

GLOBAL
EDITION



Campbell Biology

Concepts & Connections

NINTH EDITION

Taylor • Simon • Dickey • Hogan • Reece



Pearson

This page intentionally left blank

Campbell Biology: Concepts & Connections, Global Edition

Table of Contents

Front Cover

Brief Contents

Title Page

Copyright Page

About the Authors

Preface

New Content

Acknowledgments

Reviewers

Acknowledgments for the Global Edition

Detailed Contents

1 Biology: Exploring Life

Biology: The Scientific Study of Life

1.1 What Is life?

1.2 Biologists arrange the diversity of life into three domains

1.3 Visualizing The Concept In lifes hierarchy of organization, new properties emerge at each level

The Process of Science

1.4 What is science?

1.5 Hypotheses can be tested using controlled experiments

1.6 Scientific Thinking Hypotheses can be tested using observational data

1.7 The process of science is repetitive, nonlinear, and collaborative

1.8 Connection Biology, technology, and society are connected in important ways

Five Unifying Themes in Biology

1.9 Theme: Evolution is the core theme of biology

1.10 Evolution Connection Evolution is connected to our everyday lives

1.11 Theme: Life depends on the flow of information

1.12 Theme: Structure and function are related

1.13 Theme: Life depends on the transfer and transformation of energy and matter

1.14 Theme: Life depends on interactions within and between systems

Chapter Review

Unit I The Life of the Cell

2 The Chemical Basis of Life

Elements, Atoms, and Compounds

2.1 Organisms are composed of elements, usually combined into compounds

Table of Contents

- 2.2 Connection Trace elements are common additives to food and water
- 2.3 Atoms consist of protons, neutrons, and electrons
- 2.4 Connection Radioactive isotopes can help or harm us

Chemical Bonds

- 2.5 The distribution of electrons determines an atoms chemical properties
- 2.6 Visualizing The Concept Covalent bonds join atoms into molecules through electron sharing
- 2.7 Ionic bonds are attractions between ions of opposite charge
- 2.8 Hydrogen bonds are weak bonds important in the chemistry of life
- 2.9 Chemical reactions make and break chemical bonds

Waters Life-Supporting Properties

- 2.10 Hydrogen bonds make liquid water cohesive
- 2.11 Waters hydrogen bonds moderate temperature
- 2.12 Ice floats because it is less dense than liquid water
- 2.13 Water is the solvent of life
- 2.14 Scientists study the effects of rising atmospheric CO₂ on coral reef ecosystems
- 2.15 Scientific Thinking The chemistry of life is sensitive to acidic and basic conditions
- 2.16 Evolution Connection The search for extraterrestrial life centers on the search for water
- Chapter Review
- Chapter Review

3 The Molecules of Cells

Introduction to Organic Compounds

- 3.1 Lifes molecular diversity is based on the properties of carbon
- 3.2 A few chemical groups are key to the functioning of biological molecules
- 3.3 Cells make large molecules from a limited set of small molecules

Carbohydrates

- 3.4 Monosaccharides are the simplest carbohydrates
- 3.5 Two monosaccharides are linked to form a disaccharide
- 3.6 Connection Are we eating too much sugar?
- 3.7 Polysaccharides are long chains of sugar units

Lipids

- 3.8 Fats are lipids that are mostly energy-storage molecules
- 3.9 Scientific Thinking Scientific studies document the health risks of trans fats
- 3.10 Phospholipids and steroids are important lipids with a variety of functions
- 3.11 Connection Anabolic steroids pose health risks

Proteins

- 3.12 Proteins have a wide range of functions and structures
- 3.13 Proteins are made from amino acids linked by peptide bonds
- 3.14 Visualizing The Concept A Proteins functional shape results from four levels of structure

Nucleic Acids

- 3.15 The nucleic acids DNA and RNA are information-rich polymers of nucleotides
- 3.16 Evolution Connection Lactose tolerance is a recent event in human evolution

Table of Contents

Chapter Review

4 A Tour of the cell

Introduction to the Cell

- 4.1 Microscopes reveal the world of the cell
- 4.2 The small size of cells relates to the need to exchange materials across the plasma membrane
- 4.3 Prokaryotic cells are structurally simpler than eukaryotic cells
- 4.4 Eukaryotic cells are partitioned into functional compartments

The Nucleus and Ribosomes

- 4.5 The nucleus contains the cells genetic instructions
- 4.6 Ribosomes make proteins for use in the cell and for export

The Endomembrane System

- 4.7 Many organelles are connected in the endomembrane system
- 4.8 The endoplasmic reticulum is a biosynthetic workshop
- 4.9 The Golgi apparatus modifies, sorts, and ships cell products
- 4.10 Lysosomes are digestive compartments within a cell
- 4.11 Vacuoles function in the general maintenance of the cell

Energy-Converting Organelles

- 4.13 Mitochondria harvest chemical energy from food
- 4.14 A review of the structures involved in manufacturing and breakdown
- 4.15 Evolution Connection Chloroplasts convert solar energy to chemical energy
- 4.16 Mitochondria and chloroplasts evolved by endosymbiosis

The Cytoskeleton and Cell Surfaces

- 4.16 The cells internal skeleton helps organize its structure and activities
- 4.17 Scientific Thinking Scientists discovered the cytoskeleton using the tools of biochemistry and microscopy
- 4.18 Cilia and flagella move when microtubules bend
- 4.19 The extracellular matrix of animal cells functions in support and regulation
- 4.20 Three types of cell junctions are found in animal tissues
- 4.21 Cell walls enclose and support plant cells
- 4.22 Review: Eukaryotic cell structures can be grouped on the basis of four main functions

Chapter Review

5 The Working Cell

Membrane Structure and Function

- 5.1 Visualizing The Concept Membranes are fluid mosaics of lipids and proteins with many functions
- 5.2 Evolution Connection The spontaneous formation of membranes was a critical step in the origin of life
- 5.3 Passive transport is diffusion across a membrane with no energy investment
- 5.4 Osmosis is the diffusion of water across a membrane
- 5.5 Water balance between cells and their surroundings is crucial to organisms
- 5.6 Transport proteins can facilitate diffusion across membranes
- 5.7 Scientific Thinking Research on another membrane protein led to the discovery of aquaporins
- 5.8 Cells expend energy in the active transport of a solute

Table of Contents

5.9 Exocytosis and endocytosis transport large molecules across membranes

Energy and the Cell

5.10 Cells transform energy and matter as they perform work

5.11 Chemical reactions either release or store energy

5.12 ATP drives cellular work by coupling exergonic and endergonic reactions

How Enzymes Function

5.13 Enzymes speed up the cells chemical reactions by lowering energy barriers

5.14 A specific enzyme catalyzes each cellular reaction

5.15 Enzyme inhibition can regulate enzyme activity in a cell

5.16 Many drugs, pesticides, and poisons are enzyme inhibitors

Chapter Review

6 How Cells Harvestchemical Energy

Cellular Respiration: Aerobic Harvesting of Energy

6.1 Photosynthesis and cellular respiration provide energy for life

6.2 Breathing supplies O₂ for use in cellular respiration and removes CO₂

6.3 Cellular respiration banks energy in ATP molecules

6.4 The human body uses energy from ATP for all its activities

6.5 Cells capture energy from electrons falling from organic fuels to oxygen

Stages of Cellular Respiration

6.6 Overview: cellular respiration occurs in three main stages

6.7 Glycolysis harvests chemical energy by oxidizing glucose to pyruvate

6.8 After pyruvate is oxidized, the citric acid cycle completes the energy-yielding oxidation of organic molecules

6.9 Visualizing The Concept Most ATP production occurs by oxidative phosphorylation

6.10 Scientific Thinking Scientists have discovered heat-producing, calorie-burning brown fat In adults

6.11 Review: each molecule of glucose yields many molecules of ATP

Fermentation: Anaerobic Harvesting of Energy

6.12 Fermentation enables cells to produce ATP without oxygen

6.13 Evolution Connection Glycolysis evolved early in the history of life on earth

Connections Between Metabolic Pathways

6.14 Cells use many kinds of organic molecules as fuel for cellular respiration

6.15 Organic molecules from food provide raw materials for biosynthesis

Chapter Review

7 Photosynthesis:Using Light to Make Food

An Introduction to Photosynthesis

7.1 Photosynthesis fuels the biosphere

7.2 Photosynthesis occurs in chloroplasts in plant cells

7.3 Scientists traced the process of photosynthesis using isotopes

7.4 Photosynthesis is a redox process, as is cellular respiration

7.5 Photosynthesis occurs in two stages, which are linked by atp and nadph

The Light Reactions: Converting Solar Energy to Chemical Energy

7.6 Visible radiation absorbed by pigments drives the light reactions

7.7 Photosystems capture solar energy

Table of Contents

7.8 Two photosystems connected by an electron transport chain convert light energy to the chemical energy of atp and nadph

7.9 Visualizing The Concept The light reactions take place within the thylakoid membranes

The Calvin Cycle: Reducing CO₂ to Sugar

7.10 ATP and NADPH power sugar synthesis in the calvin cycle

7.11 Evolution Connection Other methods of carbon fixation have evolved in hot, dry climates

The Global Significance of Photosynthesis

7.12 Photosynthesis provides food and o₂ for almost all living organisms

7.13 Scientific Thinking Rising atmospheric levels of carbon dioxide may affect plants in various ways

7.14 Connection Reducing both fossil fuel use and deforestation may moderate climate change

Chapter Review

Unit II Cellular Reproduction and Genetics

8 The Cellular Basis of Reproduction and Inheritance

Cell Division and Reproduction

8.1 Cell division plays many important roles in the lives of organisms

8.2 Prokaryotes reproduce by binary fission

The Eukaryotic Cell Cycle and Mitosis

8.3 The large, complex chromosomes of eukaryotes duplicate with each cell division

8.4 The cell cycle includes growth and division phases

8.5 Cell division is a continuum of dynamic changes

8.6 Cytokinesis differs for plant and animal cells

8.7 The rate of cell division is affected by environmental factors

8.8 Growth factors signal the cell cycle control system

8.9 Connection Growing out of control, cancer cells produce malignant tumors

8.10 Scientific Thinking The best cancer treatment may vary by individual

Meiosis and Crossing Over

8.11 Chromosomes are matched in homologous pairs

8.12 Gametes have a single set of chromosomes

8.13 Meiosis reduces the chromosome number from diploid to haploid

8.14 Visualizing The Concept Mitosis and meiosis have important similarities and differences

8.15 Independent orientation of chromosomes in meiosis and random fertilization lead to varied offspring

8.16 Homologous chromosomes may carry different versions of genes

8.17 Visualizing The Concept Crossing over further increases genetic variability

Alterations of Chromosome Number and Structure

8.18 Accidents during meiosis can alter chromosome number

8.19 A karyotype is a photographic inventory of an individual's chromosomes

8.20 Connection An extra copy of chromosome 21 causes Down syndrome

8.21 Evolution Connection Abnormal numbers of sex chromosomes do not usually affect survival

8.22 New species can arise from errors in cell division

Table of Contents

8.23 Connection Alterations of chromosome structure can cause birth defects and cancer

Chapter Review

9 Patterns of Inheritance

Mendels Laws

- 9.1 The study of genetics has ancient roots
- 9.2 The science of genetics began in an abbey garden
- 9.3 Mendels law of segregation describes the inheritance of a single character
- 9.4 Homologous chromosomes bear the alleles for each character
- 9.5 The law of independent assortment is revealed by tracking two characters at once
- 9.6 Geneticists can use a testcross to determine unknown genotypes
- 9.7 Mendels laws reflect the rules of probability
- 9.8 Visualizing The Concept Genetic traits in humans can be tracked through family pedigrees
- 9.9 Connection Many inherited traits in humans are controlled by a single gene
- 9.10 Connection New technologies can provide insight into ones genetic legacy

Variations on Mendels Laws

- 9.11 Incomplete dominance results in intermediate phenotypes
- 9.12 Many genes have more than two alleles that may be codominant
- 9.13 A single gene may affect many phenotypic characters
- 9.14 A single character may be influenced by many genes
- 9.15 The environment affects many characters

The Chromosomal Basis of Inheritance

- 9.16 Chromosome behavior accounts for Mendels laws
- 9.17 Scientific Thinking Genes on the same chromosome tend to be inherited together
- 9.18 Crossing over produces new combinations of alleles
- 9.19 Geneticists use crossover data to map genes

Sex Chromosomes and Sex-Linked Genes

- 9.20 Chromosomes determine sex in many species
- 9.21 Sex-linked genes exhibit a unique pattern of inheritance
- 9.22 Connection Human sex-linked disorders affect mostly males
- 9.23 Evolution Connection The Y chromosome provides clues about human male evolution

Chapter Review

10 Molecular Biology of the Gene

The Structure of the Genetic Material

- 10.1 Scientific Thinking Experiments showed that DNA is the genetic material
- 10.2 DNA and RNA are polymers of nucleotides
- 10.3 DNA is a double-stranded helix

DNA Replication

- 10.4 DNA replication depends on specific base pairing
- 10.5 DNA replication proceeds in two directions at many sites simultaneously

The Flow of Genetic Information from DNA to RNA to Protein

- 10.6 Genes control phenotypic traits through the expression of proteins
- 10.7 Genetic information written in codons is translated into amino acid

Table of Contents

sequences

- 10.8 The genetic code dictates how codons are translated into amino acids
- 10.9 Visualizing The Concept Transcription produces genetic messages in the form of RNA
- 10.10 Eukaryotic RNA is processed before leaving the nucleus as mRNA
- 10.11 Transfer RNA molecules serve as interpreters during translation
- 10.12 Ribosomes build polypeptides
- 10.13 An Initiation codon marks the start of an mRNA message
- 10.14 Elongation adds amino acids to the polypeptide chain until a stop codon terminates translation
- 10.15 Review: the flow of genetic information In the cell Is DNA RNA protein
- 10.16 Mutations can affect genes

The Genetics of Viruses and Bacteria

- 10.17 Viral DNA may become part of the host chromosome
- 10.18 Connection Many viruses cause disease in animals and plants
- 10.19 Evolution Connection Emerging viruses threaten human health
- 10.20 The AIDS virus makes DNA on an RNA template
- 10.21 Prions are Infectious proteins
- 10.22 Bacteria can transfer DNA in three ways
- 10.23 Bacterial plasmids can serve as carriers for gene transfer

Chapter Review

11 How Genes Are Controlled

Control of Gene Expression

- 11.1 Proteins Interacting with DNA turn prokaryotic genes on or off in response to environmental changes
- 11.2 Chromosome structure and chemical modifications can affect gene expression
- 11.3 Complex assemblies of proteins control eukaryotic transcription
- 11.4 Eukaryotic RNA may be spliced in more than one way
- 11.5 Later stages of gene expression are also subject to regulation
- 11.6 Noncoding RNAs play multiple roles in controlling gene expression
- 11.7 Visualizing The Concept Multiple mechanisms regulate gene expression in eukaryotes
- 11.8 Cell signaling and waves of gene expression direct animal development
- 11.9 Connection Researchers can monitor the expression of specific genes
- 11.10 Signal transduction pathways convert messages received at the cell surface to responses within the cell
- 11.11 Evolution Connection Cell-signaling systems appeared early in the evolution of life

Cloning of Plants and Animals

- 11.12 Plant cloning shows that differentiated cells may retain all of their genetic potential
- 11.13 Scientific Thinking Biologists can clone animals via nuclear transplantation
- 11.14 Connection Therapeutic cloning can produce stem cells with great medical potential

The Genetic Basis of Cancer

- 11.15 Cancer results from mutations in genes that control cell division
- 11.16 Multiple genetic changes underlie the development of cancer

Table of Contents

11.17 Faulty proteins can interfere with normal signal transduction pathways

11.18 Connection Lifestyle choices can reduce the risk of cancer

Chapter Review

12 DNA Technology and Genomics

Gene Cloning and Editing

12.1 Genes can be cloned in recombinant plasmids

12.2 Visualizing The Concept Enzymes are used to cut and paste DNA

12.3 Nucleic acid probes can label specific DNA segments

12.4 Reverse transcriptase can help make genes for cloning

12.5 New techniques allow a specific gene to be edited

Genetically Modified Organisms

12.6 Recombinant cells and organisms can mass-produce gene products

12.7 Connection DNA technology has changed the pharmaceutical industry and medicine

12.8 Connection Genetically modified organisms are transforming agriculture

12.9 Scientific Thinking The use of genetically modified organisms raises questions and concerns

12.10 Connection Gene therapy may someday help treat a variety of diseases

DNA Profiling

12.11 The analysis of genetic markers can produce a dna profile

12.12 The PCR method is used to amplify DNA sequences

12.13 Gel electrophoresis sorts DNA molecules by size

12.14 Short tandem repeat analysis is used for DNA profiling

12.15 Connection DNA profiling has provided evidence in many forensic investigations

Genomics and Bioinformatics

12.16 Small segments of DNA can be sequenced directly

12.17 Genomics is the scientific study of whole genomes

12.18 Connection The Human Genome Project revealed that most of the human genome does not consist of genes

12.19 The whole-genome shotgun method of sequencing a genome can provide a wealth of data quickly

12.20 The field of bioinformatics Is expanding our understanding of genomes

12.21 Evolution Connection Genomes hold clues to human evolution

Chapter Review

Unit III Concepts of Evolution

13 How Populations Evolve

Darwins Theory of Evolution

13.1 A sea voyage helped Darwin frame his theory of evolution

13.2 The study of fossils provides strong evidence for evolution

13.3 Scientific Thinking Fossils of transitional forms support Darwins theory of evolution

13.4 Homologies provide strong evidence for evolution

13.4 Homologies indicate patterns of descent that can be shown on an evolutionary tree

13.5 Darwin proposed natural selection as the mechanism of evolution

13.6 Scientists can observe natural selection In action

Table of Contents

The Evolution of Populations

- 13.8 Mutation and sexual reproduction produce the genetic variation that makes evolution possible
- 13.9 Evolution occurs within populations
- 13.10 The Hardy-Weinberg equation can test whether a population is evolving
- 13.11 Connection The Hardy-Weinberg equation is useful in public health science

Mechanisms of Microevolution

- 13.12 Natural selection, genetic drift, and gene flow can cause microevolution
 - 13.13 Natural selection is the only mechanism that consistently leads to adaptive evolution
 - 13.14 Visualizing The Concept Natural selection can alter variation in a population in three ways
 - 13.15 Sexual selection may lead to phenotypic differences between males and females
 - 13.16 Evolution Connection The evolution of drug-resistant microorganisms is a serious public health concern
 - 13.17 Diploidy and balancing selection preserve genetic variation
 - 13.18 Natural selection cannot fashion perfect organisms
- Chapter Review

14 The Origin of Species

Defining species

- 14.1 The origin of species is the source of biological diversity
- 14.2 There are several ways to define a species
- 14.3 Visualizing The Concept Reproductive barriers keep species separate

Mechanisms of Speciation

- 14.4 In allopatric speciation, geographic isolation leads to speciation
 - 14.5 Reproductive barriers can evolve as populations diverge
 - 14.6 Sympatric speciation takes place without geographic isolation
 - 14.7 Scientific Thinking Sexual selection can lead to speciation
 - 14.8 Isolated Islands are often showcases of speciation
 - 14.9 Evolution Connection Long-term field studies document evolution in Darwin's finches
 - 14.10 Hybrid zones provide opportunities to study reproductive isolation
 - 14.11 Speciation can occur rapidly or slowly
- Chapter Review

15 Tracing Evolutionary History

Early Earth and the Origin of Life

- 15.1 Conditions on early earth made the origin of life possible
- 15.2 Scientific Thinking Experiments show that the abiotic synthesis of organic molecules is possible
- 15.3 Stages In the origin of the first cells probably included the formation of polymers, protocells, and self-replicating RNA

Major Events in the History of Life

- 15.4 The origins of single-celled and multicellular organisms and the colonization of land were key events in life's history
- 15.5 The actual ages of rocks and fossils mark geologic time
- 15.6 The fossil record documents the history of life

Table of Contents

Mechanisms of Macroevolution

- 15.7 Continental drift has played a major role in macroevolution
- 15.8 Connection Plate tectonics may imperil human life
- 15.9 Five mass extinctions have altered the course of evolution
- 15.10 Adaptive radiations have increased the diversity of life
- 15.11 Genes that control development play a major role in evolution
- 15.12 Evolution Connection Novel traits may arise in several ways
- 15.13 Evolutionary trends do not mean that evolution is goal directed

Phylogeny and the Tree of Life

- 15.14 Taxonomy names and classifies the diversity of life
 - 15.15 Phylogenies based on homologies reflect evolutionary history
 - 15.16 Shared characters are used to construct phylogenetic trees
 - 15.17 An organisms evolutionary history is documented in its genome
 - 15.18 Molecular clocks help track evolutionary time
 - 15.19 Constructing the tree of life is a work in progress
- Chapter Review

Unit IV The Evolution of Biological Diversity

16 Microbial life: Prokaryotes and Protists

Prokaryotes

- 16.1 Prokaryotes are diverse and widespread
- 16.2 External features contribute to the success of prokaryotes
- 16.3 Populations of prokaryotes can adapt rapidly to changes in the environment
- 16.4 Prokaryotes have unparalleled nutritional diversity
- 16.5 Connection Biofilms are complex associations of microbes
- 16.6 Connection Prokaryotes help clean up the environment
- 16.7 Bacteria and archaea are the two main branches of prokaryotic evolution
- 16.8 Archaea thrive in extreme environments and in other habitats
- 16.9 Bacteria Include a diverse assemblage of prokaryotes
- 16.10 Some bacteria cause disease
- 16.11 Scientific Thinking Stomach microbiota affect health and disease

Protists

- 16.12 Protists are an extremely diverse assortment of eukaryotes
 - 16.13 Protist diversity is organized In supergroups
 - 16.14 The SAR supergroup represents the range of protist diversity
 - 16.15 Connection Can algae provide a renewable source of energy?
 - 16.16 Some excavates have modified mitochondria
 - 16.17 Unikonts Include protists that are closely related to fungi and animals
 - 16.18 Archaeplastids include red algae, green algae, and land plants
 - 16.19 Evolution Connection Multicellularity evolved several times in eukaryotes
- Chapter Review

17 The Evolution of Plant and Fungal Diversity

Plant Evolution and Diversity

- 17.1 Plants have adaptations for life on land
- 17.2 Plant diversity reflects the evolutionary history of the plant kingdom
- 17.3 Visualizing The Concept Haploid and diploid generations alternate In plant life cycles

Table of Contents

Alternation of Generations and Plant Life Cycles

- 17.4 Seedless vascular plants dominated vast coal forests
- 17.5 Pollen and seeds are key adaptations for life on land
- 17.6 The flower is the centerpiece of angiosperm reproduction
- 17.7 The angiosperm plant is a sporophyte with gametophytes in its flowers
- 17.8 The structure of a fruit reflects its function in seed dispersal
- 17.9 Connection Angiosperms sustain us and add spice to our diets
- 17.10 Evolution Connection Pollination by animals has influenced angiosperm evolution
- 17.11 Connection Plant diversity is vital to the future of the world's food supply

Diversity of Fungi

- 17.12 Fungi absorb food after digesting it outside their bodies
 - 17.13 Fungi produce spores in both asexual and sexual life cycles
 - 17.14 Fungi are classified into five groups
 - 17.15 Connection Fungi have enormous ecological benefits
 - 17.16 Connection Fungi have many practical uses
 - 17.17 Fichens are symbiotic associations of fungi and photosynthetic organisms
 - 17.18 Scientific Thinking Mycorrhizae may have helped plants colonize land
 - 17.19 Connection Parasitic fungi harm plants and animals
- Chapter Review

18 The Evolution of Invertebrate Diversity

Animal Evolution and Diversity

- 18.1 What is an animal?
- 18.2 Animal diversification began more than half a billion years ago
- 18.3 Visualizing The Concept Animals can be characterized by basic features of their body plan
- 18.4 Body plans and molecular comparisons of animals can be used to build phylogenetic trees

Invertebrate Diversity

- 18.5 Sponges have a relatively simple, porous body
 - 18.6 Cnidarians are radial animals with tentacles and stinging cells
 - 18.7 Flatworms are the simplest bilateral animals
 - 18.8 Nematodes have a body cavity and a complete digestive tract
 - 18.9 Diverse molluscs are variations on a common body plan
 - 18.10 Annelids are segmented worms
 - 18.11 Arthropods are segmented animals with jointed appendages and an exoskeleton
 - 18.12 Evolution Connection Insects are the most successful group of animals
 - 18.13 Scientific Thinking The genes that build animal bodies are ancient
 - 18.14 Echinoderms have spiny skin, an endoskeleton, and a water vascular system for movement
 - 18.15 Our own phylum, Chordata, is distinguished by four features
 - 18.16 Connection Invertebrate diversity is a valuable but threatened resource
- Chapter Review

19 The Evolution of Vertebrate Diversity

Vertebrate Evolution and Diversity

Table of Contents

- 19.1 Shared derived characters define the major clades of chordates
- 19.2 Hagfishes and lampreys lack hinged jaws
- 19.3 Jawed vertebrates with gills and paired fins include sharks, ray-finned fishes, and lobe-finned fishes
- 19.4 Evolution Connection New fossil discoveries are filling in the gaps of tetrapod evolution
- 19.5 Amphibians are tetrapod vertebrates with two pairs of limbs
- 19.6 Reptiles are amniote tetrapods with a terrestrially adapted egg
- 19.7 Birds are feathered reptiles with adaptations for flight
- 19.8 Mammals are amniotes that have hair and produce milk
- 19.9 Visualizing The Concept Many primate characters are adaptations to life in the trees

Primate Diversity

- 19.10 The human story begins with our primate heritage

Hominin Evolution

- 19.11 The hominin branch of the primate tree includes species that coexisted
- 19.12 Australopithecines were bipedal and had small brains
- 19.13 Larger brains mark the evolution of Homo
- 19.14 From origins in Africa, Homo sapiens spread around the world
- 19.15 Scientific Thinking New discoveries raise new questions about the history of hominins
- 19.16 Evolution Connection Human skin color reflects adaptations to varying amounts of sunlight
- 19.17 Connection Our knowledge of animal diversity is far from complete

Chapter Review

Unit V Animals: Form and Function

20 Unifying Concepts of Animal Structure and Function

Structure and Function in Animal Tissues

- 20.1 Evolution Connection An animal's form is not the perfect design
- 20.2 Structure fits function at all levels of organization in the animal body
- 20.3 Tissues are groups of cells with a common structure and function
- 20.4 Epithelial tissue covers the body and lines its organs and cavities
- 20.5 Connective tissue binds and supports other tissues
- 20.6 Muscle tissue functions in movement
- 20.7 Nervous tissue forms a communication network

Organs and Organ Systems

- 20.8 Organs are made up of tissues
- 20.9 Connection Bioengineers are learning to produce organs for transplants
- 20.10 Organ systems work together to perform life's functions
- 20.11 The integumentary system protects the body
- 20.12 Scientific Thinking Well-designed experiments help answer scientific questions

External Exchange and Internal Regulation

- 20.13 Structural adaptations enhance exchange with the environment
- 20.14 Animals regulate their internal environment
- 20.15 Homeostasis depends on negative feedback

Chapter Review

Table of Contents

21 Nutrition and Digestion

Obtaining and Processing Food

- 21.1 Animals obtain and ingest their food in a variety of ways
- 21.2 Overview: food processing occurs in four stages
- 21.3 Digestion occurs in specialized compartments

The Human Digestive System

- 21.4 The human digestive system consists of an alimentary canal and accessory organs
- 21.5 Digestion begins in the oral cavity
- 21.6 After swallowing, peristalsis moves food through the esophagus to the stomach
- 21.7 Connection The heimlich maneuver can save lives
- 21.8 The stomach stores food and breaks it down with acid and enzymes
- 21.9 Connection Digestive ailments include acid reflux and gastric ulcers
- 21.10 The small intestine is the major organ of chemical digestion and nutrient absorption
- 21.11 The liver processes and detoxifies blood from the intestines
- 21.12 The large intestine reclaims water and compacts the feces
- 21.13 Evolution Connection Evolutionary adaptations of vertebrate digestive systems relate to diet

Nutrition

- 21.14 An animals diet must provide sufficient energy
- 21.15 An animals diet must supply essential nutrients
- 21.16 A proper human diet must include sufficient vitamins and minerals
- 21.17 Connection Food labels provide nutritional information
- 21.18 Connection Dietary deficiencies can have a number of causes
- 21.19 Evolution Connection The human health problem of obesity may reflect our evolutionary past
- 21.20 Scientific Thinking Scientists use a variety of methods to test weight loss claims
- 21.21 Connection Diet can influence risk of cardiovascular disease and cancer

Chapter Review

22 Gas Exchange

Mechanisms of Gas Exchange

- 22.1 Gas exchange in humans involves breathing, transport of gases, and exchange with body cells
- 22.2 Animals exchange O₂ and CO₂ across moist body surfaces
- 22.3 Visualizing The Concept Gills are adapted for gas exchange In aquatic environments
- 22.4 The tracheal system of insects provides direct exchange between the air and body cells
- 22.5 Evolution Connection The evolution of lungs facilitated the movement of tetrapods onto land

The Human Respiratory System

- 22.6 In mammals, branching tubes convey air to lungs located in the chest cavity
- 22.7 Scientific Thinking Warning: cigarette smoking is hazardous to your health
- 22.8 Negative pressure breathing ventilates your lungs

Table of Contents

22.9 Breathing is automatically controlled

Transport of Gases In the Human Body

22.10 Blood transports respiratory gases

22.11 Hemoglobin carries O₂, helps transport Co₂, and buffers the blood

22.12 Scientific Thinking The human fetus exchanges gases with the mothers blood

Chapter Review

23 Circulation

Circulatory systems

23.1 Circulatory systems facilitate exchange with all body tissues

23.2 Evolution Connection Vertebrate cardiovascular systems reflect evolution

The Human Cardiovascular System and Heart

23.3 Visualizing The Concept The human cardiovascular system illustrates the double circulation of mammals

23.4 The heart contracts and relaxes rhythmically

23.5 The SA node sets the tempo of the heartbeat

23.6 Scientific Thinking How should heart disease be treated?

Structure and Function of Blood Vessels

23.7 The structure of blood vessels fits their functions

23.8 Blood pressure and velocity reflect the structure and arrangement of blood vessels

23.9 Connection Measuring blood pressure can reveal cardiovascular problems

23.10 Arteriole diameter and precapillary sphincters control the distribution of blood

23.11 Capillaries allow the transfer of substances through their walls

Structure and Function of Blood

23.12 Blood consists of red and white blood cells suspended in plasma

23.13 Connection Too few or too many red blood cells can be unhealthy

23.14 Blood clots plug leaks when blood vessels are injured

23.15 Connection Stem cells offer a potential cure for blood cell diseases

Chapter Review

24 The Immune System

Innate Immunity

24.1 All animals have innate immunity

24.2 The inflammatory response disinfects damaged tissue

Adaptive Immunity

24.3 The adaptive immune response counters specific invaders

24.4 The lymphatic system becomes a crucial battleground during infection

24.5 Lymphocytes mount a dual defense

24.6 Antigen receptors and antibodies bind to specific regions on an antigen

24.7 Visualizing The Concept Clonal selection mobilizes defenses against specific antigens

24.8 The primary and secondary responses differ in speed, strength, and duration

24.9 Connection Herd immunity prevents the outbreak of infectious disease

24.10 The structure of an antibody matches its function

24.11 Scientific Thinking Scientists measure antibody levels to look for waning immunity after hpv vaccination

Table of Contents

- 24.12 Helper T cells stimulate the humoral and cell-mediated immune responses
- 24.13 Cytotoxic T cells destroy infected body cells
- 24.14 Connection HIV destroys helper T cells, compromising the bodys defenses
- 24.15 Evolution Connection The rapid evolution of HIV complicates AIDS treatment
- 24.16 The Immune system depends on our molecular fingerprints

Disorders of the Immune System

- 24.17 Connection Immune system disorders result from self-directed or underactive responses
 - 24.18 Connection Allergies are overreactions to certain environmental antigens
- Chapter Review

25 Control of Body Temperature and Water Balance

Thermoregulation

- 25.1 An animals regulation of body temperature helps maintain homeostasis
- 25.2 Thermoregulation involves adaptations that balance heat gain and loss
- 25.3 Scientific Thinking Coordinated waves of movement In huddles help penguins thermoregulate
- 25.4 Evolution Connection Visualizing The Concept Animals balance their levels of water and solutes through osmoregulation

Osmoregulation and Excretion

- 25.5 Several ways to dispose of nitrogenous wastes have evolved in animals
 - 25.6 The urinary system plays several major roles in homeostasis
 - 25.7 The kidney is a water-conserving organ
 - 25.8 Hormones regulate the urinary system
 - 25.9 Kidney dialysis can save lives
- Chapter Review

26 Hormones and The endocrine System

The nature of Chemical Regulation

- 26.1 Chemical and electrical signals coordinate body functions
- 26.2 Hormones affect target cells using two main signaling mechanisms
- 26.3 Scientific Thinking A widely used weed killer demasculinizes male frogs

The Vertebrate Endocrine System

- 26.4 The vertebrate endocrine system consists of more than a dozen major glands
- 26.5 The hypothalamus, which is closely tied to the pituitary, connects the nervous and endocrine systems

Hormones and Homeostasis

- 26.6 The thyroid regulates development and metabolism
 - 26.7 The gonads secrete sex hormones
 - 26.8 Visualizing The Concept Pancreatic hormones regulate blood glucose level
 - 26.9 Connection Diabetes Is a common endocrine disorder
 - 26.10 The adrenal glands mobilize responses to stress
 - 26.11 Evolution Connection A single hormone can perform a variety of functions in different animals
 - 26.12 Connection Hormones can promote social behaviors
- Chapter Review

27 Reproduction and Embryonic Development

Asexual and sexual reproduction

Table of Contents

27.1 Asexual reproduction results in the generation of genetically identical offspring

27.2 Sexual reproduction results in the generation of genetically unique offspring

Human Reproduction

27.3 The human female reproductive system includes the ovaries and structures that deliver gametes

27.4 The human male reproductive system includes the testes and structures that deliver gametes

27.5 The formation of sperm and egg cells requires meiosis

27.6 Hormones synchronize cyclic changes in the ovary and uterus

27.7 Scientific Thinking Sexual activity can transmit disease

27.8 Connection Contraception can prevent unwanted pregnancy

Principles of Embryonic Development

27.9 Fertilization results in a zygote and triggers embryonic development

27.10 Cleavage produces a blastula from the zygote

27.11 Gastrulation produces a three-layered embryo

27.12 Organs start to form after gastrulation

27.13 Multiple processes give form to the developing animal

27.14 Evolution Connection Pattern formation during embryonic development is controlled by ancient genes

Human Development

27.15 The embryo and placenta take shape during the first month of pregnancy

27.16 Visualizing The Concept Human pregnancy is divided into trimesters

27.17 Childbirth is induced by hormones and other chemical signals

27.18 Connection Reproductive technologies Increase our reproductive options

Chapter Review

28 Nervous Systems

Nervous System Structure and Function

28.1 Nervous systems receive sensory input, interpret it, and send out commands

28.2 Neurons are the functional units of nervous systems

28.3 A nerve signal begins as a change in the membrane potential

Nerve Signals and Their Transmission

28.4 Nerve function depends on charge differences across neuron membranes

28.5 The action potential propagates itself along the axon

28.6 Visualizing The Concept Neurons communicate at synapses

28.7 Chemical synapses enable complex information to be processed

28.8 A variety of small molecules function as neurotransmitters

28.9 Connection Many drugs act at chemical synapses

28.10 Scientific Thinking Published data are biased toward positive findings

An overview of animal nervous systems

28.11 Evolution Connection The evolution of animal nervous systems reflects changes in body symmetry

28.12 Vertebrate nervous systems are highly centralized

28.13 The peripheral nervous system of vertebrates can be divided into functional components

28.14 The vertebrate brain develops from three anterior bulges of the neural

Table of Contents

tube

The Human Brain

- 28.15 The structure of a living supercomputer: The human brain
 - 28.16 The cerebral cortex controls voluntary movement and cognitive functions
 - 28.17 Connection injuries and brain operations provide insight into brain function
 - 28.18 The nervous system can reorganize its neural connections
 - 28.19 The reticular formation is involved in arousal and sleep
 - 28.20 The limbic system is involved in emotions and memory
 - 28.21 Connection Changes in brain physiology can produce neurological disorders
- Chapter Review

29 The Senses

Sensory Reception

- 29.1 Sensory receptors convert stimuli to action potentials
- 29.2 Scientific Thinking The model for magnetic sensory reception is incomplete
- 29.3 Specialized sensory receptors detect five categories of stimuli

Hearing and Balance

- 29.4 The ear converts air pressure waves to action potentials that are perceived as sound
- 29.5 The inner ear houses our organs of balance
- 29.6 Connection What causes motion sickness?

Vision

- 29.7 Evolution Connection Several types of eyes have evolved among animals
- 29.8 The human eye focuses by changing the shape of the lens
- 29.9 Connection Many vision problems can be corrected with artificial lenses or surgery
- 29.10 The human retina contains two types of photoreceptors: rods and cones

Taste and Smell

- 29.11 Taste and odor receptors detect chemicals present in solution or air
 - 29.12 Connection Does cilantro taste like soap to you?
 - 29.13 Summary: The central nervous system couples stimulus with response
- Chapter Review

30 How Animals Move

Movement and Locomotion

- 30.1 Locomotion requires energy to overcome friction and gravity
- 30.2 Skeletons function in support, movement, and protection

The Vertebrate Skeleton

- 30.3 Evolution Connection Vertebrate skeletons are variations on an ancient theme
- 30.4 Bones are complex living organs
- 30.5 Connection Healthy bones resist stress and heal from injuries
- 30.6 Joints permit different types of movement

Muscle contraction and movement

- 30.7 The skeleton and muscles interact in movement
- 30.8 Each muscle cell has its own contractile apparatus
- 30.9 A muscle contracts when thin filaments slide along thick filaments

Table of Contents

- 3.10 Motor neurons stimulate muscle contraction
- 3.11 Connection Aerobic respiration supplies most of the energy for exercise
- 3.12 Characteristics of muscle fibers affect athletic performance
- Chapter Review

Unit VI Plants: Form and Function

31 Plant Structure, Growth, and Reproduction

Plant Structure and Function

- 31.1 The domestication of crops changed the course of human history
- 31.2 The two major groups of angiosperms are the monocots and the eudicots
- 31.3 A typical plant body contains three basic organs: roots, stems, and leaves
- 31.4 Many plants have modified roots, stems, and leaves
- 31.5 Three tissue systems make up the plant body
- 31.6 Plant cells are diverse in structure and function

Plant Growth

- 31.7 Primary growth lengthens roots and shoots
- 31.8 Secondary growth increases the diameter of woody plants

Reproduction of Flowering Plants

- 31.9 The flower is the organ of sexual reproduction in angiosperms
- 31.10 The development of pollen and ovules culminates in fertilization
- 31.11 The ovule develops into a seed
- 31.12 Scientific Thinking The ovary develops into a fruit
- 31.13 Seed germination continues the life cycle
- 31.14 Asexual reproduction produces plant clones
- 31.15 Connection Plant cloning is an important agricultural tool
- 31.16 Evolution Connection Evolutionary adaptations help some plants to live very long lives
- Chapter Review

32 Plant Nutrition and Transport

The Uptake and Transport of Plant Nutrients

- 32.1 Scientific Thinking Plants acquire nutrients from air, water, and soil
- 32.2 The plasma membranes of root cells control solute uptake
- 32.3 Visualizing The Concept Transpiration pulls water up xylem vessels
- 32.4 Connection Guard cells control transpiration
- 32.5 Phloem transports sugars
- 32.6 Connection Humans tap into plant transport structures

Plant Nutrients and the Soil

- 32.7 Plant health depends on obtaining all of the essential inorganic nutrients
- 32.8 Connection Fertilizers can help prevent nutrient deficiencies
- 32.9 Fertile soil supports plant growth
- 32.10 Connection Soil conservation is essential to human life
- 32.11 Scientific Thinking Organic farmers follow principles meant to promote health
- 32.12 Connection Genetic engineering is improving the yields and nutritional values of crops

Plant Nutrition and Symbiosis

- 32.13 Most plants depend on bacteria to supply nitrogen

Table of Contents

32.14 Evolution Connection Mutually beneficial relationships have evolved between plants and other kinds of organisms

32.15 The plant kingdom includes epiphytes, parasites, and carnivores

Chapter Review

33 Control Systems in Plants

Plant Hormones

33.1 Scientific Thinking A series of experiments by several scientists led to the discovery of a plant hormone

33.2 Botanists have identified several major types of hormones

33.3 Auxin stimulates the elongation of cells in young shoots

33.4 Cytokinins stimulate cell division

33.5 Gibberellins affect stem elongation and have numerous other effects

33.6 Abscisic acid inhibits many plant processes

33.7 Ethylene triggers fruit ripening and other aging processes

33.8 Plant hormones have many agricultural uses

Responses to Stimuli

33.9 Tropisms orient plant growth toward or away from environmental stimuli

33.10 Plants have internal clocks

33.11 Plants mark the seasons by measuring photoperiod

33.12 Phytochromes are light detectors that help set the biological clock

33.13 Evolution Connection Defenses against herbivores and infectious microbes have evolved in plants

Chapter Review

Unit VII Ecology

34 The biosphere: An Introduction to Earth's Diverse Environments

The Biosphere

34.1 Ecologists study how organisms interact with their environment at several levels

34.2 Scientific Thinking The science of ecology provides insight into environmental problems

34.3 Physical and chemical factors influence life in the biosphere

34.4 Evolution Connection Organisms are adapted to abiotic and biotic factors through natural selection

34.5 Regional climate influences the distribution of terrestrial communities

Aquatic Biomes

34.6 Sunlight and substrate are key factors in the distribution of marine organisms

34.7 Current, sunlight, and nutrients are important abiotic factors in freshwater biomes

Terrestrial Biomes

34.8 Terrestrial biomes reflect regional variations in climate

34.9 Tropical forests cluster near the equator

34.10 Savannas are grasslands with scattered trees

34.11 Deserts are defined by their dryness

34.12 Spiny shrubs dominate the chaparral

34.13 Temperate grasslands include the north american prairie

34.14 Coniferous forests are often dominated by a few species of trees

Table of Contents

- 34.15 Broadleaf trees dominate temperate forests
- 34.16 Long, bitter-cold winters characterize the tundra
- 34.17 Polar ice covers the land at high latitudes
- 34.18 Visualizing The Concept The global water cycle connects aquatic and terrestrial biomes
- Chapter Review

35 Behavioral Adaptationsto The Environment

The Scientific Study of Behavior

- 35.1 Behavioral ecologists ask both proximate and ultimate questions
- 35.2 Fixed action patterns are innate behaviors
- 35.3 Behavior is the result of both genetic and environmental factors

Learning

- 35.4 Habituation is a simple type of learning
- 35.5 Imprinting requires both innate behavior and experience
- 35.6 Connection Imprinting poses problems and opportunities for conservation programs
- 35.7 Visualizing The Concept Animal movement may be a response to stimuli or require spatial learning
- 34.8 A variety of cues guide migratory movements
- 34.9 Animals may learn to associate a stimulus or behavior with a response
- 34.10 Social learning employs observation and imitation of others
- 34.11 Problem-solving behavior relies on cognition

Survival and Reproductive Success

- 35.12 Behavioral ecologists use costbenefit analysis to study foraging
- 35.13 Communication is an essential element of interactions between animals
- 35.14 Mating behavior often includes elaborate courtship rituals
- 35.15 Mating systems and parental care enhance reproductive success
- 35.16 Connection Chemical pollutants can cause abnormal behavior

Social Behavior and Sociobiology

- 35.17 Sociobiology places social behavior in an evolutionary context
- 35.18 Territorial behavior parcels out space and resources
- 35.19 Agonistic behavior often resolves confrontations between competitors
- 35.20 Dominance hierarchies are maintained by agonistic behavior
- 35.21 Evolution Connection Altruistic acts can often be explained by the concept of inclusive fitness
- 35.22 Scientific Thinking Jane goodall revolutionized our understanding of chimpanzee behavior
- 35.23 Human behavior is the result of both genetic and environmental factors
- Chapter Review

36 Population Ecology

Population Structure and Dynamics

- 36.1 Population ecology is the study of how and why populations change
- 36.2 Density and dispersion patterns are important population variables
- 36.3 Life tables track survivorship in populations
- 36.4 Idealized models predict patterns of population growth
- 36.5 Multiple factors may limit population growth
- 36.6 Scientific Thinking Some populations have boom-and-bust cycles

Table of Contents

36.7 Evolution Connection Evolution shapes life histories

36.8 Principles of population ecology have practical applications

The Human Population

36.9 The human population continues to increase, but the growth rate is slowing

36.10 Connection Age structures reveal social and economic trends

36.11 Connection An ecological footprint is a measure of resource consumption

Chapter Review

37 Communities and Ecosystems

Community Structure and Dynamics

37.1 A community includes all the organisms inhabiting a particular area

37.2 Interspecific interactions are fundamental to community structure

37.3 Competition may occur when a shared resource is limited

37.4 Mutualism benefits both partners

37.5 Evolution Connection Predation leads to diverse adaptations in prey species

37.6 Evolution Connection Herbivory leads to diverse adaptations in plants

37.7 Parasites and pathogens can affect community composition

37.8 Trophic structure is a key factor in community dynamics

37.9 Visualizing The Concept Food chains interconnect, forming food webs

37.10 Species diversity includes species richness and relative abundance

37.11 Scientific Thinking Some species have a disproportionate impact on diversity

37.12 Disturbance is a prominent feature of most communities

37.13 Connection Invasive species can devastate communities

Ecosystem Structure and Dynamics

37.14 Ecosystem ecology emphasizes energy flow and chemical cycling

37.15 Primary production sets the energy budget for ecosystems

37.16 Energy supply limits the length of food chains

37.17 Connection An energy pyramid explains the ecological cost of meat

37.18 Chemicals are cycled between organic matter and abiotic reservoirs

37.19 The carbon cycle depends on photosynthesis and respiration

37.20 The phosphorus cycle depends on the weathering of rock

37.21 The nitrogen cycle depends on bacteria

37.22 Connection A rapid inflow of nutrients degrades aquatic ecosystems

37.23 Connection Ecosystem services are essential to human well-being

Chapter Review

38 Conservation Biology

The loss of Biodiversity

38.1 Loss of biodiversity Includes the loss of ecosystems, species, and genes

38.2 Connection Habitat loss, Invasive species, overharvesting, pollution, and climate change are major threats to biodiversity

38.3 Connection Rapid warming is changing the global climate

38.4 Connection Human activities are responsible for rising concentrations of greenhouse gases

38.5 Climate change affects biomes, ecosystems, communities, and populations

38.6 Evolution Connection Climate change is an agent of natural selection

Conservation Biology and Restoration Ecology

Table of Contents

- 38.7 Protecting endangered populations is one goal of conservation biology
- 38.8 Sustaining ecosystems and landscapes is a conservation priority
- 38.9 Establishing protected areas slows the loss of biodiversity
- 38.10 Zoned reserves are an attempt to reverse ecosystem disruption
- 38.11 Scientific Thinking The yellowstone to yukon conservation initiative seeks to preserve biodiversity by connecting protected areas
- 38.12 Connection The study of how to restore degraded habitats is a developing science
- 38.13 Sustainable development is an ultimate goal
- Chapter Review

Appendix 1 Metric Conversion Table

Appendix 2 The Periodic Table

Appendix 3 The Amino Acids of Proteins

Appendix 4 Chapter Review Answers

Appendix 5 Credits

Glossary

Index

Back Cover