importance of the relationship between the organization imposed on material at the time of study and that imposed at the time of test. These themes are so well worked that they are no longer revolutionary; discussions of them appear many places other than this volume. However, Michael Watkins does provide a good description of differences among retention tests in the cues that they provide for remembering, and he discusses ways that manipulations of cuing can be used to specify what is remembered. Battig and Bellezza present data to show the importance of organizational processes for a levels-of-processing framework of memory.

Battig and Bellezza complain that there has been a decline in organizational research over the past few years. Rather than declining, it seems to me that the focus of this research has shifted from the recall of lists of words by college sophomores to other aspects of organization. Questions have been refined, and a greater variety of tasks and materials have been employed in research. One important development, a more careful consideration of different forms of organization, is discussed in a paper by George Mandler. Another interesting development is the increasing reliance on organizational processes to describe the memory of children. Research on this topic is reviewed in a paper by Ornstein and Corsale. Perhaps the greatest changes in the last decade have been the focusing of research and theorizing on semantic memory and the attempt to analyze tasks that appear to be ecologically valid. Janet and Roy Lachman offer an evolutionary perspective and review theories and data relevant to the organization of semantic memory. In the paper that is my favorite of the collection, Jean Mandler provides an excellent discussion of schematic organizations and their application to the recall of stories and scenes.

The organizational view of memory continues to be an approach rather than a theory. As one indicator of disarray, the authors of the papers could not decide whether "organization" and "structure" (two words that appear in the title of the book) are synonymous. Organization is more easily specified and, perhaps, is better investigated by putting it in the confines of a particular task that is of real interest than by trying to find general laws of organization that extend across all tasks, as seems to be the goal of some of the papers included in this volume. The papers provide good reviews of a number of subjects of research and should be useful for the novice. Although a few of the chapters are likely to also be useful for the expert, by and large the expert could as well spend the time reading the journals that have probably been accumulating on his or her desk.

LARRY L. JACOBY
Department of Psychology,
McMaster University,
Hamilton, Ontario, Canada L8S 4K1

Differentiation in Prokaryotes

Developmental Biology of Prokaryotes. J. H. PARISH, Ed. University of California Press, Berkeley, 1979. xii, 298 pp., illus. $48.50. Studies in Microbiology, vol. 1.

In the not-too-distant past it was customary to justify research on differentiating prokaryotes by claiming that whatever insight was gained would be of crucial importance in understanding development in higher organisms. An important premise of this argument was that gene regulation in all organisms is essentially the same (that is, if you understand the *lac* operon you understand *Escherichia coli*, and if you understand *E. coli* you understand eels and elephants). It has now become clear, however, that the assumption of the universal simplicity of regulatory mechanisms is no longer tenable. Understanding the workings of the *lac* operon only begins to prepare one for dealing with the arabinose-utilization operon or the tryptophan biosynthetic operon, let alone for dealing with regulation of messenger RNA (mRNA) processing, stability, and transport or control by translational discrimination, protein degradation, or DNA rearrangement. In this atmosphere *Developmental Biology of Prokaryotes* is a welcome addition to the literature. Its contents provide clear evidence that systems of differentiation in the microbial world are worthy of intensive study, whatever their potential value as models, because of their intrinsic interest as systems of biological interactions. Such interactions, highly varied and each intriguing, beg to be understood at the molecular level. The fact that easily cultivatable unicellular organisms, many of which are amenable to genetic analysis, carry out such diverse patterns of morphological and biochemical differentiation should be a stimulus to molecular biologists to exploit these systems.

In assembling this volume J. H. Parish has chosen to define development in its least restrictive sense. Thus he includes a detailed review by W. D. Donachie of cell division in *E. coli*, on the grounds that any morphological change, including septum formation, qualifies as development. Having chosen this course Parish might have opted to include a review of phage infection as well, since phage regulatory mechanisms leading to a temporal sequence of gene expression are especially well studied.

Endospore formation is the subject of two chapters. R. S. Hanson surveys spore structure, offers informative data on the diversity of spore-formers, and speculates thoughtfully on the role of spore formation in natural environments. G. H. Chambliss follows with a simplified but clear statement of unresolved issues in the study of the initiation of sporulation and of possible molecular mechanisms involved in the response to nutrient limitation. He has been victimized, however, by the long lag time between the writing of the chapter and the publication of the book. Thus, model experiments on control of nitrogen metabolism operons in Gram-negative bacteria, to which he refers, are no longer interpreted as he describes. In dealing with the mechanisms responsible for the changing pattern of mRNA synthesis during sporulation in *Bacillus subtilis*, Chambliss presents a well-thought-out and balanced account of what is known. Recent results with transcription of cloned DNA in vitro support the thesis he favors.

K. F. Chater and M. J. Merrick review intelligently and cautiously the current state of knowledge of *Streptomyces* differentiation. In addition they provide a nice rationalization for the complexity of morphological changes in this organism and speculate appropriately on the role of antibiotic production.

In a beautifully constructed review, M. F. Thomashow and S. C. Rittenberg document what is known about the biology of *Bdellovibrio*, an intracellular parasite. Their clear statements based on reasonably detailed information allow the reader to become well versed in a difficult subject. A particularly intriguing aspect of the *Bdellovibrio* system is that this obligate parasite, which normally grows within the periplasm of *E. coli*, can mutate in a single step to host-independent growth. Such mutations seem to turn on a large number of functions that can normally be supplied only by a host cell or a very concentrated bacterial extract. This suggests that *Bdellovibrio* has cryptic genes and opens the possibility that such genes are turned on by DNA rearrangement.

Other chapters review in detail the phenomenology of the developmental

cycles in *Arthrobacter*, myxobacteria, prosthecate bacteria (such as *Caulobacter* and *Rhodomicrobium*), and cyanobacteria. Little attempt is made, however, to present mechanistic studies or even to speculate about possible mechanisms responsible for morphological and biochemical changes.

In a summary chapter, Parish pulls together the few threads that link the various developmental systems and notes that one can anticipate rapid advances in the near future, primarily because of recent technological successes in studying gene expression. An introductory chapter by Parish is less successful. In attempting to provide background on gene regulation for the unsophisticated student, Parish commits several errors in outlining repression of phage λ and regulation of phage T4 RNA synthesis. All in all, the introduction represents only a listing of phenomena without enough explanatory detail to inform the naïve or interest the sophisticated.

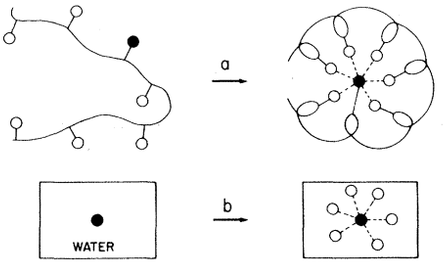
The volume, the first in a series on microbial physiology, will be useful as a basic textbook for graduate and advanced undergraduate courses that include aspects of bacterial differentiation. Its greatest drawbacks are that no references are more recent than 1978, the references given for most chapters are incomplete, and almost all of the references are gathered in one group at the end of the book. It can nonetheless be used effectively to provide an overview of each subject in conjunction with detailed analysis of the original literature.

ABRAHAM L. SONENSHEIN
Department of Molecular Biology and Microbiology, Tufts University School of Medicine, Boston, Massachusetts 02111

Assemblies in Solution

Hydrophobic Interactions. ARIEH BEN-NAIM. Plenum, New York, 1980. xiv, 312 pp., illus. $32.50.

Ever since Walter Kauzmann's pioneering work in the 1950's, the so-called "hydrophobic interaction" has become a ubiquitous explanation for the stability of biologically important macromolecular structures. The hydrophobic interaction is thought to be an effective attraction between apolar groups in water that is related in some way to the peculiar structure of liquid water and the low solubility of apolar species in water. Therefore, much effort has been invested in studies of dilute aqueous solutions of



"(a) A schematic description of a conformational change of a biopolymer. We follow a particular nonpolar group (dark circle) that is transferred from an (essentially) aqueous environment to an (essentially) nonpolar environment. (b) A model process representing the transfer of the nonpolar group in (a). The transfer is made from pure water into a nonpolar environment which is 'similar' to the environment of the darkened circle in the interior of the polymer." [From *Hydrophobic Interactions*]

apolar solutes. Nearly all the experimental studies focus on hydrophobic effects that refer to the solvation or hydration of single apolar species. But the hydrophobic interaction refers to the reversible work associated with changing the relative configurations of at least two apolar species in an aqueous environment. A quantitative link between these two classes of hydrophobic phenomena is not trivial. In addition, it is not always obvious which, if either, of the two classes is responsible for a certain stable structure.

The traditional macroscopic thermodynamic and phenomenological arguments do not lead to a clear resolution of these difficulties. The distinctions and connections between hydration and solvent-induced interactions are microscopic issues. A molecular approach seems imperative, and Arieh Ben-Naim adopts such an approach in *Hydrophobic Interactions*.

The most important ideas in the book follow from Ben-Naim's observation that the solubility of a constrained assembly of solute particles can be related directly to the reversible work or free energy required to bring the assembly together in the solution and that this reversible work is the solvent-induced potential of interaction for the assembly. In its most general form, this fact does provide a link between hydration and hydrophobic interactions. But the difficulty in exploiting it is that physical assemblies in solution are not constrained, and therefore their solubilities cannot be directly observed. It is also not clear how the solvent-induced interaction among just a few particles is related to solvent-induced interactions in biophysical structures.

Ben-Naim surmounts these obstacles by focusing on chemically bonded apolar groups. He assumes that the solvent contributions to the free energies for these aggregates are indicative of those for collections of particles in relatively expanded configurations that are not chemically bonded. Further, in many instances he assumes that the hydrophobic interactions among large numbers of particles can be treated as a superposition of interactions between small numbers.

Without contradictory information, Ben-Naim's assumptions might appear palatable, and the ramifications he presents are numerous and interesting. But the results of computer simulation studies carried out over the last few years raise some serious questions. For example, from the work carried out by Aneesur Rahman and his co-workers and also by Bruce Berne's research group, it now seems certain that the preferred solvation of an associated pair of apolar particles is in a configuration with a water molecule between the two solutes. It is unfortunate that Ben-Naim provides no meaningful discussion of the simulation results. Rather, he uses his assumptions to develop once again the traditional view that the hydrophobic interaction is unusual in its ability to drive the apolar groups together. In years past, this view grew out of the macroscopic observation that oil and water do not mix. When applied on the microscopic scale this might suggest that a pair of apolar groups in water will arrange themselves in a fashion that minimizes the contacts with water. But the macroscopic phase separation of oil and water is apparently connected in a complicated and indirect nonsuperimposable way with the solvent averaged potentials between a small number of apolar particles in water.

A major part of *Hydrophobic Interactions* is devoted to organizing and analyzing thermodynamic data. It is an important unifying contribution. The problems I find with the book are largely due to my belief that Ben-Naim has not entirely thrown off the shackles of macroscopic thermodynamic arguments. Perhaps the difficulty is that our current theoretical understanding of the hydrophobic interactions among a small number of particles has not brought us to the point where anyone can make statements about the assembly of proteins or even the formation of micelles. Until we reach that stage, Ben-Naim's book will stand as one of the few significant sources in the field.

DAVID CHANDLER
Department of Chemistry, University of Illinois, Urbana 61801