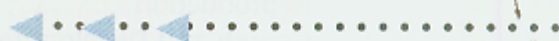


Contents



Part One

The Spectrum of Science	1
Chapter One—Science: What It Is—And Isn't.....	2
Science: Foundation and Philosophy	2
The Method and Limitations of Science	4
Science in Action	7
Biology: The Life Science	8
History of Biological Thought	8
Chapter Summary	10

Part Two

The Panorama of Life	11
Chapter Two—Earth: The Habitable Planet.....	12
Earth: Its Place in the Solar System	12
Earth and Other Planets: A General Comparison	12
Requirements for Life on Earth	15
Organic Compounds	15
Water	16
Temperature	16
Oxygen	16
Energy	18
Is Life Possible Elsewhere?	19
The Theme of Evolution.....	19
Physical Evolution: Pangaea and Plate Tectonics	19
Chemical Evolution	22
The Early Atmosphere	22
Biological Evolution	23
The Origin of Life.....	23
Theories on the Origin of Life	25
Evolution: The Integrating Theme	26
Chapter Summary	27
Chapter Three—Life: Unity in Diversity	29
Life: Diversity and Distinguishing Characteristics	29
Seven Life Features: A General Framework	30
Organization	30
Energy Transactions.....	32
Sensation and Response	32
Homeostasis	33

Reproduction	34
Growth and Development	34
Evolutionary Adaptation	35
Of Snakes and Snails: Exploring Diversity	36
Of Snakes and Snails: Exploring Unity	38
Finding Unity in Diversity: Characteristics of Living Organisms	39
Cells	39
Animals	40
Invertebrates	40
Vertebrates	41
Plants	42
Diversity: The Impact of Evolution	42
Natural Selection	44
Evolution: A Unifying Biological Theme	44
Chapter Summary	45

Part Three

Life Feature 1: Organization	47
Chapter Four—Matter: Structure, Properties, and Interactions	48
Matter and the Elements of Life	48
Atoms, Energy, and Chemical Bonds	50
Ionic Bonds	55
Covalent Bonds	57
Hydrogen Bonding	58
Chemical Bonds and Energy	59
Carbon: The Structural Element of Life	60
The Major Compounds of Life	61
Carbohydrates	61
Lipids	65
Proteins	67
Nucleic Acids	70
The Major Inorganic Compound of Life: Water	71
Solutions and pH	74
Buffers	76
Chapter Summary	77
Chapter Five—Cells: The First Life Forms	80
The Cell Theory	80
Cells: Evolution and the Emergence of Prokaryotes and Eukaryotes	80
Prokaryotic Cells	82
Eukaryotic Cells	83
Nucleus and Cytoplasm	83
Endoplasmic Reticulum and Ribosomes	85
Golgi Apparatus and Lysosomes	86
Vacuoles	86
Mitochondria	87
Microfilaments, Microtubules, and Intermediate Filaments	87

Cell Walls and Plastids	88
Cell Membranes	88
Cells and Water	89
Significance of Cell Size	90
Cell Membranes and Transport	92
Diffusion	92
Osmosis	93
Phagocytosis and Pinocytosis	96
Facilitated Diffusion	97
Active Transport	97
Chapter Summary	99
Chapter Six—From Cells to Organisms	102
Life: Levels of Organization	102
Plant Tissues	102
Dermal Tissue	102
Vascular Tissue	103
Ground Tissue	103
Animal Tissues	104
Epithelial Tissue	104
Connective Tissue	104
Connective Tissue Proper	104
Fluid Connective Tissue	105
Supporting Connective Tissue	105
Muscle Tissue	105
Nervous Tissue	106
Plant Organs	106
Roots	106
Stems	107
Leaves	107
Reproductive Structures	109
Animal Organs and Systems	110
Survey of the Kingdoms of Life	111
Kingdom Monera	111
Kingdom Protista	113
Algae	113
Protozoa	116
Slime Molds and Water Molds	117
Kingdom Plantae	118
Kingdom Fungi	119
Kingdom Animalia	120
Invertebrates	120
Sponges	123
Cnidarians	123
Flatworms	124
Roundworms	125
Mollusks	125
Segmented Worms	126
Arthropods	126
Echinoderms	127

Vertebrates	128
Agnathans	129
Fishes	131
Amphibians	132
Reptiles	132
Birds	134
Mammals	134
Chapter Summary	135

Part Four

Life Feature 2: Energy Transactions 139

Chapter Seven—Energy and Basic Life Processes 140

Energy: The First and Second Laws of Thermodynamics	140
Heterotrophs and Autotrophs	141
Photosynthesis: Starlight to Sugar	142
An Overview of Photosynthesis	142
The Light Energy of Photosynthesis	144
ATP: Energy Currency	146
Coenzymes and Electron Acceptors	147
The Coenzyme NADP +	147
Electron Transport Chains	148
The Light-Dependent Reactions of Photosynthesis	148
Photosystem I and Photosystem II	148
The Light-Independent Reactions of Photosynthesis	152
Cellular Respiration	153
An Overview of Glucose Metabolism	155
Glycolysis	155
Fermentation: Anaerobic Respiration	157
Krebs Cycle and Electron Transport Chain: Aerobic Respiration	158
Krebs Cycle Preparation: Acetyl Coenzyme A	158
The Krebs Cycle	159
The Electron Transport Chain	161
Chapter Summary	163
Concept Summary Questions	165

Chapter Eight—Energy Flow 166

Energy Conversions	166
Ecosystems: Functional Units of the Biosphere	166
Food Chains	170
Producers	171
Consumers	171
Decomposers	171
Food Webs	172
The Ten Percent Rule	172
Cycles of Matter	174
The Carbon Cycle	175
The Greenhouse Effect	176
The Oxygen Cycle	177

The Nitrogen Cycle	177
Eutrophication	179
The Water Cycle	179
Biological Magnification	180
Energy Flow: Pollution and Intervention	182
Tropical Rain Forests	183
Chapter Summary	184

Part Five

Life Feature 3: Sensation and Response 187

Chapter Nine—Acting and Reacting 188

Introduction	188
Plant Responses	189
Evolution of Nervous Systems and Receptors	190
Animal Nervous Systems	191
The Vertebrate Nervous System	193
The Nerve Impulse	194
Neuron Communication: The Synapse	197
Reflexes	199
Spinal and Visceral Reflexes	199
The Central Nervous System	200
The Brain	200
Forebrain	201
Cerebrum	201
Lateralization	202
Hypothalamus	202
Midbrain	203
Hindbrain	203
Medulla Oblongata	203
Cerebellum	203
Enkephalins and β -Endorphin	203
The Spinal Cord	204
The Peripheral Nervous System	205
Spinal Nerves	205
Cranial Nerves	205
Autonomic Nervous System	205
Sympathetic and Parasympathetic Divisions	206
Sensory Receptors	207
Human Special Senses	208
Vision	208
Hearing	210
Equilibrium	211
Taste and Smell	212
Chapter Summary	213

Chapter Ten—Plant and Animal Function 217

Plant Function	217
----------------------	-----

Nutrients	217
The Need for Water	220
Water Transport	221
Food Transport	222
Animal Function	223
Invertebrate Function	224
Vertebrate Function	227
Muscular System	228
Muscle Contraction	229
Types of Skeletal Muscle Fibers	231
Circulatory System	232
Blood Vessels and Blood	232
Heart Structure and Blood Circuit	235
The Lymphatic System	237
Respiratory System	238
Mechanics of Breathing	240
Respiratory Gas Exchange	241
Regulation of Breathing	242
Digestive System	243
Digestion of Food	244
Absorption of Food	246
Nutrition and Diet	247
Chapter Summary	249

Part Six

Life Feature 4: Homeostasis 253

Chapter Eleven—The Balance Inside 254

Concept and Significance of Homeostasis	254
Negative Feedback	254
Positive Feedback	256
Homeostasis at the Cellular Level	257
Regulating Homeostasis: Interplay of the	
Vertebrate Endocrine and Nervous Systems	258
Regulatory Effects of the Pituitary Gland and Hypothalamus	259
Other Endocrine Organs and Hormones	260
Function of the Adrenal Glands	262
The Adrenal Cortex	262
The Adrenal Medulla	263
The Thyroid Gland	263
Endocrine Function of the Pancreas	264
The Pancreas and Diabetes	265
Homeostasis and Excretion	266
Mammalian Urinary System	267
The Kidneys	267
Nephrons	267
Urine Formation	268

Water Balance	269
The Kidneys and Regulation of Blood Pressure	270
Immunity: Biological Defense	270
Specific and Nonspecific Immune Responses	271
Antibody-Mediated Immune Responses	272
Cell-Mediated Immune Responses	273
Active and Passive Immunity	273
Autoimmunity	273
Allergy	274
Hay Fever	274
Asthma	274
Loss of Immunity: Acquired Immune Deficiency Syndrome	275
Blood Type	276
Chapter Summary	278

Chapter Twelve—The Balance Outside..... 281

Ecosystem Homeostasis	281
Ecology: Life Interacting	282
Population Size	283
Regulation of Population Size	283
Environmental Effects	283
Birth and Death Rates	284
Density-Independent Factors	285
Climate and Geology	285
Density-Dependent Factors	285
Competition	285
Predation	286
Parasitism	286
Symbiotic Relationships	287
Mutualism	287
Commensalism	288
Neutralism	288
Social Interactions	289
Behavior and Societies	289
Instinctive Behavior	289
Learning Behavior	290
Social Behavior	293
Societies	294
Insect Societies	294
Vertebrate Societies	296
Ecological Succession	297
The Human Factor	299
Upsetting the Balance	300
An Alternative Hypothesis	301
Chapter Summary	302

Part Seven

Life Feature 5: Reproduction	305
Chapter Thirteen—Protein Synthesis and Cell Division	306
Evolution and Significance of Cell Division	306
Prokaryotes	306
Eukaryotes: Protists	307
Eukaryotes and Mitosis	307
The Cell Cycle	309
DNA Structure	310
DNA Replication	313
DNA, RNA, and Protein Synthesis: An Overview	314
The Code of Life	314
Making Proteins	316
Transcription	316
Translation	317
The Universal Genetic Code	319
Jumping Genes	319
Mutations: Genetic Errors	320
Sickle-Cell Anemia	320
Nuclear Division	321
Mitosis	321
Prophase	323
Metaphase	323
Anaphase	323
Telophase	323
Meiosis: The Formation of Gametes	324
Meiosis I	325
Prophase I	325
Metaphase I	325
Anaphase I	326
Telophase I	326
Meiosis II	326
Genetic Variability	327
Errors in Cell Division	327
Down Syndrome	328
Patau's Syndrome	329
Edward's Syndrome	329
Turner's Syndrome	329
Extra Sex Chromosomes	330
Genetic Screening	330
Ultrasound	330
Fetoscopy	330
Amniocentesis	331
Chorionic Villus Biopsy	331
Chapter Summary	331

Chapter Fourteen—Genetics: Determining the Future	334
A Brief History of Genetics	334
The Concept of the Gene	334
One Gene-One Protein Hypothesis	334
Theories of Inheritance	335
Gregor Mendel and the Birth of Modern Genetics	336
Mendel's Principles	336
Alleles	336
Dominant and Recessive Alleles	336
Phenotypes and Genotypes	337
The Principle of Segregation	337
The Principle of Independent Assortment	338
Monohybrid Crosses	339
Punnett Squares	339
A Test Cross	340
Dihybrid Crosses	340
A Test Cross	340
Variations in Mendelian Genetics	341
Incomplete Dominance	341
Codominance	342
Multiple Alleles	343
Pleiotropy	345
Polygenic Inheritance	345
Gene Linkage and Chromosomes	346
Linked Genes	346
Crossing Over	346
Sex-Linked Traits	347
Color Vision	348
Hemophilia	349
Extranuclear Inheritance	349
Mitochondria	350
Chloroplasts	350
Genetic Engineering	350
Restriction Enzymes	351
Plasmids	351
Gene Cloning	352
Gene Therapy	352
Ethical Considerations	353
Chapter Summary	354

Chapter Fifteen—Life Arising from Life 357

Why Sex?	357
Bacterial Reproduction	359
Binary Fission	359
Conjugation	359
Reproduction in Algae, Fungi, and Plants	360
Algal Reproduction	360

Chlamydomonas	360
Spirogyra	361
Fungal Reproduction	361
Rhizopus	362
Asexual Reproduction	362
Sexual Reproduction	362
Nonvascular Plant Reproduction	363
Mosses: Alternation of Generations	363
Vascular Plant Reproduction	364
Ferns	364
Angiosperms	365
Reproduction in Animals	366
Invertebrate Reproduction	366
Cnidaria: Aurelia	367
Rotifers	367
Other Reproductive Methods	368
Spiders	368
Slipper Shells	368
Snails	368
The Squids	368
Vertebrate Reproduction	369
Egg-Laying Mammals	369
Pouched Mammals	369
Placental Mammals	369
Human Reproduction	369
The Male Reproductive System	369
Regulation of Male Reproductive Hormones	371
The Female Reproductive System	371
Regulation of Female Reproductive Hormones	373
Ovulation	373
Fertilization	374
Menopause	375
Contraception and Abortion	376
Methods of Contraception	376
Birth Control Pills	376
Diaphragms	376
Intrauterine Devices	376
Condoms	377
Vasectomy and Tubal Ligation	377
Abortion	377
Chapter Summary	378

Part Eight

Life Feature 6: Growth and Development..... 381

Chapter Sixteen—Life Emerging..... 382

Biological Rhythms

382

Plant Cycles

384

Photoperiodism and Phytochrome

385

Photoperiodism and Flowering	385
Embryogenesis	386
Growth	387
Cellular Differentiation	387
Morphogenesis	387
Control of Development	387
The Totipotency of Cells	388
Regulation of Gene Expression	390
Transcription Regulation	391
Induction	391
Embryogenesis in Angiosperms	393
Shoot and Root Development	393
The Young Seedling	394
Embryogenesis in Echinoderms	394
Human Embryogenesis	395
First Trimester	396
Germ Layer Formation	396
Morphogenesis and Formation of the Placenta	397
Embryonic Development	398
Human Fetal Development	398
Second Trimester	399
Third Trimester	399
Labor and Birth	399
Multiple Births	400
Infertility: Causes and Treatment	401
Causes of Infertility	401
Treatment of Infertility	402
Aging and Death	402
Genetics and Aging	402
Aging: Causes or Consequences?	403
Chapter Summary	403

Part Nine

Life Feature 7: Evolutionary Adaptation 407

Chapter Seventeen—Evolution, Darwinism, and Man 408

Evolution	408
The Meaning of Evolution	408
History of Evolutionary Theory	408
Uniformitarianism	409
Fossil Discoveries	410
Lamarck's Theory of Evolution	411
Lamarck and Giraffes	411
DNA and Heredity	412
Charles Darwin and Evolutionary Theory	413
Natural Selection	414
Stabilizing Selection	415
Directional Selection	415

Disruptive Selection	415
Darwin and Giraffes	416
The Progression of Evolutionary Theory	417
Chromosomal Theory of Heredity	417
Homologous Structures	417
Vestigial Structures	418
Developmental Similarities	418
The Fossil Record	418
Genetic Studies	418
Synthetic Theory of Evolution	419
Mutation	420
Point Mutations	420
Substitutions	420
Frameshift Mutations	421
Chromosomal Alterations	422
Nondisjunction	422
Extra Chromosomes	423
Recombination	423
Speciation	424
Genetic Drift	424
Gene Flow	425
Geographic Isolation	425
Reproductive Isolation and Physical Characteristics	425
Punctuated Equilibrium or Gradual Change?	427
Humans from the Past	427
Twenty-Five Million Years Ago	428
Four Million Years Ago	428
From 500,000 Years Ago to Today	429
The Mitochondrial DNA Debate	430
Chapter Summary	431
Glossary	435
Common Word Roots Used in Biology	457
Bibliography	461
Index	463