

# Contents

- Preface, ix
- Acknowledgements, x
- 1 Origins, 1
- 1.1 Plants – what are they?, 1
  - 1.2 Back to the beginning, 1
  - 1.3 Eukaryotes emerge, 2
  - 1.4 Photosynthetic eukaryotes – the first ‘plants’, 3
  - 1.5 The greening of Earth – plants invade the land, 4
  - 1.6 Embracing the terrestrial lifestyle, 6
  - 1.7 Arrival of the angiosperms, 8
  - 1.8 Sex and the alternation of generations, 11
- 2 Introduction to Plant Cells, 14
- 2.1 Plant cells, 14
  - 2.2 Cell walls, 15
  - 2.3 The plasma membrane, 21
  - 2.4 Cell compartmentation, 23
  - 2.5 Chloroplasts, 24
  - 2.6 Mitochondria, 27
  - 2.7 The nucleus, 29
  - 2.8 The vacuole, 31
  - 2.9 Endomembrane systems, 31
  - 2.10 Microbodies/peroxisomes, 32
  - 2.11 Ribosomes, 34
  - 2.12 The cytoskeleton, 34
  - 2.13 The mitotic cell cycle, 36
  - 2.14 Metabolism, 42
- 3 Genes, Gene Expression and Development, 56
- 3.1 Genes, 56
  - 3.2 Gene expression, 59
  - 3.3 Chloroplasts and mitochondria, 65
  - 3.4 Control of gene expression – switching genes on and off, 69
  - 3.5 Molecular aspects of development, 75
  - 3.6 Plant hormones, 75
  - 3.7 Light receptors, 86
  - 3.8 Concluding comments, 92
- 4 From Embryo to Establishment, 94
- 4.1 Introduction, 94
  - 4.2 Embryogenesis, 94
  - 4.3 Endosperm, 99
  - 4.4 Perisperm, 100
  - 4.5 Late embryo growth, storage deposition and desiccation, 100
  - 4.6 Seed coat, 109
  - 4.7 ‘Recalcitrant’ seeds, 109
  - 4.8 Apomixis, 109
  - 4.9 Seeds and fruit, 110
  - 4.10 Fruit development and ripening, 112
  - 4.11 Dormancy and quiescence, 114
  - 4.12 Germination, 115
  - 4.13 Establishment, 120
- 5 Roots, 124
- 5.1 External morphology of roots, 124
  - 5.2 Root anatomy, 124
  - 5.3 Root growth, 126
  - 5.4 Soil chemistry and water relations, 130
  - 5.5 Plant mineral nutrition, 132
  - 5.6 Movement of nutrients to the root surface, 133
  - 5.7 Absorption of water and nutrients, 133
  - 5.8 Mycorrhizae, 139
  - 5.9 Root nodules and nitrogen fixation, 139
  - 5.10 Tropisms, 142
  - 5.11 Gravitropism in roots, 143
- 6 Stems, 145
- 6.1 Structure of the stem, 145
  - 6.2 The young stem, 145
  - 6.3 The shoot apical meristem, 146
  - 6.4 Shoot organizational forms, 148
  - 6.5 The mature stem, 148
  - 6.6 The tallest, largest and oldest plants, 151
  - 6.7 Ageing and senescence, 152
  - 6.8 Long-distance xylem transport, 154

- 6.9 Translocation in the phloem, 155
  - 6.10 Biological clocks in plants, 157
  - 6.11 Phototropism – how do stems curve towards the light?, 160
  - 6.12 Gravitropism in stems, 160
  - 6.13 Thigmotropism, 161
  - 6.14 Nastic movements, 161
  - 6.15 Bud dormancy, 163
  - 7 Leaves, 166
    - 7.1 External morphology of leaves, 166
    - 7.2 The anatomy of the leaf, 166
    - 7.3 Control of leaf growth and development, 167
    - 7.4 Photosynthesis, 168
    - 7.5 Photorespiration, 174
    - 7.6 The photosynthesis/transpiration dilemma, 177
    - 7.7 C<sub>4</sub> photosynthesis, 178
    - 7.8 Crassulacean acid metabolism (CAM), 181
    - 7.9 Sources and sinks, 182
    - 7.10 Stomata, 184
    - 7.11 Leaf senescence and abscission, 186
  - 8 Flowers, 189
    - 8.1 Introduction, 189
    - 8.2 What is a flower?, 189
    - 8.3 Organization of flowers and flowering – inflorescences and life-styles, 191
    - 8.4 Formation of flowers, 192
    - 8.5 Gametogenesis, 198
    - 8.6 Pollination and fertilization, 204
    - 8.7 Evolution, 214
  - 9 Environmental Stresses, 216
    - 9.1 Responses to stress, 216
      - 9.2 Temperature, 217
      - 9.3 Waterlogging, 221
      - 9.4 Drought, 223
      - 9.5 Salinity, 226
      - 9.6 Chemical stress, 228
      - 9.7 Light and radiation, 232
  - 10 Acclimation and Adaptation to Environmental Stresses, 235
    - 10.1 Adaptation and acclimation responses, 235
    - 10.2 Temperature, 236
    - 10.3 Resistance and adaptation to waterlogging, 240
    - 10.4 Resistance and adaptation to drought, 243
    - 10.5 Resistance and adaptation to salinity, 247
    - 10.6 Tolerance and adaptation to toxic metals, 252
    - 10.7 Adaptations to light and radiation, 256
  - 11 Biotic Stresses, 260
    - 11.1 Plant/plant competition, 260
    - 11.2 Plant/animal interactions, 265
    - 11.3 Plant pathology, 271
  - 12 Plants and the Future, 284
    - 12.1 Climate change, 284
    - 12.2 Loss of plant biodiversity, 288
    - 12.3 Biomass and biofuels derived from plants, 291
    - 12.4 Genetically modified crops, 297
    - 12.5 Conclusion, 300
- Glossary, 302
- Index, 309