hydrolyzed. In vitro motility assays have been used for defining the polarity of microtubules and characterizing the molecular bases of such intracellular processes as organelle transport, membrane translocation, and chromosome movement. A few chapters of the book are devoted to the methods of biochemical characterization of motor proteins, including their expression in bacteria. Each chapter contains a large section describing technical details including the methods of preparation of purified proteins, cell extracts, and microscope slide surfaces. These sections include valuable comments concerning the denaturation of proteins caused by surface adsorption and excessive illumination. The descriptions of equipment including microscopes, video imaging systems, and digital analysis methods provide valuable technical detail needed for the design of the most suitable videomicroscopy setup for a particular motile system. Most chapters contain schematic illustrations of techniques and high-quality reproductions of microscope images of motile systems. Each chapter is complemented by a list of references including the titles of quoted papers.

In summary, this book presents a wide range of approaches and techniques in studies on the molecular mechanism of biological movement and indicates the possibilities of future development. As stated in the short summary on the back cover, "this volume should prove of practical value to investigators of the cytoskeleton and many related areas of cell and developmental biology."

The Photosynthetic Bacterial Reaction Center II: Structure, Spectroscopy, and Dynamics edited by Jacques Breton and André Verméglio

Plenum Press, New York and London, published in cooperation with NATO Scientific Affairs Division, 1992. 429 pages.

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In photosynthetic organisms, the essential step in the conversion of light into chemical energy occurs at a special pair of chlorophyll or bacteriochlorophyll molecules situated in a complex of transmembrane proteins that have two broad functions: (1) to provide a pathway for transport of the pure excitation energy (excitons, created by light absorption) to the pair through "antenna" chromophores and (2) to provide stabilization of the separated charge products and transport pathways away from the pair. The centrally situated protein containing the special pair, a few of the antenna chromophores, and most of the electron transport molecules, is the reaction center (RC). This protein, along with its associated antenna proteins, comprises the photosynthetic unit. In bacteria, one type of RC suffices. In green plants, two exist, operating largely in series.

The book under review deals with the bacterial RC alone and consists of the proceedings of a NATO Advanced Study Institute held at Cadarache, near Aix-en-Provence, France, in May 1992. This workshop was the fourth in an informal series that originated at about the time of Michel and Deisenhofer's Nobel-prize-winning x-ray determination of the structure of the RC of *Rhodopseudomonas viridis*. The first workshop was held in Feldafing, Germany, in March 1985, the second in Cadarache in September 1987, and the third again at Feldafing in March 1990. The *Biophysical Journal* reader will ask whether this is not just another conference volume. In one sense it may well not be. An extraordinarily rich multidisciplinary research effort is being played out in this field, and this is the latest in a series that provides a vivid picture of the impact that a structure determination of essentially a single protein complex can have.

The availability of the *R. viridis* RC structure, along with that of *Rhodobactor sphaeroides* (from groups at LaJolla and Argonne) has had both a practical and a philosophical effect on research in the primary bioenergetics of photosynthesis. Ever since its isolation by Clayton and Reed in 1968, the bacterial RC had attracted the attention of a small army of biologists, biochemists, chemists, and physicists, particularly spectroscopists and theorists among them. Their goal was to set up a molecular model of the RC by making it consistent with all relevant data, particularly spin resonance, infrared, optical, and Raman spectra. When the x-ray-determined structure was presented on a silver platter, what then was left to do? I recall this question being asked in public, no doubt mostly in jest, by one of the heavily involved researchers.

The end of history, as we know, does not come that easily. The game had been turned around: were now all these diagnostic spectra and theories readily consistent with what was now on the platter? The answer was and still is "no," the most famous instance being that of broken symmetry. Electron transfer at the RC proceeds in a particular direction despite the observed near-perfect C2 symmetry of the center. As vexing has been the problem of the "voyeur bacteriochlorophyll," a component whose structural position puts it in or very near the primary pathway. Its contribution to electron-transfer kinetics is far from settled and its potential influence on rates has sparked great theoretical interest. Since the structure posed so many new problems, those working with related chlorophyll-proteins could not help but wonder whether attempts to use spectra alone to estimate structure (in terms of chromophore locations and orientations) would henceforth be taken seriously. There was a prime source of encouragement in that the most significant spectrally-deduced aspect of the structure, the special pair, was indeed found in the *viridis* and *sphaeroides* structures. This pair had been identified as such by its EPR and ENDOR signatures in the early 1970s.

In the post-structure era, spectroscopy and theory are being applied with even greater alacrity. It is not merely that the structure has demanded more sophisticated methods to ensure all-round compatibility. It is that the game has, indeed, changed profoundly. The new situation is very well put by Bixon, Jortner, and Michel-Beyerle on page 291:

> The basic structure-function relation in biology, which pertains to the mechanism of the primary charge separation in photosynthetic reaction centers, is not yet elucidated, although the first structure ... was determined eight years ago. The major difficulty involved in the understanding of this central energy conversion process in biology is that it requires information on energetics, electronic interactions, and nuclear dynamics in electronically excited states, which cannot readily be inferred from the structural data in the ground electronic state. This state of affairs reflects on the intrinsic limitations of structure to infer an excited state dynamics.

It is probably safe to say that such limitations will accompany most future attempts to determine structure-function relationships at the molecular level when significant localization of energy is involved for any reason.

A clear progression toward specialization and depth is found in the four sets of proceedings. At the first meeting (Michel-Beyerle, 1985) there is still room for antenna proteins; they disappear at the next (Breton and Verméglio, 1987). Separate workshops devoted to antenna proteins are now held on a regular basis. Specialization becomes greater in Feldafing-II (Michel-Beyerle, 1990) and, by the time of Cadarache-II, one participant predicts the takeover of the field by FTIR (Fourier transform infrared) spectroscopists.

It is of course not possible to review or even mention all of the book's 45 research papers, but its flavor can be caught in the following selection of methods reported, in addition to FTIR: x-ray diffraction, polarized light absorption, exchange and other mutations, absorbance-detected magnetic resonance, Fourier transform Raman spectroscopy, spin-Boson theory of electron transfer, spectral hole burning, pulsed-electric-field-induced reverse electron transfer, femtosecond fluorescence upconversion, computational modeling of proton transfer pathways, numerous conventional spectroscopies, and numerous quantum mechanical techniques.

The state of the field? As has been observed by many others, the bacterial RC must be unquestionably one of the best understood bioenergetic machines. By the same token, the number of interesting and difficult questions continues to expand without apparent limit. The present volume is a rich source for any young biophysics researcher who would like to see how bioenergetics research proceeds at the most fundamental level.

Just another conference volume? Not unless George Feher has contributed his Light Reflections on a very regular basis. Continuing a Cadarache-I tradition, George was persuaded by Jacques Breton to commit his after-dinner remarks to print. Here, among other things, are a compendium of some jokes you know and some you don't, and George's bottom line on the workshop: "Some of us came here confused on a certain topic, and after listening to the lectures and discussions are still confused on that topic, but let me assure you that our confusion is on a much higher level than when we came."

The Advanced Study Institutes (ASIs) and their published proceedings must stand as one of NATO's finest accomplishments. Breton and Verméglio's volume is no. 237 in series A, and there exist nine separate series published by three different houses! This reviewer, admittedly working from a small sample, has never attended an ASI nor seen a volume in the ASI series that was not exceptionally well done. These editors continue the tradition.

REFERENCES

Breton, J. and Verméglio, A., editors. 1988. The Photosynthetic Bacterial Reaction Center: Structure and Dynamics. Plenum Press, New York.

Michel-Beyerle, M. E., editor. 1985. Antennas and Reaction Centers of Photosynthetic Bacteria: Structure, Interactions, and Dynamics: Proceedings of an International Workshop, Feldafing, Bavaria, F. R. G., March 23–25, 1985. Springer-Verlag, New York.

Michel-Beyerle, M. E., editor. 1990. Reaction Centers of Photosynthetic Bacteria. Feldafing-II-Meeting. Springer-Verlag, New York.