

TABLE OF CONTENTS

MODULE I	1
THE SCIENCE OF LIFE	
The Process of Science	2
What Scientists Do	2
Observations and Inferences	3
Hypotheses	3
Experiments	4
Scientific Theories and Laws	5
Scientific Method in Action	6
The Limitations of Science	10
Spontaneous Generation	11
Redi's Experiments Refute Spontaneous Generation .	11
Discovering Microorganisms	12
Pasteur's Experiment	13
Why Study Science?	14
Spontaneous Generation: The Faithful Still Cling to It!	14
The Study of Life	16
Cells and Life	17
Growth and Development	17
Metabolism and Energy	17
Homeostasis	20
Responding to Stimuli	21
DNA and Reproduction	21
Tools of Biology	24
A Common Measurement System	24

Tables and Graphs	25
Microscopes	26
Light Microscopes	26
Electron Microscopes	27
Experiment 1: Introduction to the Microscope	28
Safety in Biology	32
Answers To The “On Your Own” Problems	34
Study Guide for Module 1	35

MODULE 2 37

THE CHEMISTRY OF LIFE

The Composition of Matter	38
Atoms: The Basic Building Blocks of Matter	38
Atomic Structure	39
Elements	40
Isotopes	42
Radioactive Isotopes	43
Molecules and Compounds	43
Chemical Formulas	44
Chemical Bonds	45
Ionic Bonds	46
Covalent Bonds	47
The Properties of Water	48
Experiment 2.1: Investigating Water’s Properties	48
The Structure of Water	50
Life-Supporting Properties of Water	51
The Universal Solvent	51
Cohesion, Surface Tension, and Adhesion	52
High Heat Capacity	53
Density of Ice	54
Carbon Compounds	58
Carbohydrates	58
Functional Groups and Organic Acids and Bases	62
Experiment 2.2: How Effective is Your Antacid?	64
Lipids	66
Proteins and Enzymes	69
Protein Structure	70
Enzymes	72
Experiment 2.3: The Fragility of an Enzyme	76
Nucleic Acids	78
Answers To The “On Your Own” Problems	80
Study Guide For Module 2	83

ECOLOGY

Introduction 86

Energy and Life 88

 Producers, Consumers, and Decomposers 88

 Food Chains, Food Webs, and Trophic Levels 89

 Energy Moves Through Trophic Levels 91

 Ecological Pyramids 92

The Biosphere 95

 The Water Cycle 96

 The Carbon Cycle 97

 Experiment 3.1: Carbon Dioxide And The
 Greenhouse Effect 99

 Global Climate 100

 The Oxygen Cycle 105

 The Nitrogen Cycle 106

 The Phosphorus Cycle 108

Ecosystems And Biomes 109

 Factors that Affect Ecosystems 110

 Biotic and Abiotic Factors 110

 Climate 111

 Major Biomes 112

 Terrestrial Biomes 113

 Aquatic Biomes 113

Populations and Communities 119

 Community Interactions—Competition 119

 Intraspecific Competition 119

 Interspecific Competition 120

 Community Interactions—Predation 122

 Community Interactions—Symbiosis 122

 Community Disturbances 124

 Primary Succession 124

 Secondary Succession 125

 Characteristics of Populations 125

 Population Growth 126

 Exponential Growth 127

 Logistic Growth 127

 Limits to Growth 128

 Experiment 3.2: How does Competition Affect
 Plant Growth? 128

Answers To The “On Your Own” Problems 130

Study Guide For Module 3 133

MODULE 4 137

CELL STRUCTURE AND FUNCTION

Introduction 138
History of Cell Theory..... 138
 The Cell Theory..... 140
 Characteristics of Cells 140
Cell Structure..... 142
 Organelles That All Cells Have in Common 143
 The Plasma Membrane 144
 The Cytoplasm 144
 Ribosomes..... 144
 Organelles of Eukaryotic Cells..... 145
Cell Wall 145
 The Nucleus 146
 The Endoplasmic Reticulum 147
 The Golgi Apparatus 148
 Vacuoles and Vesicles..... 148
 The Lysosome 149
 The Peroxisome..... 150
 The Mitochondrion 150
 The Plastids 151
 The Cytoskeleton..... 152
 Centrioles 153
Experiment 4.1: Plant and Animal Cell Structure..... 155
A Closer Look at Membranes 157
 Movement Through Membranes 160
 Passive Transport: Diffusion 161
 Passive Transport: Osmosis 162
 Experiment 4.2: Osmosis in Animal Cells 164
 Osmosis in Living Cells 166
 Experiment 4.3: Plasmolysis in Plant Cells..... 168
 Passive Transport: Facilitated Diffusion..... 169
 Active Transport 170
Answers To The “On Your Own” Problems..... 173
Study Guide For Module 4 176

MODULE 5 137

CELLULAR ENERGY

Introduction 180
ATP: The Energy Currency of Cells 181
Photosynthesis: Making Energy Packed Food 184
 Experiment 5.1: Pigments of Photosynthesis
 Paper Chromatography 186
 The Light Reactions..... 190
 The Calvin Cycle..... 193

Cellular Respiration: Making ATP	196
Mitochondrial Design	198
The Stages of Cellular Respiration	198
Stage 1: Glycolysis	198
Stage 2: The Link Reaction	200
Stage 3: The Krebs Cycle	200
Stage 4: The Electron Transport Chain	201
Experiment 5.2: Cellular Respiration And Fermentation In Yeast	205
Answers To The “On Your Own” Problems	208
Study Guide For Module 5	211

MODULE 6 213

DNA, PROTEINS, AND THE CELL CYCLE

Introduction	214
DNA, Genes, And Chromosomes	215
A Brief History Of The Discovery Of DNA	216
Genes And Chromosomes	217
Experiment 6.1: DNA Extraction	218
DNA Replication	219
Protein Synthesis	221
Protein Synthesis Part 1: Transcription—	
DNA To RNA	223
Editing RNA	224
Protein Synthesis Part 2: Translation—	
RNA To Protein	226
Adding Amino Acids	227
Summarizing Protein Synthesis	230
Cell Cycle And Cellular Reproduction	231
Mitosis	233
Prophase	233
Metaphase	235
Anaphase	235
Telophase And Cytokinesis	235
Experiment 6.2: Mitosis	236
Meiosis	238
Counting Chromosomes	239
The Process Of Meiosis	241
Answers To The “On Your Own” Problems	247
Study Guide For Module 6	250

MODULE 7 253

GENETICS

Introduction 254
 Experiment 7.1: Environmental Factors And Their
 Effect On Radish Leaf Color..... 254
Mendelian Genetics 255
 Mendel’s Experiments 256
 Modern Terminology..... 260
 Inheritance And Meiosis 262
 Punnett Squares..... 263
 Test Cross 267
 Pedigrees 267
 Experiment 7.2: Making Your Own Pedigree 271
 More Complex Crosses 273
 Meiosis And Dihybrid Crosses..... 273
Inheritance Patterns..... 279
 Sex-Linked Genetic Traits 279
 Nonmendelian Inheritance Patterns..... 282
Human Genetics 287
 Autosomal Disorders..... 287
 Sex-Linked Disorders..... 288
 Disorders Caused By Damaged Genes 288
 Disorders Caused By Damaged Chromosomes 291
 Disorders Due To Change In Chromosome Number .. 292
Gene Technologies..... 294
 Restriction Enzymes 295
 Gel Electrophoresis And DNA Profiling..... 295
 Polymerase Chain Reaction..... 296
 Genetic Engineering And Recombinant DNA 297
Summing Up 299
Answers To The “On Your Own” Problems..... 300
Study Guide For Module 7 304

MODULE 8 308

EVOLUTION

Introduction 309
Charles Darwin 310
 Darwin’s Theory 312
 Microevolution and Macroevolution..... 316
 A Closer Look at Macroevolution..... 319
 Macroevolution Today 319
The Geological Column and The Fossil Record..... 322
 A Detailed Look at the Fossil Record Evidence 326
 The Cambrian Explosion..... 332
 Punctuated Equilibrium and Gradualism..... 334

Structural Homology	335
Molecular Biology	337
Why Do So Many Scientists Believe in Macroevolution?	342
Answers to the “On Your Own” problems.	344
Study Guide for Module 8.	346
MODULE 9	348
PROKARYOTES AND VIRUSES	
Introduction	349
Biological Classification.	349
Five Kingdoms or Six Kingdoms?	352
Overview of 3 Domains and 4 Kingdoms	354
Classifying Phylum, Class, Order, Family, Genus, and Species using Biological Keys	356
Experiment 9.1: Using a Biological Key.	360
Archae and Bacteria.	362
Archae	362
Bacteria	363
Bacterial Cell Structure (a review)	363
Identifying Bacteria	364
Getting and Releasing Energy	368
Conditions for Bacterial Growth.	371
Reproduction	371
Genetic Variation in Bacteria.	372
Bacteria in Nature.	376
Experiment 9.2: Bacterial Fermentation- Making Yogurt	377
Viruses.	380
Viral Structure.	381
How Viruses Infect	382
The Lytic Cycle	382
The Lysogenic Cycle	382
Defenses Against Viruses	383
Answers to the “On Your Own” Problems.	386
Answers to Experiment 9.1	388
Study Guide for Module 9.	389
MODULE 10	391
PROTISTS AND FUNGI	
Introduction To Protists.	392
Experiment 10.1: Pond Life—Part A	392
General Characteristics Of Protists	393
Classifying Protists	394
Animal-Like Protists—The Protozoans	395

Protozoans With Pseudopodia—Sarcodines	395
Protozoans With Flagella—Zooflagellates	396
Protozoans With Cilia—Ciliates	397
Nonmotile Protozoans—Sporozoans	399
Fungus-Like Protists	401
Slime Molds	401
Water Molds And Mildews	402
Plant-Like Protists—Euglena And Algae	403
Euglena	405
Flame-Colored Algae—Dinoflagellates	406
Golden Algae—Diatoms	407
Green Algae	408
Red Algae	410
Brown Algae	410
Experiment 10.2: Protozoans, Algae, And Pond Life—Part B	412
Introduction To Fungi	416
General Characteristics Of Fungi	416
Structure And Function	417
Reproduction In Fungi	418
How Fungi Spread	419
Classifying Fungi	419
The Common Molds—Zygote Fungi	420
Structure And Function Of Zygote Fungi	420
Life Cycle Of Zygote Fungi	420
Experiment 10.3: Molds	421
Sac Fungi	422
Yeast	423
Experiment 10.4: Yeast	423
Other Sac Fungi	424
Club Fungi	425
The Life Cycle Of Club Fungi	426
Diversity Of Club Fungi	428
Experiment 10.5: Club Fungi	429
Chytrids	431
Imperfect Fungi	431
How Fungi Impact Life	432
Decomposers	432
Symbiotic Relationships	432
Pathogens	433
Summing Up	434
Answers To The “On Your Own” Problems	435
Study Guide For Module 10	437

MODULE 11 439

PLANT DIVERSITY AND REPRODUCTION

Introduction To Plants	440
Classifying Plants	442
Nonvascular Plants—Bryophytes	442
Designed To Live In Air	443
Diversity Of Bryophytes	443
Reproductive Life Cycle Of Bryophytes	444
Uses Of Mosses	445
Seedless Vascular Plants—Pteridophytes	446
Designed For Height	446
Diversity Of Pteridophytes	447
Reproductive Life Cycle Of Ferns	448
Seed Plants	449
Designed For Dry Land	449
Reproductive Life Cycle Of Gymnosperms	450
Diversity Of Gymnosperms	451
Diversity Of Angiosperms	452
A Closer Look At The Angiosperm Life Cycle	454
The Parts Of A Flower	455
Experiment 11.1: Flower Anatomy	457
Reproduction In Angiosperms—Part 1: Pollen And Embryo Sacs	459
Pollen Grain Formation	459
Egg Cell Formation	460
Reproduction In Angiosperms—Part 2: Pollination	461
Reproduction In Angiosperms—Part 3: Fertilization	464
Seeds And Fruits	465
Experiment 11.2: Fruit Classification	467
Germination And Early Growth	469
Vegetative Reproduction	471
Answers To The “On Your Own” Problems	474
Study Guide For Module 11	476

MODULE 12 479

PLANT STRUCTURE AND FUNCTION

Introduction To Plant Anatomy And Physiology	479
Plant Structure	479
Plant Tissue	480
Meristematic Tissue	480
Ground Tissue	480
Dermal Tissue	481
Vascular Tissue	481
Roots	481
Macroscopic View Of Roots	481

Microscopic View Of Roots	483
Stems	484
Herbaceous Stems	485
Woody Stems	486
Specialized Stems	489
Leaves	489
Macroscopic View Of Leaves	489
Microscopic View Of Leaves	491
Experiment 12.1: Cross Sections Of Roots, Stems, And A Leaf	493
Leaf Color	496
Experiment 12.2: How Anthocyanins And Ph Help Determine Leaf Color	497
Transporting Water And Nutrients	500
How A Plant Depends On Water	500
Water Absorption In Plants	502
Water Transport In Plants	503
Transpiration	503
Capillary Action	504
Root Pressure	505
Movement Of Substances In Phloem	505
Plant Growth, Hormones, And Responses	506
Auxins And Plant Responses	507
Phototropism	507
Gravitropism	508
Thigmotropism	509
Cytokinins	509
Gibberellins	509
Abscisic Acid	510
Ethylene	510
Florigen	510
Unique Designs	511
Freshwater Plants	511
Saltwater Plants	511
Desert Plants	511
Insectivorous Plants	512
Answers To The “On Your Own” Problems	513
Study Guide For Module 12	515

MODULE 13 517

ANIMALS—INVERTEBRATES PART I

Introduction	517
Characteristics Of Animals	518
Invertebrates And Vertebrates	518
Symmetry	519

Diversity Of Invertebrates	520
Sponges—Phylum Porifera	520
Sponge Anatomy	521
Feeding	522
Reproduction.	523
Uses Of Sponges	523
Experiment 13.1: Observation Of The Spicules Of A Sponge	524
Phylum Cnidaria	525
Cnidarian Anatomy	525
Hydras.	526
Experiment 13.2: Observation Of A Hydra	528
Sea Anemones	529
Corals	530
Jellyfish	531
Phylum Annelida	532
Feeding Habits Of The Earthworm	533
The Respiratory And Circulatory Systems In An Earthworm.	534
The Earthworm’s Reproductive System	535
Other Segmented Worms	536
Experiment 13.3: Earthworm Dissection	537
Phylum Platyhelminthes: The Planarian	539
Experiment 13.4: Observation Of A Planarian	540
Other Members Of Phylum Platyhelminthes	541
Phylum Nematoda	542
Phylum Mollusca	543
General Anatomy.	543
Gastropods	544
Bivalves	544
Cephalopods	544
Summing Up The Invertebrates	545
Answers To The “On Your Own” Problems.	546
Study Guide For Module 13	548

MODULE 14 551

ANIMALS—INVERTEBRATES PART 2

Introduction	551
A Closer Look At Arthropods	551
Common Characteristics	551
An Exoskeleton	551
Body Segmentation	552
Jointed Appendages.	553
Ventral Nervous System.	553
An Open Circulatory System.	554
The Diversity Of Arthropods	554

Class Crustacea: The Crayfish	554
The Crayfish’s Respiratory System	556
The Crayfish’s Circulatory System	557
The Crayfish’s Digestive System	559
The Crayfish’s Nervous System	560
The Crayfish’s Reproductive System	560
Other Crustaceans	561
An Important Note	561
Experiment 14.1: Crayfish Dissection	562
Class Arachnida	565
Characteristics Of Arachnids	565
The Spider	566
Catching Prey	567
Spider Anatomy	568
Classes Chilopoda And Diplopoda	569
Class Insecta	570
Insect Legs	570
Insect Wings	570
The Basic Anatomy Of An Insect	571
Respiration And Circulation In Insects	571
The Feeding Habits Of Insects	572
Reproduction And Development In Insects	573
A Few Orders In Class Insecta	575
Order Lepidoptera: The Butterflies And Moths	575
Order Hymenoptera: Ants, Bees, And Wasps	575
Order Coleoptera: Beetles	577
Order Diptera: Flies, Gnats, And Mosquitoes	578
Order Orthoptera: Grasshoppers And Crickets	579
A Bit About Echinoderms	580
The Unique Design Of Echinoderms	580
Diversity Of Echinoderms	581
Summing Up	582
Answers To The “On Your Own” Problems	583
Study Guide For Module 14	585

MODULE 15 588

ANIMALS—CHORDATES PART I

General Characteristics Of Chordate	588
Nonvertebrate Chordates	589
Tunicates	589
Lancelets	590
General Characteristics Of Vertebrates	590
Internall Support And Protection	590
Circulatory System	591
Nervous System	591

Reproduction	593
Diversity Of Vertebrates—Fishes	595
Jawless Fishes	595
Cartilaginous Fishes	596
Sharks	596
Rays And Skates	599
Bony Fishes	600
General Anatomy Of Bony Fishes	600
Diversity Of Bony Fishes	605
Experiment 15.1: Perch Dissection	608
Diversity Of Vertebrates—Amphibians	612
Characteristics Of Amphibians	612
Groups Of Amphibians	614
Experiment 15.2: Frog Dissection	615
Alternate Experiment For Module 15: Field Study II	616
Diversity Of Vertebrates—Reptiles	617
Characteristics Of Amphibians	617
Classification Of Reptiles	619
Lizards And Snakes	620
Turtles And Tortoises	622
Crocodilians	623
Tuataras	624
Answers To The “On Your Own” Problems	626
Study Guide For Module 15	628

MODULE 16 632

ANIMALS—CHORDATES PART 2

Introduction	632
Birds	632
Characteristics Of Birds	632
Endothermic	632
Four-Chambered Heart	632
Toothless Bill	633
Reproduction	633
A Bird’s Ability To Fly	634
Feathers	634
Wings	636
Skeletal Structure	637
Classification In Class Aves	638
Experiment 16.1: Bird Identification	641
Mammals	642
Characteristics Of Mammals	642
Hair	642
Reproduction	643
Carrying For Young	644
Endothermic With A Four-Chambered Heart	644

Classification In Class Mammalia	644
Monotremes	645
Marsupials.	646
Placental Mammals	646
Animal Behavior	651
Innate Behavior	652
Fixed Action Pattern	652
Rhythmic Patterns Of Behavior	653
Learned Behavior.	654
Habituation.	654
Imprinting	655
Conditioning	655
Social Behaviors.	656
Competitive Behaviors.	656
Courtship Behavior	657
Cooperation	658
Summing It All Up.	659
Answers To The “On Your Own” Problems.	660
Study Guide For Module 16	662

END LETTER	665
APPENDIX A	667
APPENDIX B	671