

Contents

Preface	xi	3 Non-photosynthetic metabolism	43
1 Introducing plants	1	Phloem transport	43
The beginning: the evolution of plants and the major divisions	1	Structure of the phloem	44
Conquering the land	1	Phloem loading	45
The evolution of lignin	6	Phloem unloading	46
Plants and mass extinction	7	Coping with damage to the phloem	49
Floristic kingdoms, biogeography and biomes	7	The sink tissues	50
What makes a plant?	9	How is sink strength dictated?	51
Structure of the whole plant	9	Metabolism of carbohydrate	54
Structure of the plant cell	11	Respiration	54
Chloroplasts and other plastids	11	Storage of carbohydrate or lipid	56
The vacuole	14	Potatoes and starch storage	56
Microbodies	14	Bananas and starch storage and ripening	56
The cell wall	14	Sugarcane and the storage of sucrose	57
Plasmodesmata	14	Grapes and developing fruit	57
2 Photosynthesis: the ultimate in autotrophy	17	Peanuts and lipid storage	58
Light harvesting	17	Growth and the synthesis of cell components	59
Leaf form	17	Sink regulation of photosynthesis	59
Chlorophyll and the chloroplast	19	4 Roots and the uptake of water	61
Converting light energy into chemical energy	21	Types of root	61
Photosystem I	23	Functions of roots	63
Photosystem II	25	Structure of roots	64
The Calvin cycle	26	Shoot and root growth	66
The cycle and its functions	26	Interaction with the soil	66
Regeneration	26	Uptake of water	67
CO ₂ fixation or carboxylation	26	Osmosis	67
Synthetic flux	28	Loading and movement in the xylem	67
Regulatory enzymes	28	Structure of the xylem	67
The remarkable role of RUBISCO	28	Cohesion-tension theory of water movement in the xylem	68
Photorespiration	30	Transpiration rates	72
The troubles with photosynthesis	30	Cavitation	72
The solution to the problem	31	Stomata	72
Carbohydrate synthesis and storage	32	Stomatal function	74
The major carbohydrates of photosynthesis	32	5 Mineral nutrition of plants	75
Sucrose	32	Soil structure and mineral ions	75
Starch	35	General ion uptake	76
The fate of carbon fixed during photosynthesis	37	Phosphorus uptake and assimilation	78
The efficiency of photosynthesis	40	Nitrogen uptake and assimilation	80
		Amino acid synthesis	82
		Symbiotic nitrogen fixation	82

Iron uptake and assimilation	83	Sexual reproduction	133
Sulphur uptake and assimilation	85	Wind-based pollination	134
Function and effects of deficiencies of mineral ions on plants	86	Insect-based pollination	136
Major elements	86	Pollination	139
Other important major elements	86	Mechanisms for improving cross-fertilization	141
Minor elements	87	Self-incompatibility mechanisms	142
		Gametophytic incompatibility	145
		Sporophytic incompatibility	146
6 Mycorrhizal associations and saprophytic nutrition	89	Seed development	146
Mycorrhizal associations	89	10 Plant growth	149
Vesicular arbuscular mycorrhizal associations	90	Types of growth	149
Orchidaceous mycorrhizal associations	92	Cell division and the cell cycle	150
Ectomycorrhiza	96	Polyploidy in plants	151
Ericaceous mycorrhiza	96	Seed formation and germination	151
Ericoid mycorrhiza	96	The dividing meristem	151
Arbutoid mycorrhiza	97	Shoot apical meristem	152
Monotropoid mycorrhiza	98	Leaf primordia	153
Ectendomycorrhiza	99	Root apical meristem	154
Development of the mycorrhizal association	99	The origin of root hairs	155
The role of the mycorrhizal association	99	The origin of lateral roots	155
Saprophytic nutrition	101	Flower development	155
		Vascular cambium and secondary growth	157
		Intercalary meristem	157
		Cell death	157
		Plant growth regulators and cell growth	159
7 Parasitic plants	103	11 Plant movement	161
Establishing a parasitic relationship	103	Tropism and nastic movements	161
Facultative parasitic plants	106	Tropic movements	161
Obligate parasitic plants – hemiparasites	108	Auxins and plant movement	161
Obligate parasitic plants – holoparasites	111	Phototropism	163
Parasitic species other than the dicotyledons	112	Heliotropism	165
		Gravitropism	166
		Sensing gravity	167
8 Carnivorous plants	115	Hydrotropism	167
Carnivory: the search for a definition	115	Thigmotropism	167
Why have some plants turned to carnivory?	115	Chemotropism	170
Trapping mechanisms	116	Nastic movements	171
The pitfall trap – North American pitcher plant	116	Nyctinasty (sleep movements)	171
Active spring trap – bladderworts	120	Seismonasty	171
Sticky flypaper – sundews	124	Thermonasty	172
		Epinasty	172
		Circumnutation	174
9 Asexual and sexual reproduction	131	12 Plants and stress	175
Asexual reproduction	131	Adaptations to drought stress	175
Roots	131	Crassulacean acid metabolism	176
Stems	132	C4 photosynthesis	180
Leaves	132	Resurrection plants	182
Apomixis	132		

Adaptations to salt stress	184	Temperature	219
Adaptations to flooding stress and anoxia	186	Oxygen	219
Adaptations to cold stress	187	Soil conditions	220
Adaptations to heat stress	190	Gibberellic acid	220
		Cytokinins	221
13 Plant senses and perceiving the world	193	Ethylene	221
Sensing light (sight)	193	Smoke signals	221
Protochlorophyllide	193	Pyrogenic flowering	222
Phytochromes	194	Serotiny	222
Seed germination	194	The role of heat in fires	222
Shade-avoidance response	194	Chemicals in smoke that trigger germination	223
How do phytochromes work?	196		
Phytochromes and ion movement	198	15 Interactions with the animal kingdom	225
Phytochromes and regulation of gene expression	198	Animal-mediated pollination	225
Cryptochrome	198	Mimicry in plants	227
Sensing time	198	Batesian mimicry	227
Circadian clock	198	Mimicry of toxic or poisonous species	227
Photoperiodism	199	Rewardless flowering	227
Sensing touch (feeling)	201	Lithops	230
Sensing wind and vibrations	201	Grass species as crop weeds	231
Sensing chemicals (taste)	202	Müllerian mimicry	231
Communicating (smell)	204	Aggressive mimicry	231
Ethylene	204	Egg mimics	231
Ripening fruits	205	The bee orchids	232
Pathogenic defence and stress responses	206	Pollination in the Araceae	234
Abscission	206	Seed dispersal and food reserves: the role of humans	235
Detection of ethylene	206		
Jasmonic acid	207	16 Plant defences	239
Nitric oxide	207	Physical defence structures	239
Sensing sounds (hearing)	207	The cuticle	241
		The cell wall	242
14 Seed dispersal, dormancy and germination	211	The cell wall as a passive barrier	242
Seed dispersal	211	The cell wall as an active barrier	242
Gravity-mediated dispersal	211	Poisons by injection or touch	243
Wind-mediated dispersal	211	Chemical defences	243
Water-mediated dispersal	213	Terpenes	244
Animal-mediated dispersal	213	Pyrethrins	244
Importance of post-dispersal mechanisms	214	Phenolic-based defence chemicals	245
Dormancy and germination	215	Coumarins	245
Recalcitrant seeds	215	Isoflavenoids	246
Dormant seeds	216	Tannins	247
Factors governing dormancy and germination	217	Nitrogen-containing organic compounds	248
Presence of germination inhibitors	217	Non-protein amino acids	249
Presence of inhibitory tissues	218	Proteinase and amylase inhibitors	249
Presence of germination promoters	218	Cyanogenic glycosides	249
Light	218	Glycosinolates	250
		Lectins	251
		Alkaloids	251

Defence reactions and signal pathways	251	Major elements	270
Jasmonic acid	252	Minor elements	270
Salicylic acid	252	Carbohydrates	271
Systemin	252	Vitamins	272
Phytoalexins	252	Plant growth regulators	272
Allelopathy	252	Auxins	272
Recognizing self	253	Cytokinins	273
Mimicry and the enrolment of other organisms for protection	254	Gibberellins	273
		Absciscic acid	274
		Tissue culture sterility	274
17 Plants and medicines	257	Types of plant tissue culture	275
Doctrine of signatures	257	Applications of plant tissue culture	276
Lungwort (<i>Pulmonaria officinalis</i>)	257	Micropropagation	277
Greater celandine (<i>Chelidonium majus</i>)	257	Cloning	277
Viper's bugloss (<i>Echium vulgare</i>)	259	Genetic manipulation	277
Common self-heal (<i>Prunella vulgaris</i>)	259	Hybridization	279
Sage (<i>Salvia officinalis</i>)	259	Dihaploid plants	280
Ethnobotany	259	Removal of viruses from plant tissues	281
The origins of aspirin	261	Generation of somaclonal variation	281
The origins of antimalarial drugs	261		
St. John's Wort (<i>Hypericum</i> spp.)	262	19 Remarkable plants	283
Natural alternatives to Viagra	262	Insect mimicry in the orchidaceae	283
Natural treatments for AIDS	263	Venus flytrap	284
A cure for certain cancers	264	The oldest and biggest plants in the world	286
Vincristine and vinblastine	265	Tallest plants	289
Etoposide and teniposide	266	Cycads	289
Topotecan and irinotecan	266	Welwitschia mirabilis	289
Taxol	266	The castor bean plant	290
Sustainable development of medicines from plants	267	Garlic	291
		Theobroma cacao	292
		Wheat and agriculture	292
18 Plant tissue culture and the rise of plant biotechnology	269		
The development of plant tissue culture media	269	Glossary	297
Components of the medium	269	Index	301