Lev A. Blumenfeld  Alexander N. Tikhonov

Biophysical Thermodynamics of Intracellular Processes
Molecular Machines of the Living Cell

With 54 Illustrations

Springer-Verlag
New York Berlin Heidelberg London Paris
Tokyo Hong Kong Barcelona Budapest
Biophysical thermodynamics of intracellular processes: molecular machines of the living cell / Lev A. Blumenfeld, Alexander N. Tikhonov.

p. cm.
Includes bibliographical references and index.
ISBN 0-387-94179-7
I. Tikhonov, A.N. (Aleksandr Nikolaevich) II. Title.
QP517.T48B58 1994
574.19'121—dc20
93-35826
CIP

Printed on acid-free paper.

© 1994 Springer-Verlag New York Inc.
All rights reserved. This work may not be translated or copied in whole or in part without the written permission of the publisher (Springer-Verlag New York, Inc., 175 Fifth Avenue, New York, NY 10010, USA), except for brief excerpts in connection with reviews or scholarly analysis. Use in connection with any form of information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed is forbidden.
The use of general descriptive names, trade names, trademarks, etc., in this publication, even if the former are not especially identified, is not to be taken as a sign that such names, as understood by the Trade Marks and Merchandise Marks Act, may accordingly be used freely by anyone.

Production coordinated by Brian Howe and managed by Terry Kornak; manufacturing supervised by Gail Simon.
Typeset by Ascor Trade Typesetting Ltd., Hong Kong.
Printed and bound by Braun-Brumfield, Inc., Ann Arbor, MI.
Printed in the United States of America.

9 8 7 6 5 4 3 2 1

Preface

CHAPTER 1
Introduction

CHAPTER 2
Thermodynamics and Chemical Kinetics of Living Systems

2.1. How Scientists Learned to Distinguish Energy from Force
(Brief Historic Review)

2.2. Kinetics and Thermodynamics of Chemical Reactions

2.3. Applicability of Equilibrium and Nonequilibrium Thermodynamics to
Biological Systems and Processes

2.4. The Mechanisms of Energy Coupling in Chemical Reactions

2.4.1. Indirect Mechanism of Energy Coupling in Equilibrium
(Quasi-Equilibrium) Homogeneous Mixtures of Chemical
Reagents

2.4.1.1. Enthalpic Mechanism of Indirect Coupling

2.4.1.2. Entropic Mechanism of Indirect Coupling

2.4.2. Entropic Mechanism of Coupling Chemical Reactions
in Open Systems

CHAPTER 3
Molecular Machines: Mechanics and/or Statistics?

3.1. The Second Law of Thermodynamics and Its Application
to Biochemical Systems

3.2. Energy-Transducing Molecular Machines

3.2.1. Macroscopic Machines

3.2.2. What Are Molecular Machines? Reversibility of
Energy-Transducing Devices and the Problem of the Optimal
Functioning of Molecular Machines

3.2.3. Models for Calculating the Conversion Factor

3.3. Statistical Thermodynamics of Small Systems, Fluctuations, and the
Violation of the Mass Action Law