

Contents

1 Systematics 1

- The Fundamentals of Biological Classification 2
- Recovering the Branching Structure 7
- Charting the Twigs and Leaves 10
- Outlook 11
- Basic Bibliography* 11

2 The Great Domains 12

- Toward a New Dichotomy:
"Prokaryotes"—Eukaryotes 13
- The Molecular Revolution: The Three
Domains 15
- Kinship Relationships among the Three
Domains 16
- Biodiversity and Macroevolutionary Patterns
in the Three Great Domains 17
- Basic Bibliography* 19

3 Archaea and Bacteria 20

- Abundance and Diversity of Archaea and
Bacteria 24
- Classification and Collections of Cultures 26
- The Domain Archaea 28
- The Domain Bacteria 29
- Identification and Affiliation of Uncultured
Organisms 32
- Biogeography and Speciation 33
- Basic Bibliography* 34

4 The Domain Eucarya 36

- The Five Supergroups of Eukaryotes 41
- Basic Bibliography* 46

5 The Former "Protists" 48

- Amoebozoa 50
- Rhizaria 52
- Excavata 54

- Cryptophyta and Haptophyta 57
- Heterokonta 57
- Alveolata 58
- Basic Bibliography* 62

6 Plants 64

- Characteristics of Plant Genomes 69
- Phylogenetic Results Contrasted with Previous
Classifications 71
- Evolution of Characters 72
- Evolutionary Tendencies 73
- Biogeography and Biodiversity 73
- Differentiation and Speciation 73
- Principal Questions Remaining 74
- Basic Bibliography* 74

7 Chlorobionts 76

- Characteristics of Chlorobiont Genomes 77
- Phylogenetic Results Contrasted with Previous
Classifications 79
- Evolution of Characters 80
- Evolutionary Tendencies 80
- Biogeography and Biodiversity 81
- Differentiation and Speciation 81
- Principal Questions Remaining 82
- Basic Bibliography* 83

8 Embryophytes 84

- Characteristics of Embryophyte Genomes 87
- Phylogenetic Results Contrasted with Previous
Classifications 91
- Evolution of Characters 91
- Evolutionary Tendencies 92
- Biogeography and Diversity 92
- Differentiation and Speciation 94
- Principal Questions Remaining 94
- Basic Bibliography* 95

9 Tracheophytes 96

- Characteristics of Tracheophyte Genomes 100
- Phylogenetic Results Contrasted with Previous Classifications 100
- Evolution of Characters 103
- Evolutionary Tendencies 103
- Biogeography and Biodiversity 105
- Differentiation and Speciation 107
- Principal Questions Remaining 108
- Basic Bibliography* 108

10 Ferns 110

- Characteristics of Fern Genomes 113
- Phylogenetic Results Contrasted with Previous Classifications 114
- Evolution of Characters 114
- Evolutionary Tendencies 116
- Biogeography and Biodiversity 118
- Differentiation and Speciation 119
- Principal Questions Remaining 120
- Basic Bibliography* 120

11 Conifers 122

- Characteristics of Conifer Genomes 124
- Phylogenetic Results Contrasted with Previous Classifications 125
- Evolution of Characters 127
- Evolutionary Tendencies 127
- Biogeography and Biodiversity 128
- Differentiation and Speciation 129
- Principal Questions Remaining 130
- Basic Bibliography* 130

12 Angiosperms 132

- Characteristics of Angiosperm Genomes 134
- Phylogenetic Results Contrasted with Previous Classifications 135
- Evolution of Characters 139
- Evolutionary Tendencies 139
- Biogeography and Biodiversity 140
- Differentiation and Speciation 140
- Principal Questions Remaining 141
- Basic Bibliography* 142

13 Monocotyledons 144

- Characteristics of Monocotyledon Genomes 147

- Phylogenetic Results Contrasted with Previous Classifications 148
- Evolution of Characters 150
- Evolutionary Tendencies 151
- Biogeography and Biodiversity 153
- Differentiation and Speciation 154
- Principal Questions Remaining 154
- Basic Bibliography* 155

14 Eudicotyledons 156

- Characteristics of Eudicotyledon Genomes 158
- Phylogenetic Results Contrasted with Previous Classifications 160
- Evolution of Characters 160
- Evolutionary Tendencies 162
- Biogeography and Biodiversity 164
- Differentiation and Speciation 165
- Principal Questions Remaining 166
- Basic Bibliography* 166

15 Fungi 168

- Characteristics of Fungi Genomes 172
- Recent Phylogenetic Results Contrasted with Previous Classifications 173
- Evolution of Characters 177
- Evolutionary Tendencies 177
- Biogeography and Biodiversity 177
- Differentiation and Speciation 181
- Principal Questions Remaining 181
- Basic Bibliography* 181

16 Metazoans 182

- Characteristics of Metazoan Genomes 186
- Phylogenetic Results Contrasted with Previous Classifications 188
- Evolution of Characters 194
- Genetics of Embryonic Development 199
- Evolutionary Tendencies 200
- Biogeography and Biodiversity 204
- Differentiation and Speciation 205
- Principal Questions Remaining 205
- Basic Bibliography* 205

17 Eumetazoans 206

- Characteristics of Eumetazoan Genomes 208
- Phylogenetic Results Contrasted with Previous Classifications 211
- Evolution of Characters 212

Evolutionary Tendencies	214
Biogeography and Biodiversity	215
Differentiation and Speciation	216
Principal Questions Remaining	216
<i>Basic Bibliography</i>	216

18 Bilaterians 218

Characteristics of Bilaterian Genomes	220
Phylogenetic Results Contrasted with Previous Classifications	220
Evolution of Characters	222
Evolutionary Tendencies	223
Biogeography and Biodiversity	223
Differentiation and Speciation	226
Principal Questions Remaining	227
<i>Basic Bibliography</i>	227

19 Protostomes 228

Characteristics of Protostome Genomes	230
Evolution of Characters	230
Phylogenetic Results Contrasted with Previous Classifications	230
Evolution of Characters	231
Biogeography and Biodiversity	232
Differentiation and Speciation	232
Principal Questions Remaining	233
<i>Basic Bibliography</i>	233

20 Spiralian 234

Characteristics of Spiralian Genomes	236
Evolution of Characters	236
Phylogenetic Results Contrasted with Previous Classifications	236
Evolutionary Tendencies	238
Biogeography and Biodiversity	238
Differentiation and Speciation	239
Open Questions and the Future of Spiralian Phylogeny	239
Principal Questions Remaining	240
<i>Basic Bibliography</i>	240

21 Molluscs 242

Characteristics of Mollusc Genomes	246
Phylogenetic Results Contrasted with Previous Classifications	247
Evolution of Characters	249
Evolutionary Tendencies	251
Biogeography and Biodiversity	251

Differentiation and Speciation	252
Principal Questions Remaining	253
<i>Basic Bibliography</i>	253

22 Annelids 254

Characteristics of Annelid Genomes	259
Phylogenetic Results Contrasted with Previous Classifications	259
Evolution of Characters	263
Evolutionary Tendencies	264
Biogeography and Biodiversity	266
Differentiation and Speciation	269
Principal Questions Remaining	269
<i>Basic Bibliography</i>	269

23 Platyhelminthes 270

Characteristics of Platyhelminth Genomes	272
Phylogenetic Results Contrasted with Previous Classifications	273
Evolution of Characters	276
Evolutionary Tendencies	277
Biogeography and Biodiversity	278
Differentiation and Speciation	279
Principal Questions Remaining	280
<i>Basic Bibliography</i>	280

24 Ecdysozoans 282

Characteristics of Ecdysozoan Genomes	284
Phylogenetic Results Contrasted with Previous Classifications	284
Evolution of Characters	285
Evolutionary Tendencies	286
Biogeography and Biodiversity	287
Differentiation and Speciation	288
Principal Questions Remaining	289
<i>Basic Bibliography</i>	289

25 Nematodes 290

Characteristics of Nematode Genomes	292
Phylogenetic Results Contrasted with Previous Classifications	292
Evolution of Characters	296
Evolutionary Tendencies	301
Biogeography and Biodiversity	301
Differentiation and Speciation	302
Principal Questions Remaining	302
<i>Basic Bibliography</i>	302

26 Panarthropods 304

- Characteristics of Panarthropod Genomes 306
- Phylogenetic Results Contrasted with Previous Classifications 306
- Evolution of Characters 310
- Evolutionary Tendencies 311
- Biogeography and Biodiversity 311
- Differentiation and Speciation 312
- Principal Questions Remaining 313
- Basic Bibliography* 314

27 Chelicerates 316

- Characteristics of Chelicerate Genomes 318
- Phylogenetic Results Contrasted with Previous Classifications 320
- Evolution of Characters 322
- Evolutionary Tendencies 322
- Biogeography and Biodiversity 324
- Differentiation and Speciation 324
- Principal Questions Remaining 325
- Basic Bibliography* 325

28 Mandibulates 326

- Characteristics of Mandibulate Genomes 330
- Phylogenetic Results Contrasted with Previous Classifications 330
- Evolution of Characters 333
- Evolutionary Tendencies 334
- Biogeography and Biodiversity 334
- Differentiation and Speciation 335
- Principal Questions Remaining 336
- Basic Bibliography* 336

29 Hexapods 338

- Characteristics of Hexapod Genomes 340
- Phylogenetic Results Contrasted with Previous Classifications 342
- Evolution of Characters 348
- Evolutionary Tendencies 348
- Biogeography and Biodiversity 349
- Differentiation and Speciation 350
- Principal Questions Remaining 350
- Basic Bibliography* 350

30 Odonates 352

- Characteristics of Odonate Genomes 354

Phylogenetic Results Contrasted with Previous Classifications 356

- Evolution of Characters 357
- Evolutionary Tendencies 361
- Biogeography and Biodiversity 361
- Differentiation and Speciation 362
- Principal Questions Remaining 363
- Basic Bibliography* 363

31 Orthopterans 364

- Characteristics of Orthopteran Genomes 367
- Phylogenetic Results Contrasted with Previous Classifications 369
- Evolution of Characters 372
- Evolutionary Tendencies 373
- Biogeography and Biodiversity 374
- Differentiation and Speciation 377
- Principal Questions Remaining 378
- Basic Bibliography* 378

32 Hemipterans 380

- Characteristics of Hemipteran Genomes 382
- Phylogenetic Results Contrasted with Previous Classifications 384
- Evolution of Characters 385
- Evolutionary Tendencies 387
- Biogeography and Biodiversity 388
- Differentiation and Speciation 392
- Principal Questions Remaining 392
- Basic Bibliography* 392

33 Hymenopterans 394

- Characteristics of Hymenopteran Genomes 396
- Phylogenetic Results Contrasted with Previous Classifications 398
- Evolution of Characters 400
- Evolutionary Tendencies 400
- Biogeography and Biodiversity 402
- Differentiation and Speciation 402
- Principal Questions Remaining 405
- Basic Bibliography* 406

34 Coleopterans 408

- Characteristics of Coleopteran Genomes 410
- Phylogenetic Results Contrasted with Previous Classifications 410
- Evolution of Characters 415
- Evolutionary Tendencies 416

Biogeography and Biodiversity 417
 Differentiation and Speciation 417
Principal Questions Remaining 417
Basic Bibliography 418

35 Dipterans 420

Characteristics of Dipteran Genomes 422
 Phylogenetic Results Contrasted with Previous Classifications 422
 Evolution of Characters 425
 Evolutionary Tendencies 426
 Biogeography and Biodiversity 426
 Differentiation and Speciation 426
Principal Questions Remaining 427
Basic Bibliography 427

36 Lepidopterans 428

Characteristics of Lepidopteran Genomes 430
 Phylogenetic Results Contrasted with Previous Classifications 431
 Evolution of Characters 433
 Evolutionary Tendencies 433
 Biogeography and Biodiversity 435
 Differentiation and Speciation 435
Principal Questions Remaining 437
Basic Bibliography 438

37 Deuterostomes 440

Characteristics of Deuterostome Genomes 442
 Phylogenetic Results Contrasted with Previous Classifications 442
 Evolution of Characters 444
 Evolutionary Tendencies 446
 Biogeography and Biodiversity 446
 Differentiation and Speciation 447
Principal Questions Remaining 447
Basic Bibliography 447

38 Echinoderms 448

Characteristics of Echinoderm Genomes 450
 Phylogenetic Results Contrasted with Previous Classifications 451
 Evolution of Characters 452
 Evolutionary Tendencies 456
 Biogeography and Biodiversity 457
 Differentiation and Speciation 458
Principal Questions Remaining 459
Basic Bibliography 459

39 Chordates 460

Characteristics of Chordate Genomes 464
 Phylogenetic Results Contrasted with Previous Classifications 465
 Evolution of Characters 465
 Evolutionary Tendencies 466
 Biogeography and Biodiversity 467
 Differentiation and Speciation 467
Principal Questions Remaining 468
Basic Bibliography 468

40 Actinopterygians 470

Characteristics of Actinopterygian Genomes 473
 Phylogenetic Results Contrasted with Previous Classifications 474
 Evolution of Characters 474
 Evolutionary Tendencies 474
 Biogeography and Biodiversity 476
 Differentiation and Speciation 479
Principal Questions Remaining 480
Basic Bibliography 482

41 Sarcopterygians 484

Characteristics of Sarcopterygian Genomes 486
 Phylogenetic Results Contrasted with Previous Classifications 487
 Evolution of Characters 489
 Evolutionary Tendencies 489
 Biogeography and Biodiversity 490
 Differentiation and Speciation 491
Principal Questions Remaining 492
Basic Bibliography 492

42 Amphibians 494

Characteristics of Amphibian Genomes 496
 Phylogenetic Results Contrasted with Previous Classifications 497
 Evolution of Characters 499
 Evolutionary Tendencies 499
 Biogeography and Biodiversity 500
 Differentiation and Speciation 501
Principal Questions Remaining 501
Basic Bibliography 501

43 Mammals 502

- Characteristics of Mammal Genomes 505
- Phylogenetic Results Contrasted with Previous Classifications 507
- Evolution of Characters 507
- Evolutionary Tendencies 510
- Biogeography and Biodiversity 513
- Differentiation and Speciation 517
- Principal Questions Remaining 518
- Basic Bibliography* 518

44 Sauropsids 520

- Characteristics of Sauropsid Genomes 522
- Phylogenetic Results Contrasted with Previous Classifications 524
- Evolution of Characters 526
- Evolutionary Tendencies 528
- Biogeography and Biodiversity 528
- Differentiation and Speciation 529
- Principal Questions Remaining 529
- Basic Bibliography* 529

45 Aves 530

- Characteristics of Aves Genomes 533
- Phylogenetic Results Contrasted with Previous Classifications 534
- Evolution of Characters 534
- Evolutionary Tendencies 534
- Biogeography and Biodiversity 535
- Differentiation and Speciation 539
- Principal Questions Remaining 540
- Basic Bibliography* 540

46 Speciation 541

- Biological Species: Reproductive Isolation as By-product 542
- Are Geographical Barriers Necessary? Sympatric Speciation 542
- Networks Compared to Trees of Life: Hybrid Speciation 547
- The Cohesive Species: Gene Flow Compared to Selection and Drift 552
- Basic Bibliography* 554

47 Biogeography 555

- Dispersalism and Centers of Origin 556
- Vicariance and Cladistic Biogeography 560
- Event-Based Biogeography 564

- Molecular Systematics and the Dispersalist Counterrevolution 567
- Probabilistic or Parametric Biogeography 570
- Phylogeography 572
- New Perspectives: Integration with Ecological Biogeography 574
- Conclusions 574
- Basic Bibliography* 575

48 Evolution on Islands 577

- Historical Notes on the Study of Evolution on Islands 577
- Continental Islands and Oceanic Islands 578
- The Canary Islands 579
- The Hawaiian Islands 584
- The Galápagos Islands 588
- Basic Bibliography* 594

49 Evolutionary Ecology 595

- Evolutionary Mechanisms 596
- Mechanisms That Modify Allele Frequency 597
- Natural Selection Types 599
- The Importance of Phylogeny to Evolutionary Ecology and Vice Versa 601
- Phylogenetic and Molecular Methods Used in Evolutionary Ecology 603
- The Concept of Adaptive Radiation 606
- Detection of Adaptive Radiations 608
- Detection Problems and Non-Adaptive Radiations 610
- Detection of Positive Selection and Molecular Adaptation 610
- Basic Bibliography* 611

50 Evolution of Behavior 613

- Major Behavioral Issues for Which Understanding Phylogenetic Relationships Is Necessary 614
- The Importance of Behavior for Phylogeny, Phylogeography, and Speciation 619
- Basic Bibliography* 619

51 Phylogenies and the Evolution of Development 621

- Phylogenies Are Important for Inferring Ancestral States of Development during Evolution 621
- Phylogenies Are Important for Inferring Evolutionary Modes of Development 623

- Phylogenies Are Important for Distinguishing between Homology and Convergence of Developmental Genes and Processes 625
 Phylogenies Are Important for Selecting Study Taxa in EDB 627

Basic Bibliography 628

52 Symbiosis 629

- Distribution of Symbiosis 630
 Establishment of Symbioses: Functional Analysis of the Host-Symbiont Interaction 633
 Is Mutualistic Symbiosis an Attenuated Parasitism? 634

Genomic Reduction, Replacement, and Complementation 636

Basic Bibliography 637

53 Phylogenetic Techniques and Markers 639

- Types of Markers 640
 Considerations on the Use of Molecular Markers 646

Basic Bibliography 649

54 Reconstruction of Phylogenetic Trees 651

- Phylogenetic Characters 651
 Phylogenetic Reconstruction Methods 655
 Phylogenetic Reliability 657
 Uses of Phylogenetic Trees 659
 Software 660

Basic Bibliography 661

55 Analysis of Genetic Variation and Intraspecific Phylogenies 663

- Gene Tree and Species Tree 663
 The Coalescent Theory 664
 DNA Polymorphism: Data Analysis and Interpretation 667
 Probabilistic Model Selection and Parameter Estimation 668
 Applications in Evolutionary Inference 671
Basic Bibliography 673

Illustration Credits 674

Index 677