

CONTENTS

List of Contributors · xiii

PART I: INTRODUCTION TO EXPERIMENTAL EVOLUTION · 1

1. Darwin's Other Mistake · 3
Michael R. Rose and Theodore Garland, Jr. · 3
 Correcting Darwin's Other Mistake · 4
 Definitions and Concepts · 6
 Macroevolution, Microevolution, and the Role of Selection
 Experiments · 8
 Overview of This Volume: Exclusions
 and Inclusions · 9
2. The Importance of Experimental Studies
 in Evolutionary Biology · 15
Douglas J. Futuyma and Albert F. Bennett · 15
 Methods of Studying Evolution · 16
 Two Examples of the Contribution of Experimental Studies
 to Understanding Evolution · 20
 Conclusion · 26

3.	Modeling Experimental Evolution Using Individual-Based, Variance-Components Models	31
	<i>Derek A. Roff and Daphne J. Fairbairn</i>	31
	Modeling Approaches	33
	Single-Trait Models	36
	Multiple-Trait Models	43
	A Case Study: Predicting Laboratory Evolution in the Sand Cricket, <i>Gryllus Firmus</i>	51
	Conclusion	58
 PART II: TYPES OF EXPERIMENTAL EVOLUTION • 65		
4.	Experimental Evolution from the Bottom Up	67
	<i>Daniel E. Dykhuizen and Anthony M. Dean</i>	67
	A Bottom-up Analysis of the Lactose System	69
	Other Approaches	82
	Discussion	83
5.	Experimental Evolutionary Domestication	89
	<i>Pedro Simões, Josiane Santos, and Margarida Matos</i>	89
	Evolutionary Domestication: Real-Time Studies in <i>Drosophila Subobscura</i>	93
	Comparative Studies of Domestication	99
	General Issues	104
6.	Long-Term Experimental Evolution and Adaptive Radiation	111
	<i>Michael Travisano</i>	111
	What Is Long-Term Evolution?	112
	The Need for Long-Term Evolution Studies	112
	Successes and Challenges for Long-Term Evolution	114
	Diversification and Specialization	115
	Caution Is Required	126
	How Long Is Long Enough?	127
	Recommendations	128
7.	The Experimental Study of Reverse Evolution	135
	<i>Suzanne Estes and Henrique Teotônio</i>	135
	A Brief History of the Problem of Reversions	136
	Experimental Research on Reverse Evolution	139
	Reverse Evolution and the Inference of Evolutionary Relationships	141
	Contingency and Reverse Evolution	146

	The Population Genetics of Reverse Evolution	150
	Outlook	155
8.	Field Experiments, Introductions, and Experimental Evolution: <i>A Review and Practical Guide</i>	173
	<i>Duncan J. Irschick and David Reznick</i>	173
	Methods for Field Manipulations	175
	What Can We Learn from Field Experiments That We Cannot Learn from Laboratory Studies?	185
	Conclusion	189
	PART III: LEVELS OF OBSERVATION IN EXPERIMENTAL EVOLUTION	195
9.	Fitness, Demography, and Population Dynamics in Laboratory Experiments	197
	<i>Laurence D. Mueller</i>	197
	Early Foundations of Population Biology	198
	Empirical Measures of Fitness	200
	Ecological and Evolutionary Studies of Population Dynamics	204
	Discussion	211
10.	Laboratory Selection Studies of Life-History Physiology in Insects	217
	<i>Anthony J. Zera and Lawrence G. Harshman</i>	217
	Overview	218
	Laboratory Selection: Strengths, Limitations, Caveats	219
	Model Species and Research Topics	221
	Conclusion	251
11.	Behavior and Neurobiology	263
	<i>Justin S. Rhodes and Tadeusz J. Kawecki</i>	263
	Behavior Evolves First	265
	The Evolution of Behavior	266
	Experimental Methods	268
	Examples of Correlated Responses to Selection on Behavior	284
	The Evolution of Mating Systems in Voles: From Genes to Behavior	287
	Testing Adaptive Hypotheses	290
	Relevance for Public Health	291
	Conclusions and Future Directions	291

12. Selection Experiments and Experimental Evolution of Performance and Physiology · 301

John G. Swallow, Jack P. Hayes, Pawel Koteja, and Theodore Garland, Jr. · 301

The Importance of Replication · 305

Experimental Evolution of Mice in Different Thermal Environments · 306

Wind Tunnel Flight in *Drosophila* · 307

Endurance Running and Stress-Induced Analgesia in Mice · 308

Endurance Running in Rats and Voluntary Wheel Running in Mice · 309

Evolution of the Rate of Energy Metabolism in Rodents · 314

Sexual Selection: Effects of Ornaments on Performance · 326

"Experiments" Without Precisely Defined Selection Criteria · 329

Physiological Differences Among Strains of Mice and Breeds of Dog · 331

Conclusion · 333

13. Through a Glass, Clearly: *Experimental Evolution as a Window on Adaptive Genome Evolution* · 353

Frank Rosenzweig and Gavin Sherlock · 353

Adaptive Evolution · 355

Experimental Evolutionary Genomics of Bacteria · 355

Experimental Evolutionary Genomics of Yeast · 376

Opening Windows on Genome Evolution in Higher Eukaryotes · 379

Future Prospects · 380

PART IV: APPLICATIONS OF EXPERIMENTAL EVOLUTION · 389

14. Understanding Evolution Through the Phages · 391

Samantha E. Forde and Christine M. Jessup · 391

The Biology of Phages · 394

Quantitative Models of Phage-Host Systems · 395

The Genetic Basis of Evolutionary Adaptation · 396

Adaptation to Abiotic Conditions: Genotype-by-Environment Interactions · 403

Adaptation to Biotic Conditions · 405

Phylogenetics	411
Implications of Phage Evolution Experiments	412
Conclusion	414
15. Experimental Approaches to Studying the Evolution of Animal Form: <i>The Shape of Things to Come</i>	419
<i>W. Anthony Frankino, Douglas J. Emlen, and Alexander W. Shingleton</i>	419
Mathematical Descriptions of Shape Variation	424
Development, Selection, and the Evolution of Scaling Relationships	428
Incorporating Development into Studies of Shape Evolution	435
Experimental Evolution of Scaling Relationships	440
Special Opportunities Provided by Polyphenic Species with Nonlinear Scaling Relationships	458
Conclusions and Future Directions	460
16. Sexual Exploits in Experimental Evolution	479
<i>Paul E. Turner, Robert C. McBride, and Clifford W. Zeyl</i>	479
Costs and Benefits of Sex	480
Viral Sex	485
Bacterial Sex	495
Eukaryotic Sex	499
What Have We Learned from Sexual Explorations Using Experimental Evolution?	514
17. Physiological Adaptation in Laboratory Environments	523
<i>Allen G. Gibbs and Eran Gefen</i>	523
Environmental Stress in the Laboratory	524
Temperature Stress in <i>Drosophila</i>	524
Temperature Selection in Microbes	526
Laboratory Evolution in Aquatic Environments: Osmotic Stress	527
Resource Limitation in Insects: Survival of the Fattest?	528
Nutritional Selection in Microbial Populations	530
<i>Drosophila</i> in Laboratory Deserts	532
What's the Gene?	537
Unintended Selection in Laboratory Environments	540
Conclusion	542
18. Evolution of Aging and Late Life	551
<i>Cassandra L. Rauser, Laurence D. Mueller, Michael Travisano, and Michael R. Rose</i>	551

	Evolutionary Theories of Aging	• 552
	The Role of Experimental Evolution in Testing Hamiltonian Theories of Aging	• 559
	Evolutionary Biology of Late Life	• 566
	The Impact of Experimental Evolution on Aging Research	• 577
19.	Theoretical and Experimental Approaches to the Evolution of Altruism and the Levels of Selection	• 585
	<i>Benjamin Kerr</i>	• 585
	Theoretical Background	• 590
	Experimental Research	• 597
	Discussion	• 616
20.	Laboratory Experiments on Speciation	• 631
	<i>James D. Fry</i>	• 631
	Key Concepts	• 633
	What Past Experiments Have Taught Us	• 633
	Neglected Questions	• 638
	General Guidelines for Experiments on Speciation	• 649
	Conclusion	• 651
	PART V: CONCLUSION	• 657
21.	A Critique of Experimental Phylogenetics	• 659
	<i>Todd H. Oakley</i>	• 659
	The Perceived Inferiority of Historical Science	• 660
	Testing Phylogenetic Methods	• 662
	Increased Biological Realism	• 665
	Conclusion	• 666
22.	Laboratory Evolution Meets Catch-22: <i>Balancing Simplicity and Realism</i>	• 671
	<i>Raymond B. Huey and Frank Rosenzweig</i>	• 671
	Using LNS to Test Hypotheses Derived from Comparative Studies	• 675
	Problems Associated with Laboratory Adaptation	• 678
	A Case Study: A Selection Experiment at Odds with Field Studies	• 686
	On Modifying LNS Experiments	• 689
	Conclusion	• 691
	Index	• 703