

Contents

Preface xi

1 What Is Plant Biology? 1

Chapter Outline 1
Overview 2
Some Learning Goals 2
The Relationship of Humans to Their Environment 4
Botany as a Science 7
Diversification of Plant Study 8
Plant Sciences Inquiry: Plant Biology and the Web 10
Summary 11
Review Questions 12
Discussion Questions 12
Additional Reading 12

2 The Nature of Life 13

Chapter Outline 13
Overview 14
Some Learning Goals 14
Attributes of Living Organisms 14
Chemical and Physical Bases of Life 15
Summary 27
Review Questions 28
Discussion Questions 28
Additional Reading 28

3 Cells 29

Chapter Outline 29
Overview 30
Some Learning Goals 30
Cells 30
Eukaryotic Versus Prokaryotic Cells 33
Cell Structure and Communication 33
Cellular Components 36
Cellular Reproduction 44
Plant Sciences Inquiry: Microscapes 49
Higher Plant Cells Versus Animal Cells 50
Summary 51
Review Questions 52
Discussion Questions 52
Additional Reading 52

4 Tissues 53

Chapter Outline 53
Overview 54
Some Learning Goals 54
Meristematic Tissues 54
Tissues Produced by Meristems 55
Summary 62
Review Questions 63
Discussion Questions 63
Additional Reading 63

5 Roots and Soils 64

Chapter Outline 64
Overview 65
Some Learning Goals 65
How Roots Develop 65
Root Structure 66
Specialized Roots 70
Mycorrhizae 74
Root Nodules 75
Human Relevance of Roots 75
Soils 77
Plant Sciences Inquiry: Metal-Munching Plants 80
Summary 81
Review Questions 82
Discussion Questions 82
Additional Reading 82

6 Stems 84

Chapter Outline 84
Overview 85
Some Learning Goals 85
External Form of a Woody Twig 85
Origin and Development of Stems 86
Plant Sciences Inquiry: Standing in Fields of Stone 87
Tissue Patterns in Stems 89
Specialized Stems 96
Wood and Its Uses 99
Summary 104
Review Questions 105
Discussion Questions 105
Additional Reading 105

7**Leaves 106**

- Chapter Outline 106
- Overview 107
- Some Learning Goals 107
- Leaf Arrangements and Types 108
- Internal Structure of Leaves 109
- Stomata 110
- Mesophyll and Veins 111
- Specialized Leaves 113
- Autumnal Changes in Leaf Color 122
- Abscission 122
- Human and Ecological Relevance of Leaves 123
- Plant Sciences Inquiry: Glass Cuts from Grass? 124
- Summary 124
- Review Questions 125
- Discussion Questions 125
- Additional Reading 125

8**Flowers, Fruits, and Seeds 126**

- Chapter Outline 126
- Overview 127
- Some Learning Goals 127
- Note to the Reader: 127
- Differences Between Dicots and Monocots 129
- Structure of Flowers 131
- Fruits 132
- Fruit and Seed Dispersal 139
- Seeds 143
- Plant Sciences Inquiry: The Seed That Slept for 1,200 Years 146
- Summary 147
- Review Questions 148
- Discussion Questions 148
- Additional Reading 148

9**Water in Plants 149**

- Chapter Outline 149
- Overview 150
- Some Learning Goals 150
- Molecular Movement 151
- Water and Its Movement Through the Plant 155
- Regulation of Transpiration 157
- Transport of Food Substances (Organic Solutes) in Solution 159
- Mineral Requirements for Growth 160

- Summary 163
- Review Questions 163
- Discussion Questions 164
- Additional Reading 164

10**Plant Metabolism 165**

- Chapter Outline 165
- Overview 166
- Some Learning Goals 166
- Enzymes and Energy Transfer 166
- Photosynthesis 167
- Plant Sciences Inquiry: Photosynthesis and Pizza 176
- Respiration 180
- Additional Metabolic Pathways 185
- Assimilation and Digestion 187
- Plant Sciences Inquiry: Greenhouse Gases and Plant Growth 187
- Summary 188
- Review Questions 189
- Discussion Questions 190
- Additional Reading 190

11**Growth 191**

- Chapter Outline 191
- Overview 192
- Some Learning Goals 192
- Nutrients, Vitamins, and Hormones 192
- Hormonal Interactions 199
- Other Hormonal Interactions 200
- Plant Movements 200
- Photoperiodism 208
- Phytochromes and Cryptochromes 209
- A Flowering Hormone? 210
- Temperature and Growth 211
- Dormancy and Quiescence 211
- Summary 212
- Review Questions 213
- Discussion Questions 213
- Additional Reading 214

12**Meiosis and Alternation of Generations 215**

- Chapter Outline 215
- Overview 216
- Some Learning Goals 216
- The Phases of Meiosis 217
- Alternation of Generations 221

Summary 222
 Review Questions 222
 Discussion Questions 222
 Additional Reading 223

13 Genetics 224

Chapter Outline 224
 Overview 225
 Some Learning Goals 225
 Molecular Genetics 226
Plant Sciences Inquiry: The Polymerase Chain Reaction (PCR) 229
 Cytogenetics 234
 Mendelian Genetics 235
 Quantitative Traits 242
 Extranuclear DNA 242
 Linkage and Mapping 242
 The Hardy-Weinberg Law 244
 Summary 244
 Review Questions 245
 Discussion Questions 245
 Additional Reading 245

14 Plant Breeding and Propagation 246

Chapter Outline 246
 Overview 247
 Some Learning Goals 247
 Crop Plant Evolution 247
 Plant Breeding 249
 Plant Propagation 258
 Summary 264
 Review Questions 264
 Discussion Questions 265
 Additional Reading 265

15 Evolution 266

Chapter Outline 266
 Overview 267
 Some Learning Goals 267
 A Brief Overview of the Early Development of Evolutionary Concepts 267
 Charles Darwin 268
 Evidence for Evolution 269
 Microevolution—Evolution Within Species 270
 Rates of Evolution 272
 Macroevolution—How Species Evolve 272
 The Role of Hybridization in Evolution 274

Discussion 276
 Summary 277
 Review Questions 277
 Discussion Questions 277
 Additional Reading 277

16 Plant Names and Classification 279

Chapter Outline 279
 Overview 280
 Some Learning Goals 280
 Development of the Binomial System of Nomenclature 281
 Development of the Kingdom Concept 283
 Classification of Major Groups 283
 Cladistics 287
 A Key to Major Groups of Organisms (Exclusive of Kingdom Animalia) 288
 The Future of Plant Classification 289
 Summary 290
 Review Questions 291
 Discussion Questions 291
 Additional Reading 291

17 Domain (Kingdom) Bacteria, Domain (Kingdom) Archaea, and Viruses 292

Chapter Outline 292
 Overview 293
 Some Learning Goals 293
 Features of Kingdoms (Domains) Bacteria and Archaea 294
 Domain Bacteria (Kingdom Bacteria)—The True Bacteria 297
 Human Relevance of the Unpigmented, Purple, and Green Sulfur Bacteria 297
 Class Cyanobacteriae—The Cyanobacteria (Blue-Green Bacteria) 303
 Class Prochlorobacteriae—The Prochlorobacteria 307
 Kingdom Archaea (Domain Archaea)—The Archaeobacteria 307
 Viruses 309
Plant Sciences Inquiry: Plant Viruses 311
 Viroids and Prions 314
 Summary 314
 Review Questions 315
 Discussion Questions 315
 Additional Reading 316

18 Kingdom Protista 317

- Chapter Outline 317
- Overview 318
- Some Learning Goals 318
- Features of Kingdom Protista 318
- Algae 319
 - Phylum Chlorophyta—The Green Algae 319
 - Phylum Chromophyta—The Yellow-Green Algae, Golden-Brown Algae, Diatoms, and Brown Algae 326
 - Phylum Rhodophyta—The Red Algae 330
 - Phylum Euglenophyta—The Euglenoids 333
 - Phylum Dinophyta—The Dinoflagellates 333
 - Phylum Cryptophyta—The Cryptomonads 334
 - Phylum Prymnesiophyta (Haptophyta)—The Haptophytes 335
 - Phylum Charophyta—The Stoneworts 335
- Human and Ecological Relevance of the Algae 336
- Other Members of Kingdom Protista 339
- Phylum Myxomycota—The Plasmodial Slime Molds 339
- Phylum Dictyosteliomycota—The Cellular Slime Molds 341
- Phylum Oomycota—The Water Molds 343
- Summary 343
- Review Questions 344
- Discussion Questions 344
- Additional Reading 345

19 Kingdom Fungi 346

- Chapter Outline 346
- Overview 347
- Some Learning Goals 347
- Distinctions Between Kingdoms Protista and Fungi 347
- Kingdom Fungi—The True Fungi 348
- Lichens 365
- Summary 368
- Review Questions 369
- Discussion Questions 370
- Additional Reading 370

20 Introduction to the Plant Kingdom: Bryophytes 371

- Chapter Outline 371
- Overview 372
- Some Learning Goals 372

- Introduction to the Bryophytes 372
- Phylum Hepaticophyta—Liverworts 375
- Phylum Anthocerotophyta—Hornworts 378
- Phylum Bryophyta—Mosses 379
- Plant Sciences Inquiry:** Hibernating Mosses 382
- Human and Ecological Relevance of Bryophytes 383
- Summary 383
- Review Questions 384
- Discussion Questions 384
- Additional Reading 384

21 The Seedless Vascular Plants: Ferns and Their Relatives 385

- Chapter Outline 385
- Overview 386
- Some Learning Goals 386
- Phylum Psilotophyta—The Whisk Ferns 386
- Phylum Lycopphyta—The Ground Pines, Spike Mosses, and Quillworts 388
- Phylum Equisetophyta—The Horsetails and Scouring Rushes 394
- Phylum Polypodiophyta—The Ferns 398
- Fossils 405
- Summary 407
- Review Questions 407
- Discussion Questions 408
- Additional Reading 408

22 Introduction to Seed Plants: Gymnosperms 409

- Chapter Outline 409
- Overview 410
- Some Learning Goals 410
- Phylum Pinophyta—The Conifers 411
- Other Gymnosperms 416
- Human Relevance of Gymnosperms 419
- Plant Sciences Inquiry:** A Living Fossil? 424
- Summary 425
- Review Questions 426
- Discussion Questions 426
- Additional Reading 427

23 Seed Plants: Angiosperms 428

- Chapter Outline 428
- Overview 429
- Some Learning Goals 429

Phylum Magnoliophyta—The Flowering Plants 430
 Pollination Ecology 436
 Herbaria and Plant Preservation 441
 Summary 446
 Review Questions 446
 Discussion Questions 446
 Additional Reading 447

24 Flowering Plants and Civilization 448

Chapter Outline 448
 Overview 449
 Some Learning Goals 449
 Origin of Cultivated Plants 449
 Selected Families of Flowering Plants 451
 Dicots (Now Recognized in Two Groups) 452
 Monocots 467
Plant Sciences Inquiry: Coffee and Caffeine 470
 Summary 472
 Review Questions 472
 Discussion Questions 472
 Additional Reading 473

25 Ecology 474

Chapter Outline 474
 Overview 475
 Some Learning Goals 475
 Plants and the Environment 475
 Life Histories 480
 Natural Cycles 480
 Succession 483
 The Impacts of Humans on Plant Communities 488

Global Warming 488
 Erosion 490
 Aquifer Depletion 491
 Loss of Biodiversity 491
Plant Sciences Inquiry: John Muir, Father of America's National Park System 494
 Summary 495
 Review Questions 496
 Discussion Questions 496
 Additional Reading 496

26 Biomes 498

Chapter Outline 498
 Overview 499
 Learning Goal 499
 Major Biomes of North America 499
Plant Science Inquiry: Photosynthesis, Global Warming, and Tropical Rain Forests 508
 Summary 508
 Review Questions 509
 Discussion Questions 509
 Additional Reading 509

Appendix 1 Scientific Names of Organisms Mentioned in the Text 510

Appendix 2 Biological Controls 529

Appendix 3 Useful and Poisonous Plants, Fungi, and Algae 537

Appendix 4 House Plants and Home Gardening 562

Appendix 5 Metric Equivalents and Conversion Tables 586

Glossary 588

Index 599