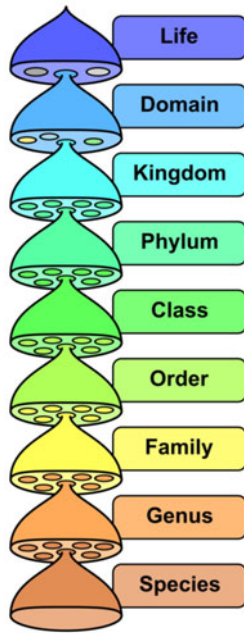


# Discovering Design with Biology

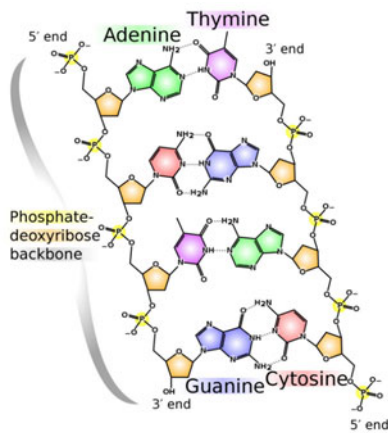
## Table of Contents

### Chapter 1: Introduction to Biology..... 1



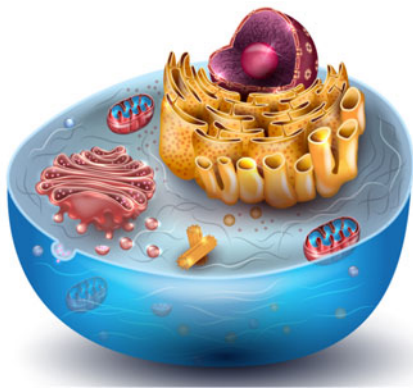
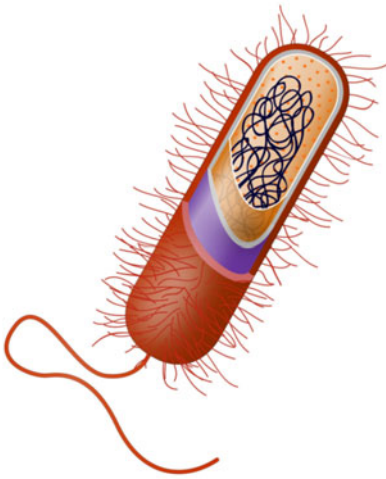
Section 1.1: The Characteristics of Life .....	2
Characteristic 1: Organization .....	3
Characteristic 2: Metabolism.....	3
Characteristic 3: Homeostasis .....	4
Characteristic 4: Response to a Stimulus .....	5
Characteristic 5: Adaptation .....	5
Characteristic 6: Reproduction and heredity .....	6
Experiment 1.1: Fruit DNA .....	7
Characteristic 7: Growth and development .....	8
Section 1.2: Organization of Life .....	9
Section 1.3: Nomenclature .....	11
Section 1.4: Philosophy of Science .....	14
Section 1.5: The Scientific Method .....	16
Section 1.6: Energy Flow .....	19
Experiment 1.2: Energy in Chemicals.....	19
Section 1.7: Natural Selection .....	22
Answers to the Comprehension Check Questions.....	26
Chapter 1 Review .....	27

### Chapter 2: The Chemistry of Life..... 29



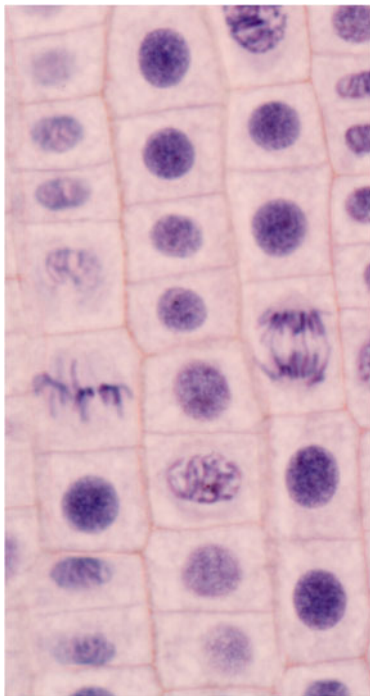
Section 2.1 The Building Blocks of Chemistry .....	29
Section 2.2: Water .....	32
Experiment 2.1: Capillary Action.....	35
Section 2.3: Carbohydrates.....	37
Experiment 2.2: Comparing Starch and Smaller Carbohydrates.....	40
Section 2.4: Lipids .....	41
Section 2.5: Proteins .....	45
Experiment 2.3: Temperature, pH, and Proteins .....	47
Section 2.6: Nucleic Acids .....	48
Section 2.7: Chemical Evolution .....	54
Answers to the Comprehension Check Questions.....	58
Chapter 2 Review .....	59

**Chapter 3: Cells ..... 61**



Section 3.1: Cell theory .....	61
Section 3.2 Prokaryotes .....	63
Section 3.3 Eukaryotes .....	66
Experiment 3.1: Using a Microscope to See Cells .....	66
Section 3.4 Organelles .....	68
Plasma Membrane.....	68
Nucleus .....	69
Endoplasmic reticulum .....	69
Golgi .....	69
Lysosome .....	70
Chloroplast.....	70
Mitochondria.....	70
Cytoskeleton .....	71
Experiment 3.2: Seeing Two Organelles .....	72
Section 3.5 Membrane Transport.....	73
Experiment 3.3: Gummy Bear Osmosis .....	74
Section 3.6: ATP.....	76
Section 3.7: Photosynthesis .....	77
Section 3.8: Cellular Respiration .....	80
Glycolysis .....	81
Fermentation .....	82
Krebs Cycle.....	83
Electron Transport Chain (ETC).....	85
Section 3.9: Evolution: Endosymbiotic Theory.....	88
Answers to the Comprehension Check Questions.....	90
Chapter 3 Review.....	92

**Chapter 4: Cell Division ..... 95**



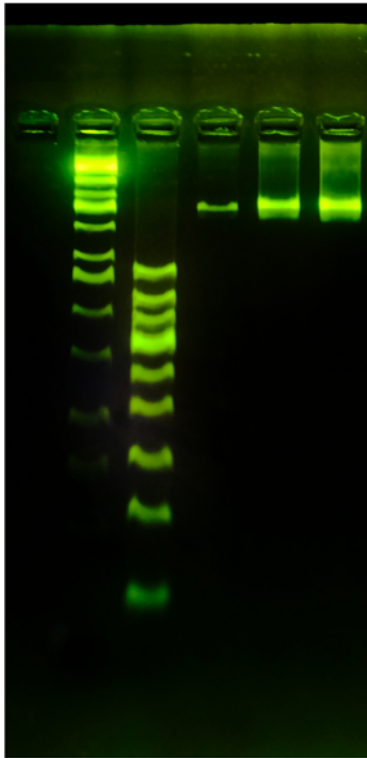
Section 4.1: Cell Cycle .....	95
Section 4.2: Apoptosis.....	98
Section 4.3: Budding .....	99
Experiment 4.1: Budding in Yeast .....	99
Section 4.4: Binary Fission.....	101
Section 4.5: Mitosis .....	102
Differences Among Organisms .....	108
Experiment 4.2: Mitosis in Animal and Plant Cells .....	109
Section 4.6: Meiosis .....	110
Meiosis I .....	111
Meiosis II.....	113
Comparison of Mitosis and Meiosis.....	115
Section 4.7: The Human Life Cycle .....	116
Spermatogenesis .....	116
Oogenesis.....	118
Fertilization.....	119
Section 4.8: Reproduction and Artificial Intelligence .....	120
Answers to the Comprehension Check Questions.....	123
Chapter 4 Review .....	124

**Chapter 5: Genetics ..... 127**



Section 5.1: Gregor Mendel and Simple Inheritance ..... 127  
 Experiment 5.1: Simple Punnett Squares ..... 132  
 More Complicated Punnett Squares ..... 133  
 Section 5.2: Patterns of Inheritance ..... 135  
 Experiment 5.2: A Possibly Bitter Pedigree ..... 139  
 Section 5.3: Non-Mendelian Inheritance ..... 140  
 Section 5.4: Environment and Genetics ..... 143  
 Section 5.5: Human Genome Project and Linkage ..... 145  
 Section 5.6: Chromosomal and Nucleotide Abnormalities ..... 146  
 Chromosomal Abnormalities ..... 146  
 Nucleotide Abnormalities ..... 148  
 Mutations in a Group of Nucleotides ..... 149  
 Point Mutations ..... 151  
 Somatic Cell Mutations versus Germline Mutations ..... 153  
 Section 5.6: Evolution: Mutations and Information ..... 154  
 Answers to the Comprehension Check Questions ..... 156  
 Chapter 5 Review ..... 159

**Chapter 6: Biotechnology ..... 161**



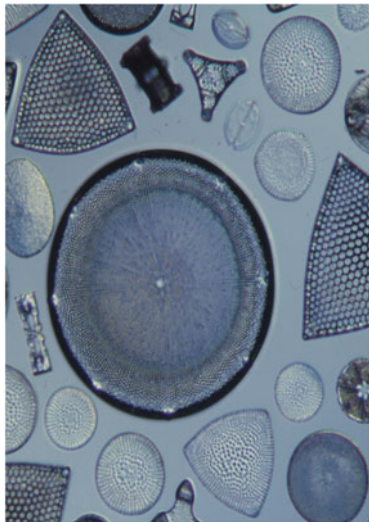
Section 6.1: Biotechnology ..... 162  
 Section 6.2: Restriction Endonucleases ..... 163  
 Section 6.3: Gel Electrophoresis ..... 165  
 Section 6.4: Polymerase Chain Reaction (PCR) ..... 166  
 Section 6.5: DNA Analysis ..... 168  
 DNA sequencing ..... 168  
 Restriction fragment length polymorphism (RFLP) ..... 169  
 Short tandem repeat (STR) profiling ..... 171  
 Section 6.6: Genetic Engineering ..... 173  
 Recombinant DNA (rDNA) ..... 173  
 Reproductive Cloning ..... 174  
 Experiment 6.1: Identical DNA Doesn't Mean Identical ..... 175  
 Therapeutic Cloning ..... 176  
 RNA interference (RNAi) ..... 178  
 Section 6.7: Biotechnology Products ..... 178  
 Section 6.8: Gene Therapy ..... 182  
 Section 6.9: Genomics ..... 183  
 Section 6.10: CRISPR ..... 184  
 Section 6.11: Bioethics ..... 186  
 Answers to the Comprehension Check Questions ..... 188  
 Chapter 6 Review ..... 189

**Chapter 7: Microbiology – Archaea and Bacteria..... 191**



Section 7.1: Microbiology..... 192  
 Microscopy ..... 192  
 Culturing..... 195  
 Experiment 7.1: Culturing Bacteria in Broth..... 196  
 Section 7.2: Archaea ..... 197  
 Section 7.3: General Characteristics of Eubacteria (bacteria) ..... 200  
 Reproduction ..... 200  
 Structure..... 200  
 Biochemistry..... 202  
 Immune system..... 204  
 Experiment 7.2: Examining Your Cultures ..... 205  
 Section 7.4: Classification of Bacteria..... 207  
 Proteobacteria Gram-Negative Bacteria..... 207  
 Nonproteobacteria Gram-Negative bacteria ..... 210  
 Gram-Positive bacteria ..... 211  
 Section 7.5: Viruses, Viroids, and Prions ..... 214  
 Section 7.6: Evolution Challenges ..... 217  
 Answers to the Comprehension Check Problems ..... 219  
 Chapter 7 Review ..... 220

**Chapter 8: Microbiology – Protists and Fungi ..... 221**



Experiment 8.1: Growing Fungi ..... 221  
 Section 8.1: Introduction to Protists..... 222  
 Section 8.2: Characteristics of Protists..... 222  
 Section 8.3: Classification of Protists ..... 224  
 Experiment 8.2: Examining Some Protists ..... 232  
 Section 8.4: Introduction to the Fungi..... 235  
 Section 8.5: Characteristics of Fungi ..... 236  
 Section 8.6: Classification of Fungi ..... 238  
 Experiment 8.3: Examining Some Fungi..... 245  
 Section 8.7: Symbiosis in Fungi..... 246  
 Section 8.8: Diseases Caused by Fungi..... 248  
 Section 8.8: Evolution – Classification Using Phylogenetics..... 249  
 Answers to the Comprehension Check Questions ..... 250  
 Chapter 8 Review ..... 251

**Chapter 9: Invertebrates.....253**



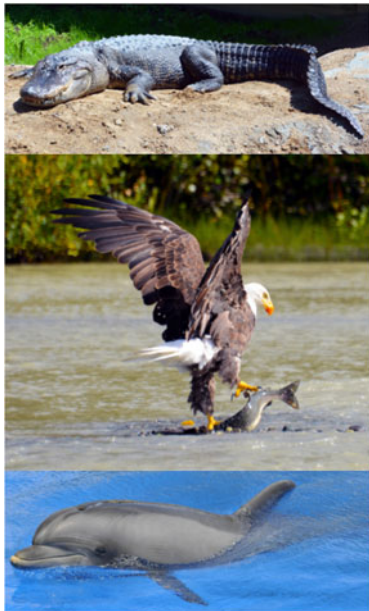
Section 9.1: Invertebrate Characteristics ..... 254  
 Section 9.2: Phylum Porifera ..... 255  
 Section 9.3: Phylum Ctenophora and Cnidaria..... 256  
 Section 9.4: Phylum Platyhelminthes ..... 259  
     Experiment 9.1: Examining a Hydra and a Planarian ..... 262  
 Section 9.5: Phylum Echinodermata..... 263  
 Section 9.6: Phylum Mollusca ..... 265  
 Section 9.7: Phylum Nematoda..... 269  
 Section 9.8: Phylum Annelida ..... 270  
     Experiment 9.2: Earthworm Dissection..... 272  
 Section 9.9: Phylum Arthropoda..... 274  
     Arachnids..... 275  
     Crustaceans..... 276  
     Experiment 9.3: Crayfish Dissection..... 277  
     Insects ..... 279  
     Millipedes and centipedes ..... 283  
 Section 9.10: Invertebrates in Phylum Chordata ..... 283  
 Section 9.11: Challenges for Evolution ..... 285  
 Answers to the Comprehension Check Questions ..... 286  
 Chapter 9 Review..... 287

**Chapter 10: Vertebrates: Fish and Amphibians.....289**



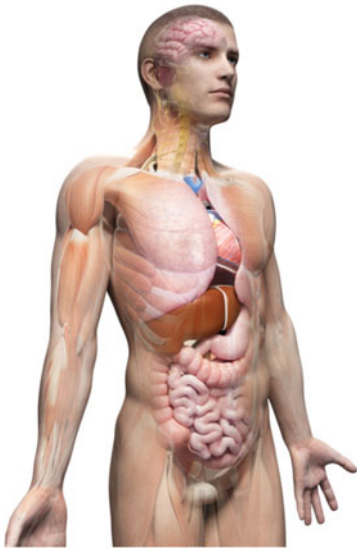
Section 10.1: Characteristics of Vertebrates ..... 289  
 Section 10.2: Characteristics of Fish..... 290  
 Section 10.3: Agnatha (the Jawless Fish) ..... 292  
 Section 10.4: Chondrichthyes (the Cartilaginous Fish) ..... 294  
 Section 10.5: Osteichthyes (the Bony Fish)..... 297  
     Experiment 10.1: Perch Dissection ..... 298  
     Ray-finned Fish ..... 300  
     Lobe-finned fish ..... 302  
 Section 10.6: Characteristics of Amphibians..... 304  
 Section 10.7: Order Caudata ..... 305  
 Section 10.8: Order Anura – Frogs and Toads..... 307  
     Experiment 10.2: Frog Dissection ..... 308  
     Diversity Among Frogs ..... 310  
     Diversity Among Toads..... 312  
 Section 10.9: Order Apoda – Caecilians ..... 314  
 Section 10.10: Evolution of Fish to Amphibians..... 315  
 Answers to the Comprehension Check Questions ..... 317  
 Chapter 10 Review..... 318

**Chapter 11: Reptiles, Birds, and Mammals ..... 321**



Section 11.1: Reptiles .....	321
Experiment 11.1: Egg Dissection .....	324
Order Crocodylia: Crocodiles, Alligators, Caimans.....	325
Order Sphenodontia: tuataras .....	326
Order Squamata: lizards, snakes.....	327
Order Testudines: turtles, tortoises, terrapins .....	332
Section 11.2: Birds.....	334
Experiment 11.2: Analyzing a Feather .....	339
Flightless birds.....	340
Flying birds.....	341
Section 11.3: Mammals.....	343
Monotremes .....	346
Marsupials.....	347
Placental mammals .....	348
Section 11.4: Challenges for Evolution .....	350
Answers to the Comprehension Check Questions .....	352
Chapter 11 Review.....	353

**Chapter 12: Primates and Humans..... 355**



Section 12.1: Primates.....	355
Section 12.2: Humans .....	357
Section 12.3: The Nervous System.....	359
Experiment 12.1: Reaction Versus Reflex .....	361
Section 12.4: The Cardiovascular System .....	363
Experiment 12.2: Examining your Own Blood.....	366
Section 12.5: The Immune System .....	367
Section 12.6: The Digestive System .....	371
Section 12.7: The Respiratory System.....	374
Experiment 12.3: Diffusion Through Plastic.....	375
Section 12.8: The Renal System .....	377
Section 12.9: The Reproductive Systems .....	379
Section 12.10: <i>Imago Dei</i> .....	380
Section 12.11: Human Evolution.....	381
Answers to the Comprehension Check Questions .....	384
Chapter 12 Review.....	385

**Chapter 13: Plants – Anatomy and Classification..... 387**



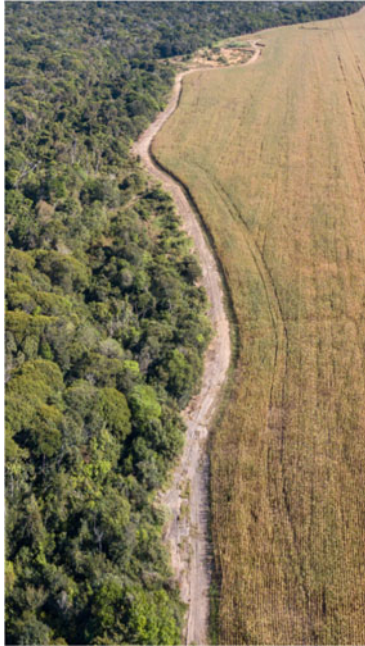
Section 13.1: Overview..... 387  
 Cells..... 387  
 Tissues..... 390  
 Organs..... 392  
 Experiment 13.1: A Flower Dissection..... 393  
 Section 13.2: Root System..... 395  
 Section 13.3: Stem (or Shoot) System..... 398  
 Experiment 13.2: Stems and Roots..... 402  
 Section 13.4: Leaf System..... 404  
 Experiment 13.3: The Microscopic Structure of a Leaf..... 407  
 Section 13.5: Flowers, Fruits, and Seeds..... 408  
 Section 13.6: Classification..... 411  
 Non-vascular plants..... 411  
 Seedless Vascular plants..... 412  
 Seed-Making plants..... 413  
 Section 13.7: Angiosperm Explosion..... 416  
 Answers to the Comprehension Check Questions..... 417  
 Chapter 13 Review..... 418

**Chapter 14: Plants – Physiology..... 419**



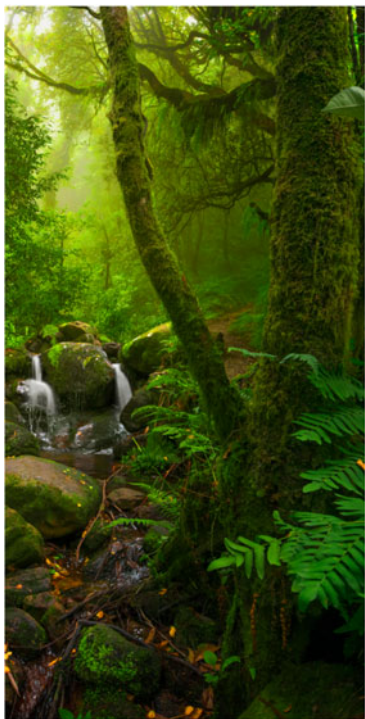
Experiment 14.1: Germination and Growth of a Bean Plant..... 419  
 Section 14.1: Photosynthesis..... 421  
 Section 14.2: Vascular System Movement..... 422  
 Xylem: cohesion-tension transport..... 422  
 Experiment 14.2: Water Transport in Plants..... 423  
 Phloem: pressure-flow..... 425  
 Section 14.3: Nitrogen Fixation..... 426  
 Section 14.4: Reproduction..... 427  
 Section 14.5: Growth..... 429  
 Section 14.6: Photoperiodism..... 430  
 Plants and Winter..... 432  
 Section 14.6: Plant Hormones..... 434  
 Section 14.8: Tropism..... 439  
 Section 14.9: Plants and Personhood..... 443  
 Answers to the Comprehension Check Questions..... 444  
 Chapter 14 Review..... 445

**Chapter 15: Environmental Science ..... 447**



Section 15.1: Energy Flow ..... 447  
 Section 15.2: Global Biogeochemical Cycles ..... 449  
     The Hydrologic Cycle ..... 449  
     Experiment 15.1: Cloud Formation ..... 450  
     The Carbon Cycle ..... 451  
     The Nitrogen Cycle ..... 452  
     The Phosphorus Cycle ..... 453  
 Section 15.3: Climate ..... 454  
 Section 15.4: Soil ..... 456  
 Section 15.5: Conservation Biology ..... 458  
 Section 15.6: Biodiversity ..... 459  
 Section 15.7: Drivers of Change ..... 462  
     Experiment 15.2: Air Pollution ..... 464  
 Section 15.8: Sustainability ..... 470  
 Section 15.9: Climate Change ..... 473  
     Experiment 15.3: Carbon Dioxide Is a Greenhouse Gas ..... 473  
 Answers to the Comprehension Check Questions ..... 476  
 Chapter 15 Review ..... 477

**Chapter 16: Ecosystems ..... 479**



Section 16.1: Interactions in Populations and Communities ..... 479  
     Population growth ..... 483  
     Ecological succession ..... 484  
 Section 16.2: Ecosystems and the Biosphere ..... 485  
 Section 16.3: Rainforests ..... 486  
 Section 16.4: Deserts ..... 489  
 Section 16.5: Temperate Forests ..... 491  
 Section 16.6: Grasslands ..... 493  
 Section 16.7: Scrublands ..... 496  
 Section 16.8: Coniferous Forests ..... 498  
 Section 16.9: Tundra ..... 500  
     Experiment 16.1: Terrestrial and Aquatic Ecosystems ..... 502  
 Section 16.10: Freshwater Ecosystems ..... 503  
 Section 16.11: Estuary Ecosystems ..... 504  
 Section 16.11: The Ocean Ecosystem ..... 505  
 Section 16.12: Fine-Tuning in Ecosystems ..... 507  
     Experiment 16.2: A Small Aquatic Ecosystem ..... 508  
 Some Final Thoughts ..... 509  
 Answers to the Comprehension Check Questions ..... 510  
 Chapter 16 Review ..... 511

**Glossary ..... 513**

**Photo and Illustration Credits ..... 532**

**Appendix A ..... 534**

**Appendix B ..... 539**

**Appendix C ..... 545**

**Index ..... 552**