader will be rewarded by a lucid primer from a master. Less rewarding is the very brief and naive treatment of the politics of drug research in the early 1970s. Also striking in its absence is any mention of Nova Pharmaceuticals, the start-up company built around Snyder whose premise is rational drug development as a consequence of understanding ligand-receptor interactions in neurobiology.

Robert Kanigel's *Apprentice to Genius* seems to place the questions posed by Cozzens and the different versions of discovery in context. In this enjoyable book, Kanigel, a professional science writer, traces the scientific genealogy of Snyder and Pert, two of the most colorful players in the opiate receptor story. Making extensive use of interviews and anecdote, Kanigel depicts how, in a mentor-to-protege chain starting with James Shannon and moving to Bernard Brodie and then to Julius Axelrod, the legacy of creativity and empirical style has passed to Snyder and then to Pert. It appears that a pattern of scientific style as well as competition between mentor and protege is inherited. The personal and scientific rivalry between Pert and Snyder that is detailed by Cozzens and is avoided in *Brainstorming* seems strangely similar to the stories Kanigel tells about Brodie and Axelrod.

The reader interested in the culture of science will be rewarded by reading all three books. Only then is the Rashomon-like, subjective nature of the discovery of the opiate receptor revealed. Who really deserves credit in a field where progress comes about in incremental steps? For those who must choose to read only one book, Cozzens's is richest for data about how credit in science is really established. Snyder will teach the most science by delivering an excellent introduction to modern neurobiology. Kanigel is very interesting, a good read, and out of print. Let the reader beware that the answer to the question "Who discovered the opiate receptor?" may not be very clear.

SANDRA PANEM
Salomon Brothers Venture Capital, New York, NY 10004

Solid Structures

Introduction to Quasicrystals. MARKO V. JARIĆ, Ed. Academic Press, San Diego, CA, 1988. x, 285 pp., illus. $49.50. Aperiodicity and Order, vol. 1.

Quasicrystals are crystalline solids that have symmetries (icosahedral, for example) that were formerly thought to be forbidden by the laws of crystallography. They were first discovered as icosahedral alloys of aluminum and manganese in 1984. Quasicrystals differ from ordinary crystals in that the atomic arrangement is not a periodic repetition through space; rather, the structure consists of a non-periodic but highly ordered arrangement that mathematicians call "quasiperiodic," which can be thought of abstractly as arising from an irrational projection from a higher-dimensional periodic lattice.

Since its outset, the science of quasicrystals has consisted of two distinct subfields: metallurgy and mathematics. On the one hand, there has been an active search in the laboratory for new quasicrystalline alloys, and progress has been made in making these materials more defect-free, characterizing their mechanical and electrical properties, and understanding the similarities of these new alloys to ordinary crystalline and glassy solids. On the other hand, the discovery of quasicrystals has stimulated advances in theoretical work on the mathematics of nonperiodic tilings of space and on physical models for novel kinds of order in matter.

This duality is reflected in the present volume. It contains six chapters, four written by theoretical physicists and two by metallurgists. In its goal of providing an introduction to the subject as a whole and tying together its two parts, the book is a partial success. The chapter by T. C. Lubensky does the best, giving some history of quasicrystals, connections with experimental results, and a general discussion of quasiperiodic-tiling theory. Unfortunately, this contribution appears at the end of the book; the reader encountering the subject for the first time would do best by starting there. Another weakness is that little effort has been made to unify the points of view represented in the different chapters; for example, the introductory remarks of the last chapter are partly undercut by those of the first.

This book will pay the greatest dividends to serious students of quasicrystals. It contains several gems: In a chapter by Schaefer and Bendersky there are the essential details that are the lifeblood of metallurgy, such as the fact that 6% Si in AlMn improves the formation of icosahedral alloys. In the last half of the book (and especially Lubensky's chapter), there is one of the best pedagogical discussions to be found anywhere of the "Landau theory" of solidification—the classic phenomenological theory of structural ordering, excitations, and hydrodynamics—which has been applied extensively and successfully to quasicrystals. And the reader will find in Bak and Goldman's and Lubensky's chapters a wealth of information about the six-dimensional geometry used in the theory of icosahedral quasiperiodic tilings.

A drawback of this book is that the most recent information it contains is from 1987. Quasicrystal science has advanced considerably in the last three years—alloys have been discovered with dramatically fewer imperfections, new models of the stability of quasicrystals have emerged, and the mathematics of tilings has progressed. Fortunately, this book is the first of a planned series, with two other volumes already available. These have kept pace with new developments and offer some particularly noteworthy and readable contributions by Roger Penrose, Linus Pauling, Veit Elser, and others.

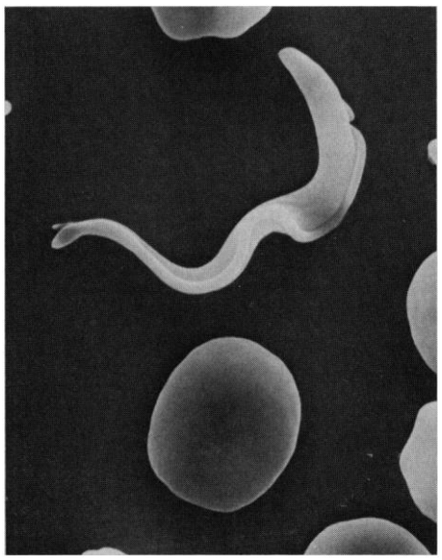
D. P. DIVINCENZO
IBM Research Division, T. J. Watson Research Center, Yorktown Heights, NY 10598

Parasitology at MBL

The Biology of Parasitism. A Molecular and Immunological Approach. PAUL T. ENGLUND and ALAN SHER, Eds. Liss, New York, 1988. xvi, 544 pp., illus. $90; paper, $45. MBL Lectures in Biology, vol. 9.

The Biology of Parasitism course at the Marine Biology Laboratory at Woods Hole, Massachusetts, has been in existence since 1980 to teach modern concepts of molecular biology and immunology to young investigators of parasites responsible for human disease. This collection of essays by current and former faculty attempts to convey the intellectual spirit of the course by presenting major concepts rather than by reviewing the literature or presenting data.

The book is divided into three sections entitled Biology of Parasites and Parasitic Disease, Parasite Immunology, and Parasite Molecular Biology, Biochemistry, and Genetics, with a total of 28 essays from an impressive group of investigators. Notable



Scanning electron micrograph of *Trypanosoma brucei brucei* among red blood cells. [From *The Biology of Parasitism*; J. E. Donelson]

chapters include Warren's on the global impact of parasitic diseases, Nelson's on parasitic zoonoses, and Sher's on vaccination against parasites. Sher discusses the suggestion by Byron Waksman that parasite vaccine development may be best directed toward molecules against which little or no response is elicited rather than toward parasite antigens recognized by infected patients, and the discussion reveals considerable understanding of parasite immunology and the courage to argue against dogma. Similarly, the chapters by Butterworth on control of schistosomiasis and by Wang on parasite pharmacology present stimulating ideas as well as data.

Most of the remaining chapters in the volume concentrate on specific parasitic diseases such as amebiasis, trypanosomiasis, leishmaniasis, and toxoplasmosis and in many instances provide not only relevant information but also a rationale for the research cited. Surprisingly, there is no similar chapter on schistosomiasis, which generally receives scant attention in this volume, or on malaria, although the chapter on malaria genetics by Walliker raises important points about the spread of drug resistance. Many of the remaining chapters do not follow Waksman's example of giving a full discussion of vaccine strategy. Instead the chapters exhaustively discuss each author's favorite (usually surface) vaccine molecule. In some chapters, information is selectively presented, and some of it is already outdated.

A major strength of the Biology of Parasitism course is the exposure of its participants to the principles of molecular biology and immunology as well as to their application to specific parasites. This book attempts to cover both principles and specific applications, and it succeeds more in the former case than in the latter. This is a valuable book, however, deserving a wide readership, especially given the successes, and recent difficulties, in designing effective parasite vaccines.

MICHAEL R. HOLLINGDALE
Biomedical Research Institute, Rockville, MD 20852

Bacterial Systems

Regulation of Procaryotic Development. Structural and Functional Analysis of Bacterial Sporulation and Germination. ISSAR SMITH, RALPH SLEPECKY, and PETER SETLOW, Eds. American Society for Microbiology, Washington, DC, 1989. xii, 304 pp., illus. $59; to ASM members, $45.

Because of their dormancy and ability to resist environmental extremes, bacterial endospores have been studied since the days of Cohn, Koch, and Pasteur, despite the fact that they are not routinely associated with outbreaks of infectious disease. The bizarre biological phenomenon of sporulation displayed by a few Gram-positive species has propelled *Bacillus subtilis* to a position of prominence because of its amenability to genetic analysis. With the development of sophisticated techniques of molecular biology, the realization that this cellular differentiation requires the precisely coordinated interplay of more than 100 genes and the utilization of this species as a host for cloning and expression of various foreign genes, molecular explanations of spore formation have ignited widespread interest.

After the tenth Spores Research Conference, the editors did not publish the papers presented at the meeting but put together this collection of overviews by 14 experts in exciting and rapidly developing specialties in the field. The editors have succeeded admirably in molding the chapters into a common format.

The collection gives lucid insights into the complicated process of sporulation and indicates important directions for further research. It also conveys how this prokaryotic phenomenon relates to a variety of developmental processes among other microbial species and higher organisms.

Some spore researchers justify their interest in the subject by the significance of sporulation to the preservation of foods. Gerhardt and Marquis give an up-to-date account of this aspect of the field.

Piggot provides the most current and extensive update of information on *B. subtilis* as a tool for genetic analysis by cataloging the more than 700 genetic markers now found on the chromosome (including at least 100 developmental loci). This chapter places special emphasis on the genes involved in germination and sporulation.

There is an attempt made throughout the book (and in considerable detail in a chapter by Youngman *et al.*) to illustrate innovative approaches to research to *B. subtilis*. This includes discussions of gene fusions, insertional mutagenesis, transposon tagging, special vectors for cloning, chimeric expression, and enhanced production of selected gene products. Foster and Johnstone discuss the fundamental concepts and the various research approaches used to analyze the mechanism triggering spore germination.

Early in the response to stress (before spore-specific antigens are synthesized), it is difficult to distinguish spore-specific events from those that would naturally be associated with the switch to stationary-phase metabolism. Three chapters focus on this part of the sequence: Sonenshein's on the metabolic regulation of sporulation and other stationary-phase phenomena; Valle and Ferrari's on the regulation and expression of subtilisin, one of the plethora of extracellular enzymes *Bacillus* populations elaborate, and of great industrial significance; and Dubnau's on genes accompanying the development of competence to actively take up high-molecular-weight DNA from the environment and to be transformed.

A particularly exciting development since the ninth Spores Conference has been the increasing number of discoveries regarding sigma factors, which coordinate the "cascade" of transcriptional events mediating each developmental change, as discussed in a chapter by Moran. This process is much more complex than originally envisaged, and these discoveries have triggered a search for similar regulatory molecules among other species.

It is now clearly established that the products of genes induced during heat shock, limitation of nitrogen or phosphate, chemotaxis, and osmoregulation in several Gram-negative species bear sensory and receptor components with striking similarities in structure and function to those playing pivotal roles in the sporulation process. These are all put into perspective in the chapter on the initiation of sporulation by Smith.

Sporulating bacteria undergo septation early in development to form the forespore (which eventually becomes dormant and acquires a multilayered protective coat) and the mother cell, which was once thought to direct spore synthesis. Three chapters related some of the excitement accompanying the realization that both genomes function in development and that different genes are