Contents

Preface		ix
Acknowledgments		
Chapter	1	
Biology, I	Mathematics, and a Mathematical Biology Laboratory	1
1.1	The Natural Linkage Between Mathematics	
	and Biology	1
		2
1.3	What Can Be Derived from a Model and	
	How Is It Analyzed?	5
Refe	erences and Suggested Further Reading	8
Chapter 2	2	
Some Mat	thematical Tools	9
2.1	Linear Dependence	10
2.2	Linear Regression, the Method of Least Squares	16
2.3	Multiple Regression	27
2.4	Modeling with Differential Equations	35
2.5	Matrix Analysis	47
2.6	Statistical Data	52
2.7	Probability	64
Refe	erences and Suggested Further Reading	75

vi Contents

Chapter 3	3	
Reproduction and the Drive for Survival		
3.1	The Darwinian Model of Evolution	78
3.2	Cells	81
3.3	Replication of Living Systems	82
3.4	Population Growth and Its Limitations	86
3.5	The Exponential Model for Growth and Decay	87
3.6	Questions for Thought and Discussion	97
Refe	erences and Suggested Further Reading	97
Chapter 4	ı	
Interaction	ns Between Organisms and Their Environment	98
4.1	How Population Growth is Controlled	99
4.2	Community Ecology	109
4.3	Environmentally Limited Population Growth	110
4.4	A Brief Look at Multiple Species Systems	119
4.5	Questions for Thought and Discussion	130
Refe	erences and Suggested Further Reading	130
Chapter 5	5	
Age-Depe	ndent Population Structures	132
5.1	Aging and Death	132
5.2		137
5.3	Predicting the Age-Structure of a Population	140
5.4	Questions for Thought and Discussion	153
Refe	erences and Suggested Further Reading	153
Chapter (5	
Random N	Movements in Space and Time	154
6.1	Biological Membranes	155
6.2	The Mathematics of Diffusion	160
6.3	Interplacental Transfer of Oxygen: Biological	
	and Biochemical Considerations	180
6.4	Oxygen Diffusion Across the Placenta:	
	Physical Considerations	183
6.5	The Spread of Infectious Diseases	191

Contents	vii

6.6	Questions for Thought and Discussion	192
Re	ferences and Suggested Further Reading	192
Chapter	7	
The Biol	ogical Disposition of Drugs and Inorganic Toxins	194
	- Barris Foundation of Drugo and Inolganic Toxins	154
7.1	Break Importance of Ecua	194
7.2	, , , , , , , , , , , , , , , , , , , ,	196
7.3	8	201
7.4		203
7.5	· · · · · · · · · · · · · · · · · · ·	206
7.6		207
	Bones	216
	The Kidneys	217
	Clinical Effects of Lead	219
	O A Mathematical Model for Lead in Mammals	220
	1 Pharmacokinetics	226
	2 Questions for Thought and Discussion	233
Ref	erences and Suggested Further Reading	233
C 1. 4	0	
Chapter	<u>8</u>	
Neurophysiology		234
0.1		
8.1	Communication Between Parts of an Organism	234
8.2	The Neuron	236
8.3	The Action Potential	240
8.4	Synapses—Interneuronal Connections	243
8.5	A Model for the Conduction of Action Potentials	247
8.6	The Fitzhugh-Nagumo Two-Variable Action	
	Potential System	259
8.7	Questions for Thought and Discussion	262
Ref	erences and Suggested Further Reading	263
		•
Chapter 9	<u> </u>	
The Bioch	nemistry of Cells	264
9.1	Atoms and Bonds in Biochemistry	264
9.2	Biopolymers	272
9.3	Molecular Information Transfer	288
9.4	Enzymes and Their Function	295
9.5	Rates of Chemical Reactions	302
_	- 	502

viii Contents

9.6	Enzyme Kinetics	308
	Questions for Thought and Discussion	317
	ences and Suggested Further Reading	317
ROIOI	oneog and baggested I armor reading	
Chapter 10) 	
A Biomathe	ematical Approach to HIV and AIDS	319
10.1	Viruses	319
10.2	The Immune System	324
	HIV and AIDS	334
10.4	An HIV Infection Model	340
10.5	A Model for a Mutating Virus	348
10.6	Predicting the Onset of AIDS	357
10.7	Questions for Thought and Discussion	367
References and Suggested Further Reading		368
Chapter 11	<u>. </u>	
Genetics		369
11.1	Asexual Cell Reproduction—Mitosis	369
11.2	Sexual Reproduction—Meiosis and Fertilization	375
11.3	Classical Genetics	379
11.4	A Final Look at Darwinian Evolution	389
11.5	The Hardy-Weinberg Principle	391
11.6	The Fixation of a Beneficial Mutation	398
11.7	Questions for Thought and Discussion	408
References and Suggested Further Reading		409
Index		411