Bioenergetics is the name given to the collection of disciplines within biochemistry and physiology that aims at a description and understanding of the function of living systems. These functions include the exchange, metabolism and accumulation of matter as well as their related energy transformations.

The authors present an accessible textbook providing the reader with the fundamental principles of the subject and how these can be applied to practical problems.

This textbook is ideal for graduate students and researchers in biochemistry, physiology and chemistry. The book should also be of interest to workers in the applied life sciences.

Bioenergetics

Bioenergetics:

its thermodynamic foundations

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CAMBRIDGE
UNIVERSITY PRESS

CAMBRIDGE UNIVERSITY PRESS
Cambridge, New York, Melbourne, Madrid, Cape Town, Singapore, São Paulo

Cambridge University Press
The Edinburgh Building, Cambridge CB2 8RU, UK

Published in the United States of America by Cambridge University Press, New York

www.cambridge.org
Information on this title: www.cambridge.org/9780521451437

First published in Danish as *Bioenergetik*
by G.E.C. Gad Publishers, Copenhagen 1991,
and © G.E.C. Gad Forlags 1991

First published in English by
Cambridge University Press 1995 as *Bioenergetics*

This digitally printed version 2008

A catalogue record for this publication is available from the British Library

Library of Congress Cataloguing in Publication data

Garby, Lars.
Bioenergetics: its thermodynamic foundations / Lars Garby and
Poul S. Larsen.
p. cm.
Includes index.
ISBN 0-521-45143-4
1. Bioenergetics. 2. Thermodynamics. I. Larsen, Poul Scheel.
II. Title.
QP517.B54G37 1995
574.19′121—dc20 94-956 CIP

ISBN 978-0-521-45143-7 hardback
ISBN 978-0-521-06635-8 paperback

I advanced some time ago the general hypothesis that in consequence of the fluid state of the protoplasm and the instability of the cell-stuffs, voluntary events of physical and chiefly of chemical nature are going on continuously which aim at a balance of the existing potentials of energy. Since life requires the continuation of these potentials of energy, work must be performed continuously for the prevention or reversion of these spontaneous changes.

(Otto Meyerhof, 1924)

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Preface

Bioenergetics is the name given to the collection of disciplines within biochemistry and physiology that aims at a description and understanding of the function of living systems, i.e. collections of whole organisms (ecosystems), individual organisms or parts thereof. The function includes the exchange, metabolism and accumulation of matter (growth) as well as the energy transformations associated with these phenomena. The quantitative description is based on the theory of macroscopic thermodynamics.

Fundamentally, thermodynamic theory is based on the recognition of: the difference between the energy content of a system and energy transfer in the form of heat and work; the difference between the energy forms heat and work; and the existence of an absolute temperature scale and a property of state called entropy. The theory leads to quantitative relations between these phenomena, thereby determining their extent. These results arise as natural consequences of satisfying the first and second laws of thermodynamics (the conservation of energy and the increase of entropy), conditions that are even more far-reaching than, for example, the conservation of mass, which, of course, must also be satisfied.

Existing textbooks and chapters on bioenergetics discuss the fundamental principles only sparsely and the language often does not correspond to that used in textbooks on thermodynamics. This fact has contributed to making the communication between biologists and physicists or engineers unnecessarily difficult. It is also one of the objectives of the present treatise to make this dialogue easier.

The text is intended for students and teachers at schools of higher education with programmes in the fields of biology and medicine, such as biochemistry, physiology, microbiology and ecology, but also for researchers in the applied sciences of, for example animal and human nutrition, food science and plant technology, including fish farming.

Readers who are already familiar with chemical thermodynamics are encouraged to read Chapters 1 and 2 as an introduction to the subject and to the philosophy of the text. They may then skip Chapter 3, which contains general definitions and concepts, an introduction to state properties and the conservation of mass for closed and open systems. The following chapters deal with biological systems in terms of conservation of energy (Chapter 4), increase of entropy (Chapter 5) and expenditure of exergy (Chapter 8). Sections on thermodynamic equilibrium (Chapter 6) and non-equilibrium systems (Chapter 7) are necessary for a complete treatment, particularly for the description of equilibria and transport processes across membranes. Throughout the text, examples illustrate applications of the theory. The property tables in the appendices are not meant to be exhaustive and exact, but they do include sufficient values to be representative and to allow the solution of simple problems.

Equations are numbered consecutively throughout each chapter and are referred to there by their number only, e.g. (72). Reference to equations outside chapters is made by chapter number and equation number, e.g. (3.72).

Our thanks are due to Professor C. Barker Jørgensen and Associate Professor F. Jørgensen for valuable comments.

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