
BOOK REVIEW

Bioenergetics 3

(Nicholls, D. G., and Ferguson, S. J., Academic Press, London, 2002)

The third edition of *Bioenergetics* by D. G. Nicholls and S. J. Ferguson formally marks a transition between the insight levels of the science concerned with the energy demand of living organisms. The refining of molecular and cellular biology methods during the last decade evoked enormous advances in molecular insight of energy generation and transduction mechanisms. At the same time, the role of mitochondria in cell life and death has attracted exponentially increasing attention. Many new methods for the investigation of bioenergetics in intact cells have been elaborated. Although significant changes are found in the division of scientific interest, the principles of the chemiosmotic theory conceptualization forms the core of this book. This is apparent from the first three chapters that are devoted to chemiosmotic energy transduction, membrane transport, and quantitative estimation of the driving forces of bioenergetic reactions. Regretfully, because of space constraints, a section that dealt with the historical background of bioenergetics was omitted. However, the reader could familiarize himself with the key persons of this science by investigating of caricatures placed at the beginning of each chapter. The book consists of nine chapters, an appendix, and a set of color plates with selected molecular structures.

One can find in a special note to the reader the detailed explanation for the substitution of protonmotive force (Δp) for electrochemical proton gradient ($\Delta \bar{\mu}_{H^+}$) and the use of P and N nomenclature for the symbolization of positively and negatively charged compartments, respectively. It should be emphasized that this terminology is actively used in many current papers and reviews.

The first chapter "Chemiosmotic energy transduction" is designed to bring to the attention of the reader the unified principle of primary and secondary proton pumps coupling in all energy-transducing membranes. The description of basic morphological features of mitochondria, chloroplasts, and photosynthetic bacteria, essential to the novice investigator, is found in this chapter. Of particular interest is the discussion concerning the advantages and disadvantages of the isolation, purification, and reconstitution of the energy-transducing membranes and related proteins.

The chapter "Ion transport across energy-conserving membranes" offers a clear systematization of a various

membrane translocation mechanisms. With this in mind, a simple classification is proposed. The grouping is based on four criteria that are necessary and sufficient for the comprehensive description of any transport process. We shall become acquainted here with basic features of membrane permeability, mediated by phospholipids, ionophores, and lipophilic anions and cations. Attention now focuses on the unity of the ion transport mechanisms in energy-transducing and other membranes. The peculiarities of protein catalyzed transport processes are described separately. Beginners will find here many helpful findings concerning the use in experimental practice of the phenomena of swelling and contraction of vesicular preparations containing coupled ion-transporting systems.

The third chapter "Quantitative bioenergetics: the measurement of driving forces" is devoted to simplification and unification of thermodynamic equations providing quantitative description of driving forces of bioenergetic reactions. It is emphasized here that potential ability of any system to do work is determined by the displacement level of the ingredients from the equilibrium state. This suggests the eventual abandonment of myths about "high-energy compounds", like ATP, and the attention focusing on the specific environment of the reaction. Thus, the three first chapters facilitate more detailed discussion of the molecular mechanism of working bioenergetic systems.

The chapter "Chemiosmotic proton circuits" is concerned with experimental approaches that are suited to following the course of the functioning of proton circuits under various conditions. The specific patterns provide additional insights into the peculiarities concerning the quantifying and redistribution of the protonmotive force components (electrical and chemical gradients) by means of oxygen and ion-specific electrodes, radioisotopes, and endogenous and exogenous optical probes. The procedures of proton translocation stoichiometry estimation for primary and secondary proton pumps are briefly outlined. Vivid examples of the theoretical and experimental traces enhance the understanding of the mitochondrial metabolic states, respiratory control, and proton conductance regulation pathways in natural and artificial vesicular systems.

The largest chapter of the book "Respiratory chains" is dedicated to the detailed analysis of the structures of various eukaryotic and prokaryotic respiratory chains. It is emphasized that the regulation of redox potentials of electron transfer centers is rendered possible by variation of their molecular microenvironments. The principles described in the third chapter are conveniently illustrated by the content of this section. Novice experimenters will find here a practically vital critical overview of the important approaches for investigation of the respiratory chain redox centers. The mechanism of proton and electron transport is discussed in the light of up-to-date information concerning molecular structure of the components of the proton pumps. The conditions of superoxide-radical generation by mitochondrial respiratory chain complexes and the glutathione-dependent defenses against oxidative stress are briefly described.

The next two chapters are filled with the bright examples of the usefulness of structural information for explaining the functional features of the Δp -generators. Numerous molecular models of the conversion of energy forms in biological systems have been suggested as a result of X-ray diffraction studies, electron microscopy, spectroscopic experiments, and site-directed mutagenesis of the Δp -generators. Abundant figures and schemes have been specially designed to avoid dead weight and meet uniform style. Structural information concerning more than fifty proteins that are mentioned in chapters 5-8 and that can be accessed on the Protein Data Bank receive the attention it needs in a specialized Appendix. The reader can inspect ten additional color plates to look more closely at the molecular structure of frequently mentioned proteins. The chapter "Photosynthetic generators of protonmotive force" provides thorough analysis of the structure and function of the antennae and reaction centers of various phototrophic organisms. The probable relation of the reaction centers of thermophilic cyanobacteria, purple non-sulfur bacteria, and photosystem II in green plants is discussed here. The authors look forward to the discovery of structural similarities between green plant photosystem I and photosystems of green-sulfur bacteria along with heliobacteria. A recent plausible scheme concerning the physiological role of cyclic electron transport in thylakoids is discussed. The direct generation of Δp in response to the photon capture, inherent to the photosynthetic activity in halobacteria receives proper attention at the end of the chapter. The interrelation between structure and function of secondary proton pumps is illustrated by the examples of the bacterial and mitochondrial F_0F_1 -type ATP-synthases. It becomes apparent from the chapter "The ATP synthase" that the structure of

these pumps is highly conserved. The current concept of the ATP generation mechanism is described as the alternating cooperative binding of the substrates with three catalytic sites followed by product release owing to a direct coupling of electrical, chemical, and mechanical work. The pathways of regulation of F_0F_1 -type ATP-synthases as well as distinctive features of the other ATP synthases and the proton-translocating pyrophosphatases are discussed in a few words at the end of the chapter.

The beginning of the chapter "Metabolite and ion transport" focuses the reader's attention on the five main strategies of electroneutral and electrogenic translocation. The authors briefly review the features of the mitochondrial translocators of monovalent cations, anions, and low-molecular-weight metabolites. The adenine nucleotide transporter and uncouplers from various mammal tissues have received much notice. The reader can acquire a familiarity with the basic features and metabolic role of mitochondrial Ca^{2+} transport. Considerable attention has been given to the role of calcium ions in the induction of the mitochondrial inner membrane permeability transition, resulting in apoptosis. Bacterial transport systems received the bulk of attention with special emphasis on lactose symporter and ATP-dependent translocators. The mechanisms of bacterial motility and transport of macromolecules across bacterial membranes are mentioned at the end of the chapter.

The final chapter, "Mitochondria in the cell", has no counterpart in the previous editions of the book and reflects the present interest of scientists in elucidation of physiological and pathophysiological role of mitochondria in the life of intact cells. The first part of the chapter considers problems accompanying investigations of calcium homeostasis, the consequences of oxidative stress, plus the realization of necrotic and apoptotic cell death scenarios. Practicing experimenters will find here comprehensive analysis of the advantages and disadvantages of approaches adapted to monitoring bioenergetic processes *in situ*. Import and assembly of mitochondrial proteins are briefly covered. The rest of the chapter concerns directly or indirectly the mitochondrial genome and corresponding mutations. The authors call attention to bioenergetic dysfunctions as a root cause of various diseases.

In conclusion, it must be said that D. G. Nicholls and S. J. Ferguson succeeded in preparation of an easily perceivable and interesting textbook based on the great and complex body of primary information. As a result, this book will be helpful for biomedical field specialists and students to provide more penetrating insight into recent trends in biological energetics.

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