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.

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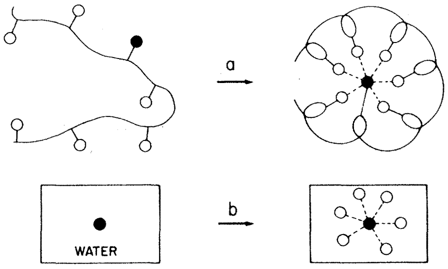
Assemblies in Solution

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 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.



"(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*]

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.

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