



PHYLOGENY
and
EVOLUTION
of
Angiosperms

DOUGLAS E. SOLTIS • PAMELA S. SOLTIS
PETER K. ENDRESS • MARK W. CHASE

Contents

Chapter 1

Relationships of the Angiosperms to Other Seed Plants 1

- Introduction 1
- Phylogenetic Studies: Extant Taxa 2
- Phylogenetic Studies: Integrating Fossils 10
- Future Studies 19

Chapter 2

Phylogeny of Angiosperms: An Overview 21

- Introduction 21
- History of Efforts to Reconstruct Angiosperm Phylogeny 22
- Angiosperm Topology: Overview and Comparison with Modern Classifications 27
- Sequence Variation: General Patterns and Rapid Radiations 33
- Timing of Diversification Events 35
- Future Studies 39

Chapter 3

Basal Angiosperms 43

- Introduction 43
- Morphological Cladistic Analyses 44

- Molecular Analyses 45
- Combined DNA and Morphology 47
- Combined DNA Datasets 48
- Amborellaceae, Nymphaeaceae, and Austrobaileyales 50
- Other Basal Angiosperms: Monocots, Ceratophyllaceae, and Chloranthaceae 54
- Other Basal Angiosperms: The Magnoliids 57
- Character Evolution in Basal Angiosperms 59
- Genetics of Floral Development: Implications for the Early Diversification of the Flower 82
- The Appearance of Angiosperms in the Fossil Record 85
- Reconstructing the Earliest Angiosperms 86
- Future Research 89

Chapter 4

Monocots 91

- Introduction 91
- Phylogenetic Analyses Based on Morphology 93
- Molecular Analyses of Monocot Relationships 94
- Current Understanding of Relationships Within Monocots 95

Fossil History of Monocots 116
Future Research 116

Chapter 5 **Early-Diverging Eudicots 119**

Introduction 119
Ranunculales 124
Proteales 125
Sabiaceae 125
Buxaceae 126
Trochodendraceae 126
Character Evolution in Early-Diverging Eudicots 126
Floral Developmental Genetics 136
Future Research 137

Chapter 6 **Core Eudicots: Introduction and Smaller Lineages 139**

Introduction 139
Gunnerales 141
"Berberidopsidales" 142
Saxifragales 142
Santalales 153
Future Research 156

Chapter 7 **Caryophyllales 157**

Introduction 157
Phylogeny of Caryophyllales 159
Character Evolution in Caryophyllales 163
Future Research 167

Chapter 8 **Rosids 169**

Introduction 169
Vitaceae 171
Eurosoid I (Fabids) 171
Eurosoid II (Malvids) 189
Other Rosids 200
Parasitism in the Rosids 204
Future Research 205

Chapter 9 **Asterids 207**

Introduction 207

Euasterids 213
Euasterid I (Lamiids) 214
Euasterid II (Campanulids) 221
Unplaced Euasterid II 228
Unplaced Asterids 229
Patterns of Character Evolution in Asterids 229
Future Research 236

Chapter 10 **Angiosperm Classification 237**

Introduction 237
The Angiosperm Phylogeny Group (APG) Classification 238
Ranked versus Rank-Free Classification 239
Classification of Angiosperms (Modified from APG II 2003) 243

Chapter 11 **Parallel and Convergent Evolution 249**

Introduction 249
Parasitism 250
Carnivory 256
C₄ Photosynthesis 263
Future Directions 266

Chapter 12 **Floral Diversification 269**

Introduction 269
Pathways of Evolutionary Innovations 270
Evolutionary Radiations 271
Floral Phyllotaxis 272
Floral Merism 273
Floral Symmetry 273
Perianth 274
Androecium 277
Gynoecium 280
Ovules 282
Morphological Elaborations in Flowers Pollinated by Animals 283
Morphological Reduction in Flowers that are not Animal-Pollinated 284
Evolutionary Diversification in Flowers of the Major Angiosperm Groups 285
Future Directions 286

Chapter 13
Evolution of Genome Size and Base
Chromosome Number 287

Introduction 287

Genome Size 288

Base Chromosome Number 298

Future Studies 302

Appendix 303

References 311

Taxonomic Index 353

Subject Index 365