

---

# Contents

---

List of Figures	xi
List of Tables	xv
Preface	xvii
Acknowledgments	xix
Author	xxi
<b>CHAPTER 1 ■ Introduction</b>	<b>1</b>
1.1 MOTOR PROTEINS IN BIOLOGICAL SYSTEMS	1
1.2 SINGLE-MOLECULE EXPERIMENTS	6
1.3 DISCUSSION OF THEORETICAL MODELS FOR MOLECULAR MOTORS	7
1.4 MOTOR PROTEINS AS NANOSCALE MACHINES	9
1.5 OUTLOOK	10
<b>CHAPTER 2 ■ Basic Properties of Motor Proteins</b>	<b>13</b>
2.1 HISTORY OF MOTOR PROTEINS	13
2.2 CLASSIFICATION OF BIOLOGICAL MOLECULAR MOTORS	18
2.3 STRUCTURES OF MOTOR PROTEINS	22
2.4 BIOLOGICAL FUNCTIONS OF MOLECULAR MOTORS	25
2.5 SUMMARY	27
<b>CHAPTER 3 ■ Experimental Studies of Motor Proteins</b>	<b>29</b>

3.1	INTRODUCTION	29
3.2	BULK CHEMICAL-KINETIC MEASUREMENTS	30
3.3	STRUCTURAL STUDIES	35
3.4	SINGLE-MOLECULE FORCE SPECTROSCOPY	37
3.4.1	<i>Optical-Trap Spectroscopy</i>	39
3.4.2	<i>Magnetic Tweezers Spectroscopy</i>	41
3.4.3	<i>Atomic-Force Microscopy</i>	44
3.5	FLUORESCENT LABELING AND SUPER-RESOLUTION TECHNIQUES	47
3.6	MAJOR EXPERIMENTAL OBSERVATIONS	51
3.7	SUMMARY	52
CHAPTER 4 ■ Fundamental Physical Concepts: Equilibrium Approaches		53
<hr/>		
4.1	INTRODUCTION	53
4.2	BASIC EQUILIBRIUM THERMODYNAMICS	54
4.3	BASIC STATISTICAL MECHANICS	63
4.4	APPLICATION FOR MOTOR PROTEINS	67
4.5	SUMMARY	68
CHAPTER 5 ■ Fundamental Physical Concepts: Non-Equilibrium Approaches		69
<hr/>		
5.1	INTRODUCTION	69
5.2	MACROSCOPIC CHEMICAL KINETICS	70
5.2.1	<i>Irreversible Processes</i>	72
5.2.2	<i>Reversible Processes</i>	76
5.2.3	<i>Temperature Dependence</i>	78
5.3	RANDOM WALKS	80
5.4	FIRST-PASSAGE PROCESSES	86
5.5	SUMMARY	90
5.6	MATHEMATICAL APPENDIX	90
5.6.1	<i>Irreversible Second-Order Chemical Reactions</i>	90
5.6.2	<i>Reversible Chemical Reactions</i>	91
5.6.3	<i>Calculations of Average Properties for the Simplest One-Dimensional Random Walk</i>	92

5.6.4	<i>Calculations of First-Passage Probabilities and Dynamic Properties</i>	94
<b>CHAPTER 6 ■ Motor Proteins as Enzymes</b>		<b>97</b>
<hr/>		
6.1	INTRODUCTION	97
6.2	CATALYSIS	98
6.3	ENZYMATIC PROCESSES	101
6.4	SUMMARY	106
6.5	MATHEMATICAL APPENDIX	107
6.5.1	<i>Michaelis–Menten Mechanism</i>	107
6.5.2	<i>Inhibition Processes</i>	108
6.5.3	<i>Single-Molecule Derivation of the Michaelis–Menten Equation</i>	109
<b>CHAPTER 7 ■ Theory for Motor Proteins: Continuum Ratchets</b>		<b>113</b>
<hr/>		
7.1	INTRODUCTION	113
7.2	CONTINUUM RATCHET POTENTIALS	115
7.3	CRITICAL ANALYSIS	121
7.4	SUMMARY	122
<b>CHAPTER 8 ■ Theory for Motor Proteins: Discrete-State Stochastic Models</b>		<b>125</b>
<hr/>		
8.1	INTRODUCTION	125
8.2	DISCRETE-STATE STOCHASTIC APPROACH	126
8.2.1	<i>Linear Sequential Models</i>	126
8.2.2	<i>Forces in Motor Proteins</i>	131
8.2.3	<i>Dwell Times and First-Passage Analysis</i>	135
8.2.4	<i>Efficiency of Motor Proteins</i>	138
8.2.5	<i>Discrete-State Stochastic Models for Systems with Complex Biochemical Pathways</i>	141
8.3	CRITICAL ANALYSIS	142
8.4	SUMMARY	144
8.5	MATHEMATICAL APPENDIX	145
8.5.1	<i>Calculation of Dynamic Properties of Motor Proteins Using Derrida’s Method</i>	145

8.5.2	<i>Calculation of First-Passage Probabilities and Dynamic Properties for <math>N = 2</math> Linear Discrete-State Models</i>	149
<b>CHAPTER 9 ■ Collective Properties of Motor Proteins</b>		<b>151</b>
<hr/>		
9.1	COOPERATIVITY AND INTERACTIONS IN MOTOR PROTEINS DYNAMICS	151
9.2	EXPERIMENTAL OBSERVATIONS	152
9.3	THEORETICAL IDEAS	156
9.4	SUMMARY	160
<b>CHAPTER 10 ■ Artificial Molecular Motors and Rotors</b>		<b>163</b>
<hr/>		
10.1	INTRODUCTION	163
10.2	BIOLOGICAL ARTIFICIAL MOLECULAR MOTORS	164
10.3	NON-BIOLOGICAL ARTIFICIAL MOLECULAR MOTORS	170
10.4	ARTIFICIAL MOLECULAR ROTORS	173
10.5	SUMMARY	175
<b>CHAPTER 11 ■ Future Directions in Studies of Motor Proteins and Molecular Motors</b>		<b>177</b>
<hr/>		
11.1	WHAT WE UNDERSTAND NOW ABOUT MOTOR PROTEINS AND MOLECULAR MOTORS	177
11.2	OPEN QUESTIONS AND PROBLEMS	178
11.3	LOOKING INTO THE FUTURE	182
	Bibliography	183
	<b>Index</b>	<b>197</b>
<hr/>		