

CONTENTS

Preface	page xi
Acknowledgements	xiv

Part I Evolution by Natural Selection 1

1 Darwin Questions the Fixity of Species	3
1.1 Darwin's Early Life and Education	3
1.2 The Earth's Crust: Uniformitarian and Catastrophist Theories	5
1.3 The Voyage of the <i>Beagle</i> (1831–1836)	7
1.4 The Experts Provide the Key (1836–1837)	13
2 Darwin's Evolutionary Theories	15
2.1 Darwin's Development of Evolutionary Theories	15
2.2 <i>On the Origin of Species</i>	17
2.3 The Reaction to his Theories	26
3 Understanding Natural Selection	27
3.1 Incorporating Genetics into Darwin's Theory	27
3.2 The Philosophy of Natural Selection	31
3.3 Is Natural Selection a Valid Scientific Theory?	31
3.4 The Argument from Design	32
3.5 Explaining the Seemingly Impossible	33
3.6 Conclusions	42

Part II Population Growth Models 43

4 Exponential Growth	45
4.1 Introducing Density-Independent Growth	45
4.2 Developing the Geometric and Exponential Growth Models	46
4.3 Applying the Geometric and Exponential Growth Models	49
4.4 Simulating Exponential and Geometric Growth	51

4.5 Two Examples of Exponential Growth	51
4.6 Summary and Conclusions	54
4.7 Problems	54
5 Logistic Growth	56
5.1 The Logistic Growth Model	56
5.2 Simulating Logistic Growth	58
5.3 Time Lags	60
5.4 Varying the Carrying Capacity	61
5.5 Examples of Logistic Growth	63
5.6 Maximum Sustainable Yield	66
5.7 Summary and Conclusions	67
5.8 Problems	67
6 Life Tables	69
6.1 Developing a Life Table	69
6.2 Different Types of Life Tables	71
6.3 Comparison of Life Tables	80
6.4 Summary and Conclusions	81
7 Growth of Age-Structured and Stage-Structured Populations	82
7.1 Population Growth Rates in Age-Structured Populations	82
7.2 Analysing the Influence of Demographic Variables on Population Growth Rates	91
7.3 Analysing Stage-Classified Life Cycles	94
7.4 Summary and Conclusions	99
7.5 Problem	99
8 Evolution of Life Histories	100
8.1 Reproductive Value	101
8.2 Frequency of Reproduction: Semelparity Versus Iteroparity	104
8.3 Life Span and Aging	107
8.4 Senescence: Comparing Theory and Empirical Observations	115
8.5 Summary	122
Part III Population Genetics and Evolution	123
9 The Hardy-Weinberg Principle	125
9.1 Terminology	125
9.2 Frequencies of Alleles, Genotypes and Phenotypes	126

9.3	The Hardy–Weinberg Principle	127
9.4	Applying the Hardy–Weinberg Principle	129
9.5	Complications	133
9.6	Non-Random Mating	136
9.7	Summary and Conclusions	137
9.8	Problems	137
10	Mutation and the Genetic Variation of Populations	139
10.1	Gene Mutations	139
10.2	The Randomness of Mutations	141
10.3	Mutation Rates and Evolution	142
10.4	Genetic Variation of Populations	146
10.5	Mutation and Genetic Variation in Humans	152
10.6	Summary and Conclusions	155
11	Genetic Drift and Effective Population Size	156
11.1	Genetic Drift in Idealized Populations	157
11.2	Genetic Drift in a Biological Population	161
11.3	Effective Population Size	164
11.4	Examples of Genetic Drift in Nature	166
11.5	Summary and Conclusions	172
12	Inbreeding	173
12.1	Quantifying Inbreeding	174
12.2	Consequences of Inbreeding	178
12.3	Summary and Conclusions	182
13	Migration, Gene Flow and Differentiation of Populations	183
13.1	One-way Migration: the Continent–Island Model	184
13.2	Island Model	187
13.3	Stepping-Stone Model	188
13.4	Populations with Large Continuous Distributions	190
13.5	Quantifying Population Subdivision	193
13.6	Estimating Gene Flow	196
13.7	Summary and Conclusions	200
13.8	Problems	200
14	Haploid and Zygotic Selection	202
14.1	Defining Fitness and Selection	202
14.2	Selection in Action	203

14.3	Modelling Haploid Selection	204
14.4	Conclusions About Haploid Selection	206
14.5	Zygotic Selection Models	207
14.6	Conclusions About Zygotic Selection	212
15	Applying Zygotic Selection Models to Natural Systems	218
15.1	Industrial Melanism	218
15.2	Sickle-Cell Anaemia	230
15.3	Eugenics	232
15.4	The Balance between Selection and Mutation	233
15.5	Summary and Conclusions	236
15.6	Problems	236
16	Polygenic Inheritance and Quantitative Genetics	239
16.1	Types of Quantitative Traits	239
16.2	Polygenic Inheritance	239
16.3	Partitioning Phenotypic Variation	241
16.4	Heritability	246
16.5	Response to Selection	247
16.6	Empirical Examples	250
16.7	Summary and Conclusions	255
16.8	Problem	255
17	Population Genetics: Summary and Synthesis	256
17.1	Mutations and Genetic Diversity	256
17.2	Genetic Differentiation of Populations	258
17.3	Limiting the Divergence between Subpopulations: Gene Flow	262
17.4	Evolution of New Adaptations	264
17.5	Epigenetics	267
 Part IV Interactions between Species, and Community Structure		 269
18	Interspecific Competition	271
18.1	The Lotka-Volterra Model of Interspecific Competition	274
18.2	Complicating the Model: Introducing a Removal Factor	279
18.3	Resource Competition Models	283
18.4	Evaluating Competition Models	290

18.5	Summary and Conclusions	295
18.6	Problems	295
19	Predator–Prey Interactions	297
19.1	Cycles in Predator–Prey Densities	297
19.2	The Lotka–Volterra Model of Predation	298
19.3	The Rosenzweig and MacArthur Graphical Model of Predation	303
19.4	Functional Responses of Predators	304
19.5	Choosing Where to Forage: Patch Selection	312
19.6	Prey Characteristics that Reduce the Risk of Predation	314
19.7	Summary and Conclusions	324
20	Species Interactions and Community Structure	325
20.1	The Trophic Structure of Communities	325
20.2	The Ecological Niche	327
20.3	Niche Evolution: Reducing Interspecific Competition	328
20.4	Empirical Examples Showing the Relationship between Species' Niches and Community Structure	330
20.5	Evolution of Niches: an Example	333
20.6	Predation, Herbivory and Community Structure	337
20.7	Parasites and Community Structure	338
20.8	Mutualism and Community Structure	339
20.9	Summary and Conclusions	343
 Part V Animal Behaviour, Altruism and Sexual Selection		 345
21	Animal Behaviour, Altruism and Limiting Aggression	347
21.1	Genetic Basis of Behaviour	347
21.2	The Development of Evolutionary Theories of Altruism	350
21.3	Studies of Kin Selection	353
21.4	Altruism: a Summary and Recent Developments	357
21.5	Aggressive Behaviour and Game Theory	358
21.6	Summary and Conclusions	366
22	Sexual Selection and Mating Systems	367
22.1	Sexual Selection, Parental Investment and Mating Systems	367
22.2	Examples of Sexual Selection	370

22.3 Animal Mating Systems	376
22.4 Summary and Conclusions	385
23 Epilogue	386
Glossary	388
Solutions to Problems	400
References	411
Index	429