

Contents in Brief

About the Authors ix

Preface x

- 1** What Is Plant Biology? 1
 - 2** The Nature of Life 13
 - 3** Cells 29
 - 4** Tissues 53
 - 5** Roots and Soils 65
 - 6** Stems 85
 - 7** Leaves 104
 - 8** Flowers, Fruits, and Seeds 124
 - 9** Water in Plants 147
 - 10** Plant Metabolism 164
 - 11** Growth and Development 191
 - 12** Meiosis and Alternation of Generations 216
 - 13** Genetics and Molecular Biology 226
 - 14** Plant Breeding, Propagation, and Biotechnology 249
 - 15** Evolution 268
 - 16** Plant Names and Classification 282
 - 17** Domain (Kingdom) Bacteria, Domain (Kingdom) Archaea, and Viruses 298
 - 18** Kingdom Protista 322
 - 19** Kingdom Fungi 351
 - 20** Introduction to the Plant Kingdom: Bryophytes 376
 - 21** The Seedless Vascular Plants: Ferns and Their Relatives 391
 - 22** Introduction to Seed Plants: Gymnosperms 416
 - 23** Seed Plants: Angiosperms 435
 - 24** Flowering Plants and Civilization 455
 - 25** Ecology 481
 - 26** Biomes 506
-
- Appendix 1** Scientific Names of Organisms Mentioned in the Text 518
 - Appendix 2** Biological Controls 537
 - Appendix 3** Useful and Poisonous Plants, Fungi, and Algae 544
 - Appendix 4** House Plants and Home Gardening 569
 - Appendix 5** Metric Equivalents and Conversion Tables 593

Glossary G1

Photo Credits C1

Index I1

Contents

About the Authors ix

Preface x

1 What Is Plant Biology? 1

- Overview 2
- Learning Outcomes 2
- The Relationship of Humans to Their Environment 3
- KEY THEME: ecology** Who Needs Plants? 4
- Botany as a Science 7
- Diversification of Plant Study 7
- Plant Biology and the Internet 9
- SUMMARY 11
- REVIEW QUESTIONS 11
- DISCUSSION QUESTIONS 11
- ADDITIONAL READING 11
- LEARNING ONLINE 12

2 The Nature of Life 13

- Overview 14
- Learning Outcomes 14
- Attributes of Living Organisms 14
- Chemical and Physical Bases of Life 15
- KEY THEME: molecular** The Skinny on Fats 23
- SUMMARY 27
- REVIEW QUESTIONS 28
- DISCUSSION QUESTIONS 28
- ADDITIONAL READING 28
- LEARNING ONLINE 28

3 Cells 29

- Overview 30
- Learning Outcomes 30
- Cells 30
- Eukaryotic versus Prokaryotic Cells 33
- Cell Structure and Communication 33
- Cellular Components 36
- Cellular Reproduction 44
- Microscapes 48
- Higher Plant Cells versus Animal Cells 50
- SUMMARY 51
- REVIEW QUESTIONS 52
- DISCUSSION QUESTIONS 52
- ADDITIONAL READING 52
- LEARNING ONLINE 52

4 Tissues 53

- Overview 54
- Learning Outcomes 54
- Meristematic Tissues 54
- KEY THEME: molecular** Chimeras and Variegated Leaves 55
- Tissues Produced by Meristems 56
- KEY THEME: ecology** Plants and Environment 61
- SUMMARY 63
- REVIEW QUESTIONS 64
- DISCUSSION QUESTIONS 64
- ADDITIONAL READING 64
- LEARNING ONLINE 64

5 Roots and Soils 65

- Overview 66
- Learning Outcomes 66
- How Roots Develop 66
- Root Structure 67
- Specialized Roots 71
- KEY THEME: ecology** Plants Need Roots 75
- Mycorrhizae 76
- Root Nodules 77
- Human Relevance of Roots 77
- Soils 78
- KEY THEME: ecology** Metal-Munching Plants 81
- SUMMARY 82
- REVIEW QUESTIONS 83
- DISCUSSION QUESTIONS 83
- ADDITIONAL READING 84
- LEARNING ONLINE 84

6 Stems 85

- Overview 86
- Learning Outcomes 86
- External Form of a Woody Twig 86
- Origin and Development of Stems 87
- KEY THEME: ecology** Standing in Fields of Stone 88
- Tissue Patterns in Stems 90
- KEY THEME: ecology** Dendroclimatology 92

Specialized Stems 97
 Wood and Its Uses 99
 SUMMARY 102
 REVIEW QUESTIONS 103
 DISCUSSION QUESTIONS 103
 ADDITIONAL READING 103
 LEARNING ONLINE 103

7 Leaves 104

Overview 105
 Learning Outcomes 105
 Leaf Arrangements and Types 106
 Internal Structure of Leaves 107
 Stomata 108
 Mesophyll and Veins 110
 Specialized Leaves 111
KEY THEME: ecology More on Leaf
 Structure 112
 Autumnal Changes in Leaf Color 119
 Abscission 120
 Human and Ecological Relevance
 of Leaves 121
 Glass Cuts from Grass? 122
 SUMMARY 122
 REVIEW QUESTIONS 123
 DISCUSSION QUESTIONS 123
 ADDITIONAL READING 123
 LEARNING ONLINE 123

8 Flowers, Fruits, and Seeds 124

Overview 125
 Learning Outcomes 125
 Differences between Dicots and
 Monocots 128
 Structure of Flowers 128
 Fruits 129
KEY THEME: ecology Goober Peas 131
 Fruit and Seed Dispersal 137
 Seeds 141
 The Seed That Slept for 1,200 Years 144
 SUMMARY 145
 REVIEW QUESTIONS 146
 DISCUSSION QUESTIONS 146
 ADDITIONAL READING 146
 LEARNING ONLINE 146

9 Water in Plants 147

Overview 148
 Learning Outcomes 148
 Molecular Movement 149
 Measuring Water Potential and
 Psychrometry 151

Water and Its Movement through the Plant 153
 Regulation of Transpiration 156
 Transport of Food Substances (Organic
 Solutes) in Solution 157
 Mineral Requirements for Growth 159
 SUMMARY 162
 REVIEW QUESTIONS 162
 DISCUSSION QUESTIONS 162
 ADDITIONAL READING 163
 LEARNING ONLINE 163

10 Plant Metabolism 164

Overview 165
 Learning Outcomes 165
 Enzymes and Energy Transfer 166
 Photosynthesis 166
 Photosynthesis and Pizza 176
 Respiration 180
 Additional Metabolic Pathways 186
 Assimilation and Digestion 187
 SUMMARY 187
KEY THEME: ecology Photosynthesis, Global
 Warming, and Tropical Rain Forests 188
 REVIEW QUESTIONS 190
 DISCUSSION QUESTIONS 190
 ADDITIONAL READING 190
 LEARNING ONLINE 190

11 Growth and Development 191

Overview 192
 Learning Outcomes 192
 Nutrients, Vitamins, and Hormones 192
 Plant Hormones beyond “The Classic Five” 200
 Hormonal Interactions 201
 Other Hormonal Interactions 201
 Plant Movements 202
 Photoperiodism 209
 Phytochromes and Cryptochromes 210
 A Flowering Hormone? 211
 Temperature and Growth 212
 Dormancy and Quiescence 213
 SUMMARY 214
 REVIEW QUESTIONS 215
 DISCUSSION QUESTIONS 215
 ADDITIONAL READING 215
 LEARNING ONLINE 215

12 Meiosis and Alternation of Generations 216

Overview 217
 Learning Outcomes 217
 The Phases of Meiosis 218

KEY THEME : ecology Why Plants Have a Sex

Life 219

Alternation of Generations 222

KEY THEME : molecular FISH and GISH Molecular

Techniques 223

SUMMARY 224

REVIEW QUESTIONS 224

DISCUSSION QUESTIONS 224

ADDITIONAL READING 225

LEARNING ONLINE 225

13 Genetics and Molecular Biology 226

Overview 227

Learning Outcomes 227

Molecular Genetics 228

KEY THEME : molecular Massive DNA

Sequencing 230

KEY THEME : molecular The Polymerase

Chain Reaction (PCR) 232

Cytogenetics 237

Mendelian Genetics 238

Quantitative Traits 244

Extranuclear DNA 245

Linkage and Mapping 245

The Hardy-Weinberg Law 247

SUMMARY 247

REVIEW QUESTIONS 248

DISCUSSION QUESTIONS 248

ADDITIONAL READING 248

LEARNING ONLINE 248

14 Plant Breeding, Propagation, and Biotechnology 249

Overview 250

Learning Outcomes 250

Crop Plant Evolution 250

Plant Breeding 252

Plant Propagation 260

SUMMARY 266

REVIEW QUESTIONS 266

DISCUSSION QUESTIONS 267

ADDITIONAL READING 267

LEARNING ONLINE 267

15 Evolution 268

Overview 269

Learning Outcomes 269

An Introduction to Evolution 269

A Brief Overview of the Early Development of Evolutionary Concepts 271

Charles Darwin 273

Evidence for Evolution 274

Microevolution—Evolution within Species 275

Rates of Evolution 276

Macroevolution—How Species Evolve 276

The Role of Polyploidy in Evolution 278

Discussion 279

KEY THEME : evolution Our Daily Bread 280

SUMMARY 280

REVIEW QUESTIONS 281

DISCUSSION QUESTIONS 281

ADDITIONAL READING 281

LEARNING ONLINE 281

16 Plant Names and Classification 282

Overview 283

Learning Outcomes 283

Development of the Binomial System of Nomenclature 283

Development of the Kingdom Concept 286

Classification of Major Groups 287

Species Concepts 292

A Key to Major Groups of Organisms (Exclusive of Kingdom Animalia) 294

The Future of Plant Classification 296

SUMMARY 296

REVIEW QUESTIONS 297

DISCUSSION QUESTIONS 297

ADDITIONAL READING 297

LEARNING ONLINE 297

17 Domain (Kingdom) Bacteria, Domain (Kingdom) Archaea, and Viruses 298

Overview 299

Learning Outcomes 299

Features of Domains (Kingdoms) Bacteria and Archaea 300

Domain (Kingdom) Bacteria—the True Bacteria 303

Human Relevance of the Unpigmented, Purple, and Green Sulfur Bacteria 303

KEY THEME : ecology The Social Life of Prokaryotes 304

Class Cyanobacteriae—the Cyanobacteria (Blue-Green Bacteria) 310

Class Prochlorobacteriae—the Prochlorobacteria 313

Domain (Kingdom) Archaea—the Archaeobacteria 313

Viruses 315

KEY THEME : **molecular** Plant Viruses 316

Viroids and Prions 320

SUMMARY 320

REVIEW QUESTIONS 321

DISCUSSION QUESTIONS 321

ADDITIONAL READING 321

LEARNING ONLINE 321

18 Kingdom Protista 322

Overview 323

Learning Outcomes 323

Features of Kingdom Protista 324

Algae 324

Phylum Chlorophyta—the Green

Algae 324

Phylum Chromophyta—the Yellow-Green

Algae, Golden-Brown Algae, Diatoms,
and Brown Algae 331

Phylum Rhodophyta—the Red Algae 336

Phylum Euglenophyta—the Euglenoids 337

Phylum Dinophyta—the Dinoflagellates 338

Phylum Cryptophyta—the

Cryptomonads 340

Phylum Prymnesiophyta (Haptophyta)—the

Haptophytes 340

Phylum Charophyta—the Stoneworts 340

Human and Ecological Relevance of the

Algae 341

Other Members of Kingdom Protista 344

Phylum Myxomycota—the Plasmodial

Slime Molds 345

Phylum Dictyosteliomycota—the Cellular

Slime Molds 346

Phylum Oomycota—the Water Molds 346

SUMMARY 348

REVIEW QUESTIONS 349

DISCUSSION QUESTIONS 350

ADDITIONAL READING 350

LEARNING ONLINE 350

19 Kingdom Fungi 351

Overview 352

Learning Outcomes 352

Distinctions Between Kingdoms Protista

and Fungi 352

Kingdom Fungi 353

Lichens 371

SUMMARY 373

REVIEW QUESTIONS 374

DISCUSSION QUESTIONS 375

ADDITIONAL READING 375

LEARNING ONLINE 375

20 Introduction to the Plant Kingdom: Bryophytes 376

Overview 377

Learning Outcomes 377

Introduction to the Bryophytes 378

Phylum Hepaticophyta—Liverworts 379

Phylum Anthocerotophyta—Hornworts 383

Phylum Bryophyta—Mosses 383

KEY THEME : **ecology** Hibernating Mosses 387

Human and Ecological Relevance of

Bryophytes 388

SUMMARY 388

REVIEW QUESTIONS 389

DISCUSSION QUESTIONS 389

ADDITIONAL READING 390

LEARNING ONLINE 390

21 The Seedless Vascular Plants: Ferns and Their Relatives 391

Overview 392

Learning Outcomes 392

Phylum Psilotophyta—the Whisk Ferns 392

Phylum LycopHYta—the Ground Pines, Spike
Mosses, and Quillworts 394

Phylum Equisetophyta—the Horsetails
and Scouring Rushes 400

Phylum Polypodiophyta—the Ferns 404

Fossils 411

KEY THEME : **ecology** Ferns and Fossil

Fuels 412

SUMMARY 413

REVIEW QUESTIONS 414

DISCUSSION QUESTIONS 414

ADDITIONAL READING 414

LEARNING ONLINE 415

22 Introduction to Seed Plants: Gymnosperms 416

Overview 417

Learning Outcomes 417

Phylum Pinophyta—the Conifers 418

KEY THEME : **ecology** Resilient and Useful
Gymnosperms 419

Other Gymnosperms 422

Human Relevance of Gymnosperms 427

KEY THEME : **evolution** A Living Fossil? 432

SUMMARY 433

REVIEW QUESTIONS 434

DISCUSSION QUESTIONS 434

ADDITIONAL READING 434

LEARNING ONLINE 434

23 Seed Plants: Angiosperms 435

Overview 436

Learning Outcomes 436

Phylum Magnoliophyta—the Flowering Plants 437

KEY THEME : molecular The Difference between “n” and “x” in Plant Life Cycles 444

Pollination Ecology 446

Herbaria and Plant Preservation 450

SUMMARY 453

REVIEW QUESTIONS 453

DISCUSSION QUESTIONS 454

ADDITIONAL READING 454

LEARNING ONLINE 454

24 Flowering Plants and Civilization 455

Overview 456

Learning Outcomes 456

Origin of Cultivated Plants 456

Selected Families of Flowering Plants 457

Dicots (Now Recognized in Two Groups) 459

Monocots 474

KEY THEME : ecology Wild Rice—More Than Just Food 476

KEY THEME : ecology Coffee and Caffeine 478

SUMMARY 479

REVIEW QUESTIONS 479

DISCUSSION QUESTIONS 480

ADDITIONAL READING 480

LEARNING ONLINE 480

25 Ecology 481

Overview 482

Learning Outcomes 482

Plants and the Environment 482

Life Histories 487

Natural Cycles 488

Succession 491

KEY THEME : ecology Plant Population Ecology 491

Impact of Humans on Plant Communities 496

Loss of Biodiversity 499

Restoration of the Land 501

KEY THEME : ecology John Muir, Father of America’s National Park System 502

SUMMARY 503

REVIEW QUESTIONS 504

DISCUSSION QUESTIONS 504

ADDITIONAL READING 504

LEARNING ONLINE 505

26 Biomes 506

Overview 507

Learning Outcome 507

Major Biomes of the World 507

KEY THEME : ecology Alpine Flora as an Indication of Climate Change: The Gloria Project 512

SUMMARY 516

REVIEW QUESTIONS 517

DISCUSSION QUESTIONS 517

ADDITIONAL READING 517

LEARNING ONLINE 517

Appendix 1 Scientific Names of Organisms Mentioned in the Text A1

Appendix 2 Biological Controls A20

General Controls A20

Specific Controls A22

Companion Planting A22

Additional Reading A26

Appendix 3 Useful and Poisonous Plants, Fungi, and Algae A27

Wild Edible Plants, Fungi, and Algae A27

Poisonous Plants and Fungi A27

Medicinal Plants, Fungi, and Algae A27

Hallucinogenic Plants A45

Spice Plants A45

Dye Plants A45

Additional Reading A51

Appendix 4 House Plants and Home Gardening A52

Growing House Plants A52

Common House Plants A53

Growing Vegetables A62

Common Vegetables and their Nutritional Values A63

Pruning A68

Major Types of Grafting A69

Additional Reading A75

Appendix 5 Metric Equivalents and Conversion Tables A76

Glossary G1

Photo Credits C1

Index I1