

Contents

1	Introduction	1
	References	2
2	Exponential Growth and Decay	3
2.1	Exponential Growth	3
2.2	Exponential Decay	7
2.3	Summary	9
2.4	Exercises	9
	References	10
3	Discrete Time Models	11
3.1	Solutions of the Discrete Logistic	11
3.2	Enhancements to the Discrete Logistic Function	12
3.3	Summary	14
3.4	Exercises	14
	References	14
4	Fixed Points, Stability, and Cobwebbing	15
4.1	Fixed Points and Cobwebbing	15
4.2	Linear Stability Analysis	17
4.3	Summary	18
4.4	Exercises	19
	Reference	20
5	Population Genetics Models	21
5.1	Two Phenotypes Case	22
5.2	Three Phenotypes Case	24
5.3	Summary	28
5.4	Exercises	28
	References	28

6	Chaotic Systems	29
6.1	Robert May's Model	29
6.2	Solving the Model	29
6.3	Model Fixed Points	31
6.4	Summary	34
6.5	Exercises	34
	References	35
7	Continuous Time Models	37
7.1	The Continuous Logistic Equation	37
7.2	Equilibrium States and Their Stability	38
7.3	Continuous Logistic Equation with Harvesting	40
7.4	Summary	42
7.5	Exercises	42
	References	42
8	Organism-Organism Interaction Models	43
8.1	Interaction Models Introduction	43
8.2	Competition	44
8.3	Predator-Prey	46
8.4	Mutualism	47
8.5	Summary	48
8.6	Exercises	49
	References	49
9	Host-Parasitoid Models	51
9.1	Beddington Model	51
9.2	Some Solutions of the Beddington Model	52
9.3	MATLAB Solution for the Host-Parasitoid Model	54
9.4	Python Solution for the Host-Parasitoid Model	55
9.5	Summary	56
9.6	Exercises	56
	References	56
10	Competition Models with Logistic Term	57
10.1	Addition of Logistic Term to Competition Models	57
10.2	Predator-Prey-Prey Three Species Model	59
10.3	Predator-Prey-Prey Model Solutions	61
10.4	Summary	63
10.5	Exercises	64
	References	64
11	Infectious Disease Models	65
11.1	Basic Compartment Modeling Approaches	65
11.2	SI Model	65
11.3	SI Model with Growth in S	67
11.4	Applications Using Mathematica	69

11.5	Applications Using MATLAB	70
11.6	Summary	70
11.7	Exercises	70
	References	71
12	Organism Environment Interactions	73
12.1	Introduction to Energy Budgets	73
12.2	Radiation	74
12.3	Convection	74
12.4	Transpiration	74
12.5	Total Energy Budget	75
12.6	Solving the Budget: Newton's Method for Root Finding	76
12.7	Experimenting with the Leaf Energy Budget	79
12.8	Summary	81
12.9	Exercises	82
	Reference	82
	Appendix 1: Brief Review of Differential Equations in Calculus	83
	Appendix 2: Numerical Methods for Solving ODEs	89
	Appendix 3: Mathematica Tutorial	93
	Appendix 4: MATLAB Introductory Tutorial	103
	Appendix 5: Introduction to Python Programming	119
	Index	123

Computational biology has been defined by some as equivalent to bioinformatics, but we choose a broader definition encompassing any use of computational approaches to studying biological systems. Given the growing role of computational approaches in biology, an increasing focus on courses that teach computational methods will be important, as noted by Pezner and Siamis (2009). This could include numerical methods and computer programming along with an introduction to existing software tools such as Mathematica, MATLAB, or Python.

Why is mathematical biology important? For the next generation of biologists to flourish in new mathematical directions at this interface, much greater interaction between biologists and mathematicians will be necessary. The importance of an academic link between mathematics and biology is clear from the NSF-sponsored workshop entitled *Mathematics and Biology: The Interface, Challenges and Opportunity*, where the authors describe the potential for mathematics to revolutionize biology as Newton's calculus did for physics (Levin 1992). Benefits will flow in both directions; such interactions will also enrich mathematics, as has occurred in the past where dynamical systems and chaos theory were largely developed in response to biological problems.