

Contents

CHAPTER 1	An Introduction to Botany	1	CHAPTER 3	The Molecular Composition of Cells	45
	The Evolution of Plants	1		Organic Compounds	45
	The Evolution of Communities	7		Carbohydrates	46
	The Appearance of Human Beings	9		<i>Essay: Radiocarbon Dating</i>	47
	Summary	11		Lipids	48
	Suggestions for Further Reading	11		Proteins	51
				Nucleic Acids	56
				Other Nucleotide Derivatives	56
				Summary	56
SECTION 1	The Plant Cell	13	CHAPTER 4	The Movement of Substances into and out of Cells	58
CHAPTER 2	Introduction to the Eukaryotic Cell	15		Principles of Water Movement	58
	Prokaryotes and Eukaryotes	16		<i>Essay: Imbibition</i>	60
	The Plant Cell	16		Structure of Cellular Membranes	62
	<i>Essay: Origin of the Cell Theory</i>	17		Transport across Membranes	63
	Plasma Membrane	17		Endocytosis and Exocytosis	65
	Nucleus	17		Transport via Plasmodesmata	66
	<i>Essay: Viewing the Microscopic World</i>	19		Summary	67
	Plastids	19		Suggestions for Further Reading	67
	Mitochondria	23	SECTION 2	Energy and the Living Cell	69
	Microbodies	24	CHAPTER 5	The Flow of Energy	71
	Vacuoles	25		The Laws of Thermodynamics	72
	Ribosomes	26		<i>Essay: $E = mc^2$</i>	74
	Endoplasmic Reticulum	27		Oxidation-Reduction	75
	Golgi Apparatus	28		Enzymes and Living Systems	75
	Microtubules	29		Enzymes as Catalysts	76
	Microfilaments	30		The Active Site	76
	Ground Substance	30		Cofactors in Enzyme Action	78
	Lipid Droplets	30		Enzymatic Pathways	78
	Ergastic Substances	31			
	Flagella and Cilia	31			
	The Cell Wall	32			
	Plasmodesmata	35			
	Cell Division	36			
	The Cell Cycle	36			
	<i>Essay: Immunofluorescence Microscopy of Tubulin and Microtubules</i>	41			
	Summary	42			

Regulation of Enzyme Activity	79	Essay: The Control of Multicellular Differentiation	128
The Energy Factor: ATP	79	Summary	131
Summary	81		
 CHAPTER 6		 CHAPTER 9	
Respiration	82	The Genetics of Eukaryotic Organisms	132
Glycolysis	83	Eukaryotes versus Prokaryotes	132
Aerobic Pathway	86	Structure of Eukaryotic Chromosomes	133
Other Important Energy-Yielding Pathways	92	Meiosis	134
Essay: Bioluminescence	92	How Are Characteristics Determined?	138
Anaerobic Pathways	93	Mutations	143
Summary	94	Gene Organization	146
		The Determination of the Phenotype	146
 CHAPTER 7		Summary	147
Photosynthesis	95	Suggestions for Further Reading	147
Overview of Photosynthesis	95		
The Light Reactions	97	 SECTION 4	
Essay: Light and Life	102	Diversity	149
The Dark Reactions	105		
Essay: The Carbon Cycle	109	 CHAPTER 10	
Essay: Carbon Isotope Composition of C ₃ and C ₄		The Classification of Living Things	151
Plants	111	The Binomial System	152
Summary	111	The Major Groups of Organisms	158
Suggestions for Further Reading	112	Relationships within the Eukaryotes	159
		Formal Classification of Organisms	160
 SECTION 3		Sexual Reproduction	162
Genetics	115	Summary	164
		Suggestions for Further Reading	164
 CHAPTER 8		 CHAPTER 11	
The Chemistry of Heredity	117	Bacteria	165
The Chemistry of the Gene: DNA versus Protein	117	General Characteristics of Bacteria	166
The Nature of DNA	118	Essay: Bacteria and Fossil Fuel	178
How Do Genes Work?	123	Essay: Citrus Canker	182
Essay: Right-Handed and Left-Handed DNA	123	Summary	185
Regulating Gene Transcription	127	Suggestions for Further Reading	185
The Control of Development in Plants	128		

CHAPTER 12		CHAPTER 16	
Viruses	186	Bryophytes	280
The Nature of Viruses	187	Characteristics of the Bryophytes	281
The Structure of Viral Particles	188	The Liverworts: Class Hepaticae	285
Replication of Viruses	190	<i>Essay: Spore Discharge in Liverworts</i>	287
The Diversity of Viruses	191	The Hornworts: Class Anthocerotae	291
Viral Diseases of Plants	192	The Mosses: Class Musci	292
Viroids and Other Infectious Particles	193	<i>Essay: Insect Dispersal of Moss Spores</i>	295
Viruses and Cancer	194	Summary	299
The Origin of Viruses	194	Suggestions for Further Reading	299
Summary	195		
Suggestions for Further Reading	195	CHAPTER 17	
CHAPTER 13		Seedless Vascular Plants	300
Fungi	196	Organization of the Vascular Plant Body	301
Biology of the Fungi	198	Reproductive Systems	305
The Evolution of Fungi	199	The Divisions of Seedless Vascular Plants	306
Fungal Reproduction	200	Division Rhyniophyta	307
The Major Groups of Fungi	201	Division Zosterophyllophyta	308
<i>Essay: Phototaxis in a Fungus</i>	203	Division Trimerophyta	308
<i>Essay: Ergotism</i>	208	Division Psilophyta	308
<i>Essay: Predaceous Fungi</i>	210	Division Lycopphyta	312
Mycorrhizae	224	Division Sphenophyta	317
Summary	226	Division Pterophyta	321
Suggestions for Further Reading	227	<i>Essay: Coal Age Plants</i>	324
		Summary	330
CHAPTER 14		Suggestions for Further Reading	330
Unicellular Protista: Water Molds, Slime Molds, Chytrids, and Unicellular Algae	229	CHAPTER 18	
Ecology of Unicellular Protista	230	Seed Plants	333
Symbiosis and the Origin of the Chloroplast	230	The Progymnosperms	335
Characteristics of the Divisions	231	The Gymnosperms	337
Division Oomycota	232	The Angiosperms	353
<i>Essay: Hormonal Control of Sexuality in a Water Mold</i>	235	Summary	369
Division Chytridiomycota	236	Suggestions for Further Reading	369
Division Acrasiomycota	238		
Division Myxomycota	239	SECTION 5	
Chrysophytes: Division Chrysophyta	241	The Angiosperm Plant Body: Structure and Development	371
The Dinoflagellates: Division Pyrrhophyta	245		
<i>Essay: Mitosis in Dinoflagellates</i>	246	CHAPTER 19	
The Euglenoids: Division Euglenophyta	248	Early Development of the Plant Body	373
Summary	249		
Suggestions for Further Reading	250	The Mature Embryo and Seed	373
CHAPTER 15		Formation of the Embryo	377
Multicellular Protista: Red, Brown, and Green Algae	251	<i>Essay: Wheat</i>	377
Characteristics of Red, Brown, and Green Algae	252	Requirements for Seed Germination	381
Red Algae: Division Rhodophyta	253	From Embryo to Adult Plant	382
Brown Algae: Division Phaeophyta	257	Summary	383
<i>Essay: The Economic Uses of Seaweeds</i>	262		
Green Algae: Division Chlorophyta	263	CHAPTER 20	
<i>Essay: Symbiotic Green Algae</i>	274	Cells and Tissues of the Plant Body	384
Summary	278		
Suggestions for Further Reading	278	The Tissue Systems	385
		Tissues and Their Component Cells	385
		Summary	397

CHAPTER 21

The Root: Primary Structure and Development 400

Root Systems	400
Origin and Growth of Primary Tissues	401
Primary Structure	405
Origin of Lateral Roots	409
Aerial Roots	409
Adaptations for Food Storage	411
Summary	412

CHAPTER 22

The Shoot: Primary Structure and Development 413

Origin and Growth of the Primary Tissues of the Stem	414
Primary Structure of the Stem	416
Relation between the Vascular Tissues of the Stem and the Leaf	422
Morphology of the Leaf	423
Structure of the Leaf	424
<i>Essay: Plants, Air Pollution, and Acid Rain</i>	430
Grass Leaves	432
Development of the Leaf	433
Leaf Abscission	437
Transition between Vascular Systems of the Root and the Shoot	437
Development of the Flower	437
Stem and Leaf Modifications	440
<i>Essay: Leaf Dimorphism in Aquatic Plants</i>	441
<i>Essay: Convergent Evolution</i>	443
Summary	445

CHAPTER 23

Secondary Growth 446

The Vascular Cambium	447
Effect of Secondary Growth on the Primary Plant Body	449
The Wood: Secondary Xylem	459
<i>Essay: Density and Specific Gravity of Wood</i>	467
Summary	469
Suggestions for Further Reading	470

SECTION 6

Growth Regulation and Growth Responses 473

CHAPTER 24

Regulating Growth and Development: The Plant Hormones 475

Auxin	476
Cytokinins	480

<i>Essay: Plant Hormones, Tissue Culture, and Biotechnology</i>	482
Ethylene	485
Abscisic Acid	487
Gibberellins	487
Summary	492

CHAPTER 25

External Factors and Plant Growth 493

The Tropisms	493
Circadian Rhythms	496
Photoperiodism	498
Chemical Basis of Photoperiodism	501
Hormonal Control of Flowering	504
Dormancy	506
Cold and the Flowering Response	509
Nastic Movements	509
Solar Tracking	511
In Conclusion	511
Summary	512
Suggestions for Further Reading	512

SECTION 7

Uptake and Transport in Plants 515

CHAPTER 26

Plant Nutrition and Soils 517

General Nutritional Requirements	517
Functions of Inorganic Nutrients in Plants	520
The Soil	521
<i>Essay: The Water Cycle</i>	524
Nutrient Cycles	525
<i>Essay: Mycorrhizae and Plant Nutrition</i>	526
Nitrogen and the Nitrogen Cycle	527
<i>Essay: Carnivorous Plants</i>	529
The Phosphorus Cycle	536
Human Impact on Nutrient Cycles	536
<i>Essay: Compost</i>	537
Soils and Agriculture	537
Plant Nutrition Research	538
Summary	540

CHAPTER 27

The Movement of Water and Solutes in Plants 541

Movement of Water through the Plant Body	541
Movement of Inorganic Nutrients throughout the Plant Body	551
Translocation: The Movement of Substances in the Phloem	553
<i>Essay: Radioactive Tracers and Autoradiography in Plant Research</i>	555
Summary	558
Suggestions for Further Reading	558

SECTION 8	Evolution	561	Trophic Levels	662
CHAPTER 28	The Process of Evolution	563	Essay: Plant Defense in Solanaceae	663
	The Behavior of Genes in Populations	565	Development of Communities and Ecosystems	665
	Responses to Selection	567	Summary	670
	Essay: Vegetative Reproduction: Some Ways and Means	570	CHAPTER 32	
	The Divergence of Populations	572	The Biomes	671
	The Evolutionary Role of Hybridization	575	Life on the Land	671
	Essay: Adaptive Radiation in Hawaiian Tarweeds	576	Rainforests	675
	The Origin of Major Groups of Organisms	581	Essay: Alexander von Humboldt	676
	Summary	582	Essay: Rodent Pollination of Tropical Plants	678
	Suggestions for Further Reading	583	Savannas and Deciduous Tropical Forests	679
CHAPTER 29	Evolution of the Flowering Plants	584	Deserts	681
	Origin of the Angiosperms	584	Grasslands	685
	Evolution of the Flower	590	Temperate Deciduous Forests	688
	Essay: Early Angiosperms and Their Flowers	592	Temperate Mixed and Coniferous Forests	690
	Essay: Genetic Self-Incompatibility	598	Mediterranean Scrub	692
	The Diversity of Fruits	611	Taiga	693
	Biochemical Coevolution	616	Arctic Tundra	695
	Summary	619	Summary	696
	Suggestions for Further Reading	620	Suggestions for Further Reading	696
CHAPTER 30	Plants and People	621	APPENDIX A	
	The Agricultural Revolution	622	Fundamentals of Chemistry	699
	Essay: The Origin of Corn	628	Atoms	699
	The Growth of Human Populations	632	Bonds and Molecules	703
	Agriculture in the Future	635	Water and the Hydrogen Bond	706
	Essay: The Conservation of Plants	647	Water as a Solvent	706
	Summary	648	Acids and Bases	707
	Suggestions for Further Reading	648	Chemical Reactions	708
SECTION 9	Ecology	651	APPENDIX B	
CHAPTER 31	The Dynamics of Communities and Ecosystems	653	Metric Table	712
	Interactions between Organisms	653	Temperature Conversion Scale	713
	Essay: Pesticides and Ecosystems	660	APPENDIX C	
	Cycling of Nutrients	661	Classification of Organisms	715
			APPENDIX D	
			Geologic Eras	721
			GLOSSARY	723
			ILLUSTRATION ACKNOWLEDGMENTS	747
			INDEX	755