

Preface

Bioenergetics is at the heart of biochemistry, biophysics and molecular biology, and encompasses the key reactions by which the processes of life harness the energy of sunlight and foodstuffs and transduce it into adenine triphosphate (ATP), the currency of energy that is found throughout the three kingdoms of life. As they have a common evolutionary origin, the majority of these basic processes are virtually the same, or at least very similar, in the mitochondria of eukaryotes as they are in prokaryotes, although the mitochondrial versions often exhibit a higher degree of sophistication and regulation. In all cases, the catalysts involved in these reactions are complex assemblies of membrane proteins that carry out primary energy transduction by mechanisms based on Peter Mitchell's universal electrochemical proton gradient. For a long time, research in this area was hampered by the difficulty of crystallising and solving the structures of membrane proteins, but, as described in this volume, today that problem has been largely overcome, so that the three-dimensional structures of all the major energy transducing protein complexes are known to various degrees of resolution. Bioenergetics is also a unique area of biological research in the sense that the atomic level reaction mechanisms of these complex enzymes have been studied in real time, either in molecular ensembles, or by single molecule techniques. The development of computational chemistry has led to especially valuable comparisons between such real-time experiments and advanced atomic simulations using quantum-chemical and molecular dynamics technologies, as well as combinations of the two.

The volume starts out with a chapter by Moser *et al.* (Chapter 1) that describes their outstanding work to build and engineer bioenergetically relevant structures in the laboratory. This is followed by three chapters by Sazanov (Chapter 2), Zickermann (Chapter 3), and Kaila (Chapter 4) on the

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respiratory Complex I, which is the part of the respiratory chain that contains the largest remaining mechanistic enigmas at this time despite the crystal structures. Gennis *et al.* (Chapter 5) then review the knowledge on transhydrogenase, an honorary member of the respiratory chain, and Barquera *et al.* (Chapter 6) describe the interesting Na^+ -translocating NADH-quinone reductase (NQR) found in several pathogenic bacteria. This is followed by two insightful contributions on the bc_1 complex of the respiratory chain by Crofts *et al.* (Chapter 7) and Osyczka *et al.* (Chapter 8). Here we need to recall that analogues of the bc_1 complex are also part of the reactions of Photosystem II of photosynthetic bacteria and green plants. Then follows a contribution by Ferguson-Miller and Hosler on cytochrome *c* oxidase (Chapter 9), the complex of the respiratory chain that enables it to use O_2 as the terminal oxidant. Their emphasis is on the enigmatic subunit III of this enzyme complex, which is lacking in many bacterial variants of the superfamily of heme-copper oxidases. Swanson complements the description of cytochrome *c* oxidase (Chapter 10) with an incisive account of the computational work that has been performed to better understand the proton-pumping function of this enzyme. Siegbahn (Chapter 11) presents the only account here of the structure and function of the photosynthetic water-splitting complex of cyanobacteria and green plants. The remarkable earlier structural achievements by X-ray crystallography are here complemented by advanced quantum-chemical calculations, which give unique atomic insight into the mechanism of dioxygen formation in photosynthesis. In Chapter 12, Lenaz *et al.* present a critical assessment of the currently very popular concept of supercomplexes of the respiratory chain. Finally, in the concluding Chapter 13, Walker gives a survey of the recent status of research on the universally important ATP synthase, also called F_1F_0 -ATPase. Apart from interesting details relevant for the proton-driven rotor of this remarkable molecular machine, which is central for all of bioenergetics, there are discussions of ATP synthase as a possible drug target, and its possible role in providing the mitochondrial permeability transition pore that has historically gained great popularity in cell biology.

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