

Biology

A Global Approach

TWELFTH EDITION

Campbell • Urry • Cain Wasserman • Minorsky • Orr



Brief Contents

1 Biology and Its Themes 50

Unit 1 THE ROLE OF CHEMISTRY IN BIOLOGY

- 2 Atoms and Molecules 76
- **3** The Chemistry of Water 92
- 4 Carbon: The Basis of Molecular Diversity 104
- 5 Biological Macromolecules and Lipids 114
- 6 Energy and Life 141

Unit 2 CELL BIOLOGY

162

303

75

- 7 Cell Structure and Function 163
- 8 Cell Membranes 196
- **9** Cellular Signaling 214
- **10** Cell Respiration 236
- **11** Photosynthetic Processes 259
- **12** Mitosis 284

Unit 3 THE GENETIC BASIS OF LIFE

- 13 Sexual Life Cycles and Meiosis 304
- **14** Mendelian Genetics 319
- 15 Linkage and Chromosomes 344
- **16** Nucleic Acids and Inheritance 364
- **17** Expression of Genes 385
- **18** Control of Gene Expression 415
- 19 DNA Technology 449
- **20** The Evolution of Genomes 476

Unit 4 EVOLUTION

501

- **21** How Evolution Works 502
- 22 Phylogenetic Reconstruction 521
- 23 Microevolution 542
- **24** Species and Speciation 562
- 25 Macroevolution 581

Unit 5 THE DIVERSITY OF LIFE

609

- **26** Introduction to Viruses 610
- **27** Prokaryotes 627
- 28 The Origin and Evolution of Eukaryotes 647
- 29 Nonvascular and Seedless Vascular Plants 672
- **30** Seed Plants 690
- **31** Introduction to Fungi 708
- **32** An Introduction to Animal Diversity 727
- **33** Invertebrates 740
- **34** Vertebrates 772

Unit 6 PLANTS: STRUCTURE AND FUNCTION

811

- **35** Plant Structure and Growth 812
- **36** Transport in Vascular Plants 838
- **37** Plant Nutrition 859
- **38** Reproduction of Flowering Plants 876
- 39 Plant Signals and Behavior 896

Unit 7 ANIMALS: STRUCTURE AND FUNCTION

926

- **40** The Animal Body 927
- **41** Chemical Signals in Animals 953
- **42** Animal Digestive Systems 974
- **43** Animal Transport Systems 997
- **44** Animal Excretory Systems 1029
- 45 Animal Reproductive Systems 1051
- **46** Development in Animals 1075
- **47** Animal Defenses Against Infection 1100
- **48** Electrical Signals in Animals 1125
- 49 Neural Regulation in Animals 1143
- **50** Sensation and Movement in Animals 1165

Unit 8 THE ECOLOGY OF LIFE

1197

- **51** An Overview of Ecology 1198
- **52** Behavioral Ecology 1225
- **53** Populations and Life History Traits 1248
- **54** Biodiversity and Communities 1272
- **55** Energy Flow and Chemical Cycling in Ecosystems 1296
- 56 Conservation and Global Ecology 1318

Biology: A Global Approach, Global Edition

Table of Contents

F	r۸	nt	Cc	ver

Brief contents

Title page

About the Authors

Preface

Acknowledgments

Detailed Contents

1 Biology and Its Themes

Concept 1.1 The study of life reveals unifying themes

Theme: New Properties Emerge at Successive Levels of Biological Organization

Theme: Lifes Processes Involve the Expression and Transmission of Genetic Information

Theme: Life Requires the Transfer and Transformation of Energy and Matter

Theme: From Molecules to Ecosystems, Interactions Are Important in Biological Systems

Concept 1.2 The Core Theme: Evolution accounts for the unity and diversity of life

Classifying the Diversity of Life

Charles Darwin and the Theory of Natural Selection

The Tree of Life

Concept 1.3 In studying nature, scientists form and test hypotheses

Exploration and Observation

Gathering and Analyzing Data

Forming and Testing Hypotheses

The Flexibility of the Scientific Process

A Case Study in Scientific Inquiry:Investigating Coat Coloration in Mouse Populations

Variables and Controls in Experiments

Theories in Science

Concept 1.4 Science benefits from a cooperative approach and diverse viewpoints

Building on the Work of Others

Science, Technology, and Society

The Value of Diverse Viewpoints in Science

Unit 1 The Role of Chemistry in Biology



2 Atoms and Molecules

Concept 2.1 Matter consists of chemical elements in pure form and in combinations called compounds

Elements and Compounds

The Elements of Life

Case Study: Evolution of Tolerance to Toxic Elements

Concept 2.2 An elements properties depend on the structure of its atoms

Subatomic Particles

Atomic Number and Atomic Mass

Isotopes

The Energy Levels of Electrons

Electron Distribution and Chemical Properties

Electron Orbitals

Concept 2.3 The formation and function of molecules and ionic compounds depend on chemical bonding between atoms

Covalent Bonds

Ionic Bonds

Weak Chemical Interactions

Molecular Shape and Function

Concept 2.4 Chemical reactions make and break chemical bonds

3 The Chemistry of Water

Concept 3.1 Polar covalent bonds in water molecules result in hydrogen bonding

Concept 3.2 Four emergent properties of water contribute to Earths suitability for life

Cohesion of Water Molecules

Moderation of Temperature by Water

Floating of Ice on Liquid Water

Water: The Solvent of Life

Possible Evolution of Life on Other Planets

Concept 3.3 Acidic and basic conditions affect living organisms

Acids and Bases

The pH Scale

Buffers

Acidification: A Threat to Our Oceans

4 Carbon: The Basis of Molecular Diversity

Concept 4.1 Organic chemistry is key to the origin of life

Concept 4.2 Carbon atoms can form diverse molecules by bonding to four other atoms

The Formation of Bonds with Carbon

Molecular Diversity Arising from Variation in Carbon Skeletons

Concept 4.3 A few chemical groups are key to molecular function

The Chemical Groups Most Important in the Processes of Life



ATP: An Important Source of Energy for Cellular Processes

The Chemical Elements of Life: A Review

5 Biological Macromolecules and Lipids

Concept 5.1 Macromolecules are polymers, built from monomers

The Synthesis and Breakdown of Polymers

The Diversity of Polymers

Concept 5.2 Carbohydrates serve as fuel and building material

Sugars

Polysaccharides

Concept 5.3 Lipids are a diverse group of hydrophobic molecules

Fats

Phospholipids

Steroids

Concept 5.4 Proteins include a diversity of structures, resulting in a wide range of functions

Amino Acids (Monomers)

Polypeptides (Amino Acid Polymers)

Protein Structure and Function

Concept 5.5 Nucleic acids store, transmit, and help express hereditary information

The Roles of Nucleic Acids

The Components of Nucleic Acids

Nucleotide Polymers

The Structures of DNA and RNA Molecules

Concept 5.6 Genomics and proteomics have transformed biological inquiry and applications

DNA and Proteins as Tape Measures of Evolution

6 Energy and Life

Concept 6.1 An organisms metabolism transforms matter and energy

Metabolic Pathways

Forms of Energy

The Laws of Energy Transformation

Concept 6.2 The free-energy change of a reaction tells us whether or not the reaction occurs spontaneously

Free-Energy Change,

Free Energy, Stability, and Equilibrium

Free Energy and Metabolism

Concept 6.3 ATP powers cellular work by coupling exergonic reactions to endergonic reactions

The Structure and Hydrolysis of ATP

How ATP Provides Energy That Performs Work

The Regeneration of ATP

Concept 6.4 Enzymes speed up metabolic reactions by lowering energy barriers

The Activation Energy Barrier

How Enzymes Speed Up Reactions



Substrate Specificity of Enzymes

Catalysis in the Enzymes Active Site

Effects of Local Conditions on Enzyme Activity

The Evolution of Enzymes

Concept 6.5 Regulation of enzyme activity helps control metabolism

Allosteric Regulation of Enzymes

Localization of Enzymes Within the Cell

Unit 2 Cell Biology

7 Cell Structure and Function

Concept 7.1 Biologists use microscopes and biochemistry to study cells

Microscopy

Cell Fractionation

Concept 7.2 Eukaryotic cells have internal membranes that compartmentalize their functions

Comparing Prokaryotic and Eukaryotic Cells

A Panoramic View of the Eukaryotic Cell

Concept 7.3 The eukaryotic cells genetic instructions are housed in the nucleus and carried out by the ribosomes

The Nucleus: Information Central Ribosomes: Protein Factories

Concept 7.4 The endomembrane system regulates protein traffic and performs metabolic

functions

The Endoplasmic Reticulum: Biosynthetic Factory
The Golgi Apparatus: Shipping and Receiving Center

Lysosomes: Digestive Compartments

Vacuoles: Diverse Maintenance Compartments

The Endomembrane System: A Review

Concept 7.5 Mitochondria and chloroplasts change energy from one form to another

The Evolutionary Origins of Mitochondria and Chloroplasts

Mitochondria: Chemical Energy Conversion Chloroplasts: Capture of Light Energy

Peroxisomes: Oxidation

Concept 7.6 The cytoskeleton is a network of fibers that organizes structures and activities in the cell

Roles of the Cytoskeleton: Support and Motility

Components of the Cytoskeleton

Concept 7.7 Extracellular components and connections between cells help coordinate cellular activities

Cell Walls of Plants

The Extracellular Matrix (ECM) of Animal Cells

Cell Junctions

Concept 7.8 A cell is greater than the sum of its parts

8 Cell Membranes



Concept 8.1 Cellular membranes are fluid mosaics of lipids and proteins

The Fluidity of Membranes

Evolution of Differences in Membrane Lipid Composition

Membrane Proteins and Their Functions

The Role of Membrane Carbohydrates in Cell-Cell Recognition

Synthesis and Sidedness of Membranes

Concept 8.2 Membrane structure results in selective permeability

The Permeability of the Lipid Bilayer

Transport Proteins

Concept 8.3 Passive transport is diffusion of a substance across a membrane with no energy

investment

Effects of Osmosis on Water Balance

Facilitated Diffusion: Passive Transport Aided by Proteins

Concept 8.4 Active transport uses energy to move solutes against their gradients

The Need for Energy in Active Transport

How Ion Pumps Maintain Membrane Potential

Cotransport: Coupled Transport by a Membrane Protein

Concept 8.5 Bulk transport across the plasma membrane occurs by exocytosis and endocytosis

Exocytosis

Endocytosis

9 Cellular Signaling

Concept 9.1 External signals are converted to responses within the cell

Evolution of Cell Signaling

Local and Long-Distance Signaling

The Three Stages of Cell Signaling: A Preview

Concept 9.2 Signal reception: A signaling molecule binds to a receptor, causing it to change shape

Receptors in the Plasma Membrane

Intracellular Receptors

Concept 9.3 Signal transduction: Cascades of molecular interactions transmit signals from receptors to relay molecules in the cell

Signal Transduction Pathways

Protein Phosphorylation and Dephosphorylation

Small Molecules and Ions as Second Messengers

Concept 9.4 Cellular response: Cell signaling leads to regulation of transcription or cytoplasmic activities

Nuclear and Cytoplasmic Responses

Regulation of the Response

Concept 9.5 Apoptosis requires integration of multiple cell-signaling pathways

Apoptosis in the Soil Worm Caenorhabditis elegans

Apoptotic Pathways and the Signals That Trigger Them

10 Cell Respiration



Concept 10.1 Catabolic pathways yield energy by oxidizing organic fuels

Catabolic Pathways and Production of ATP
Redox Reactions: Oxidation and Reduction
The Stages of Cellular Respiration: A Preview

Concept 10.2 Glycolysis harvests chemical energy by oxidizing glucose to pyruvate

Concept 10.3 After pyruvate is oxidized, the citric acid cycle completes the energy-yielding oxidation of organic molecules

Oxidation of Pyruvate to Acetyl CoA

The Citric Acid Cycle

Concept 10.4 During oxidative phosphorylation, chemiosmosis couples electron transport to ATP synthesis

The Pathway of Electron Transport

Chemiosmosis: The Energy-Coupling Mechanism

An Accounting of ATP Production by Cellular Respiration

Concept 10.5 Fermentation and anaerobic respiration enable cells to produce ATP without the use of oxygen

Types of Fermentation

Comparing Fermentation with Anaerobic and Aerobic Respiration

The Evolutionary Significance of Glycolysis

Concept 10.6 Glycolysis and the citric acid cycle connect to many other metabolic pathways

The Versatility of Catabolism

Biosynthesis (Anabolic Pathways)

Regulation of Cellular Respiration via Feedback Mechanisms

11 Photosynthetic Processes

Concept 11.1 Photosynthesis feeds the biosphere

Concept 11.2 Photosynthesis converts light energy to the chemical energy of food

Chloroplasts: The Sites of Photosynthesis in Plants

Tracking Atoms Through Photosynthesis
The Two Stages of Photosynthesis: A Preview

Concept 11.3 The light reactions convert solar energy to the chemical energy of ATP and NADPH

The Nature of Sunlight

Photosynthetic Pigments: The Light Receptors

Excitation of Chlorophyll by Light

A Photosystem: A Reaction-Center Complex Associated with Light-Harvesting Complexes

Linear Electron Flow Cyclic Electron Flow

A Comparison of Chemiosmosis in Chloroplasts and Mitochondria

Concept 11.4 The Calvin cycle uses the chemical energy of ATP and NADPH to reduce CO2 to sugar

Concept 11.5 Alternative mechanisms of carbon fixation have evolved in hot, arid climates



Photorespiration: An Evolutionary Relic?

C4 Plants
CAM Plants

Concept 11.6 Photosynthesis is essential for life on Earth: a review

12 Mitosis

Concept 12.1 Most cell division results in genetically identical daughter cells

Key Roles of Cell Division

Cellular Organization of the Genetic Material

Distribution of Chromosomes During Eukaryotic Cell Division

Concept 12.2 The mitotic phase alternates with interphase in the cell cycle

Phases of the Cell Cycle

The Mitotic Spindle: A Closer Look

Cytokinesis: A Closer Look Binary Fission in Bacteria

The Evolution of Mitosis

Concept 12.3 The eukaryotic cell cycle is regulated by a molecular control system

The Cell Cycle Control System

Loss of Cell Cycle Controls in Cancer Cells

Unit 3 The Genetic Basis of Life

13 Sexual Life Cycles and Meiosis

Concept 13.1 Offspring acquire genes from parents by inheriting chromosomes

Inheritance of Genes

Comparison of Asexual and Sexual Reproduction

Concept 13.2 Fertilization and meiosis alternate in sexual life cycles

Sets of Chromosomes in Human Cells

Behavior of Chromosome Sets in the Human Life Cycle

The Variety of Sexual Life Cycles

Concept 13.3 Meiosis reduces the number of chromosome sets from diploid to haploid

The Stages of Meiosis

Crossing Over and Synapsis During Prophase

A Comparison of Mitosis and Meiosis

Concept 13.4 Genetic variation produced in sexual life cycles contributes to evolution

Origins of Genetic Variation Among Offspring

The Evolutionary Significance of Genetic Variation Within Populations

14 Mendelian Genetics

Concept 14.1 Mendel used the scientific approach to identify two laws of inheritance

Mendels Experimental, Quantitative Approach

The Law of Segregation

The Law of Independent Assortment

Concept 14.2 Probability laws govern Mendelian inheritance



The Multiplication and Addition Rules Applied to Monohybrid Crosses

Solving Complex Genetics Problems with the Rules of Probability

Concept 14.3 Inheritance patterns are often more complex than predicted by simple Mendelian genetics

Extending Mendelian Genetics for a Single Gene

Extending Mendelian Genetics for Two or More Genes

Nature and Nurture: The Environmental Impact on Phenotype

A Mendelian View of Heredity and Variation

Concept 14.4 Many human traits follow Mendelian patterns of inheritance

Pedigree Analysis

Recessively Inherited Disorders

Dominantly Inherited Disorders

Multifactorial Disorders

Genetic Testing and Counseling

15 Linkage and Chromosomes

Concept 15.1 Mendelian inheritance has its physical basis in the behavior of chromosomes

Morgans Choice of Experimental Organism

Correlating Behavior of a Genes Alleles with Behavior of a Chromosome Pair: Scientific Inquiry

Concept 15.2 Sex-linked genes exhibit unique patterns of inheritance

The Chromosomal Basis of Sex

Inheritance of X-Linked Genes

X Inactivation in Female Mammals

Concept 15.3 Linked genes tend to be inherited together because they are located near each other on the same chromosome

How Linkage Affects Inheritance

Genetic Recombination and Linkage

Mapping the Distance Between Genes Using Recombination Data: Scientific Inquiry

Concept 15.4 Alterations of chromosome number or structure cause some genetic disorders

Abnormal Chromosome Number

Alterations of Chromosome Structure

Human Conditions Due to Chromosomal Alterations

Concept 15.5 Some inheritance patterns are exceptions to standard Mendelian inheritance

Genomic Imprinting

Inheritance of Organelle Genes

16 Nucleic Acids and Inheritance

DNA is the genetic material

The Search for the Genetic Material: Scientific Inquiry

Building a Structural Model of DNA

Concept 16.2 Many proteins work together in DNA replication and repair

The Basic Principle: Base Pairing to a Template Strand



DNA Replication: A Closer Look
Proofreading and Repairing DNA

Evolutionary Significance of Altered DNA Nucleotides

Replicating the Ends of DNA Molecules

Concept 16.3 A chromosome consists of a DNA molecule packed together with proteins

17 Expression of Genes

Concept 17.1 Genes specify proteins via transcription and translation

Evidence from Studying Metabolic Defects

Basic Principles of Transcription and Translation

The Genetic Code

Concept 17.2 Transcription is the DNA-directed synthesis of RNA: A Closer Look

Molecular Components of Transcription

Split Genes and RNA Splicing

Concept 17.3 Eukaryotic cells modify RNA after transcription

Alteration of mRNA Ends

Synthesis of an RNA Transcript

Concept 17.4 Translation is the RNA-directed synthesis of a polypeptide: A Closer Look

Molecular Components of Translation

Building a Polypeptide

Completing and Targeting the Functional Protein

Making Multiple Polypeptides in Bacteria and Eukaryotes

Concept 17.5 Mutations of one or a few nucleotides can affect protein structure and function

Types of Small-Scale Mutations

New Mutations and Mutagens

Using CRISPR to Edit Genes and Correct Disease-Causing Mutations

What Is a Gene? Revisiting the Question

18 Control of Gene Expression

Concept 18.1 Bacteria often respond to environmental change by regulating transcription

Operons: The Basic Concept

Repressible and Inducible Operons: Two Types of Negative Gene Regulation

Positive Gene Regulation

Concept 18.2 Eukaryotic gene expression is regulated at many stages

Differential Gene Expression

Regulation of Chromatin Structure

Regulation of Transcription Initiation

Mechanisms of Post-transcriptional Regulation

Concept 18.3 Noncoding RNAs play multiple roles in controlling gene expression

Effects on mRNAs by MicroRNAs and Small Interfering RNAs

Chromatin Remodeling and Effects on Transcription by ncRNAs

Concept 18.4 A program of differential gene expression leads to the different cell types in a multicellular



organism

A Genetic Program for Embryonic Development

Cytoplasmic Determinants and Inductive Signals

Sequential Regulation of Gene Expression During Cellular Differentiation

Pattern Formation: Setting Up the Body Plan

Concept 18.5 Cancer results from genetic changes that affect cell cycle control

Types of Genes Associated with Cancer

Interference with Normal Cell-Signaling Pathways

The Multistep Model of Cancer Development

Inherited Predisposition and Environmental Factors Contributing to Cancer

The Role of Viruses in Cancer

19 DNA Technology

Concept 19.1 DNA sequencing and DNA cloning are valuable tools for genetic engineering and biological inquiry

DNA Sequencing

Making Multiple Copies of a Gene or Other DNA Segment

Using Restriction Enzymes to Make a Recombinant DNA Plasmid

Amplifying DNA: The Polymerase Chain Reaction (PCR) and Its Use in DNA Cloning

Expressing Cloned Eukaryotic Genes

Concept 19.2 Biologists use DNA technology to study gene expression and function

Analyzing Gene Expression

Determining Gene Function

Concept 19.3 Cloned organisms and stem cells are useful for basic research and other applications

Cloning Plants: Single-Cell Cultures

Cloning Animals: Nuclear Transplantation

Stem Cells of Animals

Concept 19.4 The practical applications of DNA-based biotechnology affect our lives in many ways

Medical Applications

Forensic Evidence and Genetic Profiles

Environmental Cleanup

Agricultural Applications

Safety and Ethical Questions Raised by DNA Technology

20 The Evolution of Genomes

Concept 20.1 The Human Genome Project fostered development of faster, less expensive sequencing techniques

Concept 20.2 Scientists use bioinformatics to analyze genomes and their functions

Centralized Resources for Analyzing Genome Sequences

Identifying Protein-Coding Genes and Understanding Their Functions

Understanding Genes and Gene Expression at the Systems Level



Concept 20.3 Genomes vary in size, number of genes, and gene density

Genome Size

Number of Genes

Gene Density and Noncoding DNA

Concept 20.4 Multicellular eukaryotes have a lot of noncoding DNA and many multigene families

Transposable Elements and Related Sequences

Other Repetitive DNA, Including Simple Sequence DNA

Genes and Multigene Families

Concept 20.5 Duplication, rearrangement, and mutation of DNA contribute to genome evolution

Duplication of Entire Chromosome Sets

Alterations of Chromosome Structure

Duplication and Divergence of Gene-Sized Regions of DNA

Rearrangements of Parts of Genes: Exon Duplication and Exon Shuffling

How Transposable Elements Contribute to Genome Evolution

Concept 20.6 Comparing genome sequences provides clues to evolution and development

Comparing Genomes

Widespread Conservation of Developmental Genes Among Animals

Unit 4 Evolution

21 How Evolution Works

Concept 21.1 The Darwinian revolution challenged traditional views of a young Earth inhabited by unchanging species

Endless Forms Most Beautiful

Scala Naturae and Classification of Species

Ideas About Change over Time

Lamarcks Hypothesis of Evolution

Concept 21.2 Descent with modification by natural selection explains the adaptations of organisms and the unity and diversity of life

Darwins Research

Ideas from The Origin of Species

Key Features of Natural Selection

Concept 21.3 Evolution is supported by an overwhelming amount of scientific evidence

Direct Observations of Evolutionary Change

Homology

The Fossil Record

Biogeography

What Is Theoretical About Darwins View of Life?

22 Phylogenetic Reconstruction

Concept 22.1 Phylogenies show evolutionary relationships

Binomial Nomenclature

Hierarchical Classification



Linking Classification and Phylogeny

What We Can and Cannot Learn from Phylogenetic Trees

Applying Phylogenies

Concept 22.2 Phylogenies are inferred from morphological and molecular data

Morphological and Molecular Homologies

Sorting Homology from Analogy

Evaluating Molecular Homologies

Concept 22.3 Shared characters are used to construct phylogenetic trees

Cladistics

Phylogenetic Trees with Proportional Branch Lengths

Maximum Parsimony and Maximum Likelihood

Phylogenetic Trees as Hypotheses

Concept 22.4 An organisms evolutionary history is documented in its genome

Gene Duplications and Gene Families

Genome Evolution

Concept 22.5 Molecular clocks help track evolutionary time

Molecular Clocks

Applying a Molecular Clock: Dating the Origin of HIV

Concept 22.6 Our understanding of the tree of life continues to change based on new data

From Two Kingdoms to Three Domains

The Important Role of Horizontal Gene Transfer

23 Microevolution

Concept 23.1 Genetic variation makes evolution possible

Genetic Variation

Sources of Genetic Variation

Concept 23.2 The Hardy-Weinberg equation can be used to test whether a population is evolving

Gene Pools and Allele Frequencies

The Hardy-Weinberg Equation

Concept 23.3 Natural selection, genetic drift, and gene flow can alter allele frequencies in a population

Natural Selection

Genetic Drift

Gene Flow

Concept 23.4 Natural selection is the only mechanism that consistently causes adaptive evolution

Natural Selection: A Closer Look

The Key Role of Natural Selection in Adaptive Evolution

Sexual Selection

Balancing Selection

Why Natural Selection Cannot Fashion Perfect Organisms

24 Species and Speciation

Concept 24.1 The biological species concept emphasizes reproductive isolation



The Biological Species Concept

Other Definitions of Species

Concept 24.2 Speciation can take place with or without geographic separation

Allopatric (Other Country) Speciation

Sympatric (Same Country) Speciation

Allopatric and Sympatric Speciation: A Review

Concept 24.3 Hybrid zones reveal factors that cause reproductive isolation

Patterns Within Hybrid Zones

Hybrid Zones and Environmental Change

Hybrid Zones over Time

Concept 24.4 Speciation can occur rapidly or slowly and can result from changes in few or

many genes

The Time Course of Speciation

Studying the Genetics of Speciation

From Speciation to Macroevolution

25 Macroevolution

Concept 25.1 Conditions on early Earth made the origin of life possible

Synthesis of Organic Compounds on Early Earth

Abiotic Synthesis of Macromolecules

Protocells

Self-Replicating RNA

Concept 25.2 The fossil record documents the history of life

The Fossil Record

How Rocks and Fossils Are Dated

The Origin of New Groups of Organisms

Concept 25.3 Key events in lifes history include the origins of unicellular and multicellular organisms and the colonization of land

The First Single-Celled Organisms

The Origin of Multicellularity

The Colonization of Land

Concept 25.4 The rise and fall of groups of organisms reflect differences in speciation and extinction rates

Plate Tectonics

Mass Extinctions

Adaptive Radiations

Concept 25.5 Major changes in body form can result from changes in the sequences and regulation of developmental genes

Effects of Developmental Genes

The Evolution of Development

Concept 25.6 Evolution is not goal oriented

Evolutionary Novelties

Evolutionary Trends



Unit 5 The Diversity of Life

26 Introduction to Viruses

Concept 26.1 A virus consists of a nucleic acid surrounded by a protein coat

The Discovery of Viruses: Scientific Inquiry

Structure of Viruses

Concept 26.2 Viruses replicate only in host cells

General Features of Viral Replicative Cycles

Replicative Cycles of Phages

Replicative Cycles of Animal Viruses

Evolution of Viruses

Concept 26.3 Viruses and prions are formidable pathogens in animals and plants

Viral Diseases in Animals

Emerging Viral Diseases

Viral Diseases in Plants

Prions: Proteins as Infectious Agents

27 Prokaryotes

Concept 27.1 Structural and functional adaptations contribute to prokaryotic success

Cell-Surface Structures

Motility

Internal Organization and DNA

Reproduction

Concept 27.2 Rapid reproduction, mutation, and genetic recombination promote genetic diversity in prokaryotes

Rapid Reproduction and Mutation

Genetic Recombination

Concept 27.3 Diverse nutritional and metabolic adaptations have evolved in prokaryotes

The Role of Oxygen in Metabolism

Nitrogen Metabolism

Metabolic Cooperation

Concept 27.4 Prokaryotes have radiated into a diverse set of lineages

An Overview of Prokaryotic Diversity

Bacteria

Archaea

Concept 27.5 Prokaryotes play crucial roles in the biosphere

Chemical Recycling

Ecological Interactions

Concept 27.6 Prokaryotes have both beneficial and harmful impacts on humans

Mutualistic Bacteria

Pathogenic Bacteria

Antibiotic Resistance



Prokaryotes in Research and Technology

28 The Origin and Evolution of Eukaryotes

Concept 28.1 Most eukaryotes are singlecelled organisms

Structural and Functional Diversity in Protists

Endosymbiosis in Eukaryotic Evolution

Four Supergroups of Eukaryotes

Concept 28.2 Excavates include protists with modified mitochondria and protists with unique flagella

Diplomonads and Parabasalids

Euglenozoans

Concept 28.3 SAR is a highly diverse group of protists defined by DNA similarities

Stramenopiles

Alveolates

Rhizarians

Concept 28.4 Red algae and green algae are the closest relatives of plants

Red Algae

Green Algae

Concept 28.5 Unikonts include protists that are closely related to fungi and animals

Amoebozoans

Opisthokonts

Concept 28.6 Protists play key roles in ecological communities

Symbiotic Protists

Photosynthetic Protists

29 Nonvascular and Seedless Vascular Plants

Concept 29.1 Plants evolved from green algae

Evidence of Algal Ancestry

Adaptations Enabling the Move to Land

Derived Traits of Plants

The Origin and Diversification of Plants

Concept 29.2 Mosses and other nonvascular plants have life cycles dominated by gametophytes

Bryophyte Gametophytes

Bryophyte Sporophytes

The Ecological and Economic Importance of Mosses

Concept 29.3 Ferns and other seedless vascular plants were the first plants to grow tall

Origins and Traits of Vascular Plants

Classification of Seedless Vascular Plants

The Significance of Seedless Vascular Plants

30 Seed Plants

Concept 30.1 Seeds and pollen grains are key adaptations for life on land

Advantages of Reduced Gametophytes

Heterospory: The Rule Among Seed Plants



Ovules and Production of Eggs

Pollen and Production of Sperm

The Evolutionary Advantage of Seeds

Concept 30.2 Gymnosperms bear naked seeds, typically on cones

The Life Cycle of a Pine

Early Seed Plants and the Rise of Gymnosperms

Gymnosperm Diversity

Concept 30.3 The reproductive adaptations of angiosperms include flowers and fruits

Characteristics of Angiosperms

Angiosperm Evolution

Angiosperm Diversity

Concept 30.4 Human welfare depends on seed plants

Products from Seed Plants

Threats to Plant Diversity

31 Introduction to Fungi

Concept 31.1 Fungi are heterotrophs that feed by absorption

Nutrition and Ecology

Body Structure

Specialized Hyphae in Mycorrhizal Fungi

Concept 31.2 Fungi produce spores through sexual or asexual life cycles

Sexual Reproduction

Asexual Reproduction

Concept 31.3 The ancestor of fungi was an aquatic, single-celled, flagellated protist

The Origin of Fungi

The Move to Land

Concept 31.4 Fungi have radiated into a diverse set of lineages

Cryptomycetes and Microsporidians

Zoopagomycetes

Mucoromycetes

Ascomycetes

Basidiomycetes

Concept 31.5 Fungi play key roles in nutrient cycling, ecological interactions, and human welfare

Fungi as Decomposers

Fungi as Mutualists

Practical Uses of Fungi

32 An Introduction to Animal Diversity

Concept 32.1 Animals are multicellular, heterotrophic eukaryotes with tissues that develop from embryonic layers

Nutritional Mode

Cell Structure and Specialization



Reproduction and Development

Concept 32.2 The history of animals spans more than half a billion years

Steps in the Origin of Multicellular Animals

Neoproterozoic Era (1 Billion541 Million Years Ago)

Paleozoic Era (541252 Million Years Ago)

Mesozoic Era (25266 Million Years Ago)

Cenozoic Era (66 Million Years Ago to the Present)

Concept 32.3 Animals can be characterized by body plans

Symmetry

Tissues

Body Cavities

Protostome and Deuterostome Development

Concept 32.4 Views of animal phylogeny continue to be shaped by new molecular and morphological data

The Diversification of Animals

Future Directions in Animal Systematics

33 Invertebrates

Concept 33.1 Sponges are basal animals that lack tissues

Concept 33.2 Cnidarians are an ancient phylum of eumetazoans

Medusozoans

Anthozoans

Concept 33.3 Lophotrochozoans, a clade identified by molecular data, have the widest range of animal body forms

Flatworms

Rotifers and Acanthocephalans

Ectoprocts and Brachiopods

Molluscs

Annelids

Concept 33.4 Ecdysozoans are the most species-rich animal group

Nematodes

Arthropods

Concept 33.5 Echinoderms and chordates are deuterostomes

Echinoderms

Chordates

34 Vertebrates

Concept 34.1 Chordates have a notochord and a dorsal, hollow nerve cord

Derived Characters of Chordates

Lancelets

Tunicates

Early Chordate Evolution



Concept 34.2 Vertebrates are chordates that have a backbone

Derived Characters of Vertebrates

Hagfishes and Lampreys

Early Vertebrate Evolution

Concept 34.3 Gnathostomes are vertebrates that have jaws

Derived Characters of Gnathostomes

Fossil Gnathostomes

Chondrichthyans (Sharks, Rays, and Their Relatives)

Ray-Finned Fishes and Lobe-Fins

Concept 34.4 Tetrapods are gnathostomes that have limbs

Derived Characters of Tetrapods

The Origin of Tetrapods

Amphibians

Concept 34.5 Amniotes are tetrapods that have a terrestrially adapted egg

Derived Characters of Amniotes

Early Amniotes

Reptiles

Concept 34.6 Mammals are amniotes that have hair and produce milk

Derived Characters of Mammals

Early Evolution of Mammals

Monotremes

Marsupials

Eutherians (Placental Mammals)

Concept 34.7 Humans are mammals that have a large brain and bipedal locomotion

Derived Characters of Humans

The Earliest Hominins

Australopiths

Bipedalism

Tool Use

Early Homo

Neanderthals

Homo sapiens

Unit 6 Plants: Structure and Function

35 Plant Structure and Growth

Concept 35.1 Plants have a hierarchical organization consisting of organs, tissues, and cells

Vascular Plant Organs: Roots, Stems, and Leaves

Dermal, Vascular, and Ground Tissues

Common Types of Plant Cells

Concept 35.2 Different meristems generate new cells for primary and secondary growth

Concept 35.3 Primary growth lengthens roots and shoots



Primary Growth of Roots

Primary Growth of Shoots

Concept 35.4 Secondary growth increases the diameter of stems and roots in woody plants

The Vascular Cambium and Secondary Vascular Tissue

The Cork Cambium and the Production of Periderm

Evolution of Secondary Growth

Concept 35.5 Growth, morphogenesis, and cell differentiation produce the plant body

Model Organisms: Revolutionizing the Study of Plants

Growth: Cell Division and Cell Expansion

Morphogenesis and Pattern Formation

Gene Expression and the Control of Cell Differentiation

Shifts in Development: Phase Changes

Genetic Control of Flowering

36 Transport in Vascular Plants

Concept 36.1 Adaptations for acquiring resources were key steps in the evolution of vascular plants

Shoot Architecture and Light Capture

Root Architecture and Acquisition of Water and Minerals

Concept 36.2 Different mechanisms transport substances over short or long distances

The Apoplast and Symplast: Transport Continuums

Short-Distance Transport of Solutes Across Plasma Membranes

Short-Distance Transport of Water Across Plasma Membranes

Long-Distance Transport: The Role of Bulk Flow

Concept 36.3 Transpiration drives the transport of water and minerals from roots to shoots via the xylem

Absorption of Water and Minerals by Root Cells

Transport of Water and Minerals into the Xylem

Bulk Flow Transport via the Xylem

Xylem Sap Ascent by Bulk Flow: A Review

Concept 36.4 The rate of transpiration is regulated by stomata

Stomata: Major Pathways for Water Loss

Mechanisms of Stomatal Opening and Closing

Stimuli for Stomatal Opening and Closing

Effects of Transpiration on Wilting and Leaf Temperature

Adaptations That Reduce Evaporative Water Loss

Concept 36.5 Sugars are transported from sources to sinks via the phloem

Movement from Sugar Sources to Sugar Sinks

Bulk Flow by Positive Pressure: The Mechanism of Translocation in Angiosperms

Concept 36.6 The symplast is highly dynamic

Changes in Plasmodesmatal Number and Pore Size

Phloem: An Information Superhighway

Electrical Signaling in the Phloem

37 Plant Nutrition



Concept 37.1 Soil contains a living, complex ecosystem

Soil Texture

Topsoil Composition

Soil Conservation and Sustainable Agriculture

Concept 37.2 Plant roots absorb many types of essential elements from the soil

Essential Elements

Symptoms of Mineral Deficiency

Global Climate Change and Food Quality

Concept 37.3 Plant nutrition often involves relationships with other organisms

Bacteria and Plant Nutrition

Fungi and Plant Nutrition

Epiphytes, Parasitic Plants, and Carnivorous Plants

38 Reproduction of Flowering Plants

Concept 38.1 Flowers, double fertilization, and fruits are key features of the angiosperm life cycle

Flower Structure and Function

Methods of Pollination

The Angiosperm Life Cycle: An Overview

Development of Female Gametophytes (Embryo Sacs)

Development of Male Gametophytes in Pollen Grains

Seed Development and Structure

Sporophyte Development from Seed to Mature Plant

Fruit Structure and Function

Concept 38.2 Flowering plants reproduce sexually, asexually, or both

Mechanisms of Asexual Reproduction

Advantages and Disadvantages of Asexual and Sexual Reproduction

Mechanisms That Prevent Self-Fertilization

Totipotency, Vegetative Reproduction, and Tissue Culture

Concept 38.3 People modify crops by breeding and genetic engineering

Plant Breeding

Plant Biotechnology and Genetic Engineering

The Debate over Plant Biotechnology

39 Plant Signals and Behavior

Concept 39.1 Signal transduction pathways link signal reception to response

Transduction

Reception

Response

Concept 39.2 Plants use chemicals to communicate

General Characteristics of Plant Hormones

A Survey of Plant Hormones

Concept 39.3 Responses to light are critical for plant success



Blue-Light Photoreceptors

Phytochrome Photoreceptors

Biological Clocks and Circadian Rhythms

The Effect of Light on the Biological Clock

Photoperiodism and Responses to Seasons

Concept 39.4 Plants respond to a wide variety of stimuli other than light

Gravity

Mechanical Stimuli

Environmental Stresses

Concept 39.5 Plants respond to attacks by pathogens and herbivores

Defenses Against Pathogens

Defenses Against Herbivores

Unit 7 Animals: Structure and Function

40 The Animal Body

Concept 40.1 Animal form and function are correlated at all levels of organization

Evolution of Animal Size and Shape

Exchange with the Environment

Hierarchical Organization of Body Plans

Coordination and Control

Concept 40.2 Feedback control maintains the internal environment in many animals

Regulating and Conforming

Homeostasis

Concept 40.3 Homeostatic processes for thermoregulation involve form, function, and behavior

Endothermy and Ectothermy

Variation in Body Temperature

Balancing Heat Loss and Gain

Acclimatization in Thermoregulation

Physiological Thermostats and Fever

Concept 40.4 Energy requirements are related to animal size, activity, and environment

Energy Allocation and Use

Quantifying Energy Use

Minimum Metabolic Rate and Thermoregulation

Influences on Metabolic Rate

Torpor and Energy Conservation

41 Chemical Signals in Animals

Concept 41.1 Hormones and other signaling molecules bind to target receptors, triggering specific response pathways

Intercellular Information Flow

Chemical Classes of Hormones

Cellular Hormone Response Pathways



Endocrine Tissues and Organs

Concept 41.2 Feedback regulation and coordination with the nervous system are common in hormone pathways

Simple Endocrine Pathways

Simple Neuroendocrine Pathways

Feedback Regulation

Coordination of the Endocrine and Nervous Systems

Thyroid Regulation: A Hormone Cascade Pathway

Hormonal Regulation of Growth

Concept 41.3 Endocrine glands respond to diverse stimuli in regulating homeostasis,

development, and behavior

Parathyroid Hormone and Vitamin D: Control of Blood Calcium

Adrenal Hormones: Response to Stress

Sex Hormones

Hormones and Biological Rhythms

Evolution of Hormone Function

42 Animal Digestive Systems

Concept 42.1 An animals diet must supply chemical energy, organic building blocks, and essential nutrients

Essential Nutrients

Variation in Diet

Dietary Deficiencies

Assessing Nutritional Needs

Concept 42.2 Food processing involves ingestion, digestion, absorption, and elimination

Digestive Compartments

Concept 42.3 Organs specialized for sequential stages of food processing form the mammalian

digestive system

The Oral Cavity, Pharynx, and Esophagus

Digestion in the Stomach

Digestion in the Small Intestine

Absorption in the Small Intestine

Processing in the Large Intestine

Concept 42.4 Evolutionary adaptations of vertebrate digestive systems correlate with diet

Dental Adaptations

Stomach and Intestinal Adaptations

Mutualistic Adaptations

Concept 42.5 Feedback circuits regulate digestion, energy storage, and appetite

Regulation of Digestion

Regulation of Energy Storage

Regulation of Appetite and Consumption

43 Animal Transport Systems



Concept 43.1 Circulatory systems link exchange surfaces with cells throughout the body

Gastrovascular Cavities

Open and Closed Circulatory Systems

Organization of Vertebrate Circulatory Systems

Concept 43.2 Coordinated cycles of heart contraction drive double circulation in mammals

Mammalian Circulation

The Mammalian Heart: A Closer Look Maintaining the Hearts Rhythmic Beat

Concept 43.3 Patterns of blood pressure and flow reflect the structure and arrangement of blood vessels

Blood Vessel Structure and Function

Blood Flow Velocity

Blood Pressure

Capillary Function

Fluid Return by the Lymphatic System

Concept 43.4 Blood components function in exchange, transport, and defense

Blood Composition and Function

Cardiovascular Disease

Concept 43.5 Gas exchange occurs across specialized respiratory surfaces

Partial Pressure Gradients in Gas Exchange

Respiratory Media

Respiratory Surfaces

Gills in Aquatic Animals

Tracheal Systems in Insects

Lungs

Concept 43.6 Breathing ventilates the lungs

How an Amphibian Breathes

How a Bird Breathes

How a Mammal Breathes

Control of Breathing in Humans

Concept 43.7 Adaptations for gas exchange include pigments that bind and transport gases

Coordination of Circulation and Gas Exchange

Respiratory Pigments

Respiratory Adaptations of Diving Mammals

44 Animal Excretory Systems

Concept 44.1 Osmoregulation balances the uptake and loss of water and solutes

Osmosis and Osmolarity

Osmoregulatory Challenges and Mechanisms

Energetics of Osmoregulation

Transport Epithelia in Osmoregulation

Concept 44.2 An animals nitrogenous wastes reflect its phylogeny and habitat

Forms of Nitrogenous Waste



The Influence of Evolution and Environment on Nitrogenous Wastes

Concept 44.3 Diverse excretory systems are variations on a tubular theme

Survey of Excretory Systems

Concept 44.4 The nephron is organized for stepwise processing of blood filtrate

From Blood Filtrate to Urine: A Closer Look

Solute Gradients and Water Conservation

Adaptations of the Vertebrate Kidney to Diverse Environments

Concept 44.5 Hormonal circuits link kidney function, water balance, and blood pressure

Homeostatic Regulation of the Kidney

45 Animal Reproductive Systems

Concept 45.1 Both asexual and sexual reproduction occur in the animal kingdom

Mechanisms of Asexual Reproduction

Variation in Patterns of Sexual Reproduction

Reproductive Cycles

Sexual Reproduction: An Evolutionary Enigma

Concept 45.2 Fertilization depends on mechanisms that bring together sperm and eggs of the same species

Ensuring the Survival of Offspring

Gamete Production and Delivery

Concept 45.3 Reproductive organs produce and transport gametes

Human Male Reproductive Anatomy

Human Female Reproductive Anatomy

Gametogenesis

Concept 45.4 The interplay of tropic and sex hormones regulates reproduction in mammals

Biological Sex, Gender Identity, and Sexual Orientation in Human Sexuality

Hormonal Control of the Male Reproductive System

Hormonal Control of Female Reproductive Cycles

Human Sexual Response

Concept 45.5 In placental mammals, an embryo develops fully within the mothers uterus

Conception, Embryonic Development, and Birth

Maternal Immune Tolerance of the Embryo and Fetus

Contraception and Abortion

Modern Reproductive Technologies

46 Development in Animals

Concept 46.1 Fertilization and cleavage initiate embryonic development

Fertilization

Cleavage

Concept 46.2 Morphogenesis in animals involves specific changes in cell shape, position, and survival

Gastrulation

Developmental Adaptations of Amniotes



Organogenesis

The Cytoskeleton in Morphogenesis

Concept 46.3 Cytoplasmic determinants and inductive signals regulate cell fate

Fate Mapping

Axis Formation

Restricting Developmental Potential

Cell Fate Determination and Pattern Formation by Inductive Signals

Cilia and Cell Fate

47 Animal Defenses Against Infection

Concept 47.1 In innate immunity, recognition and response rely on traits common to groups of pathogens

Innate Immunity of Invertebrates

Innate Immunity of Vertebrates

Evasion of Innate Immunity by Pathogens

Concept 47.2 In adaptive immunity, receptors provide pathogen-specific recognition

Antigen Recognition by B Cells and Antibodies

Antigens as the Trigger for Adaptive Immunity

Antigen Recognition by T Cells

B Cell and T Cell Development

Concept 47.3 Adaptive immunity defends against infection of body fluids and body cells

Helper T Cells: Activating Adaptive Immunity

B Cells and Antibodies: A Response to Extracellular Pathogens

Cytotoxic T Cells: A Response to Infected Host Cells

Summary of the Humoral and Cell-Mediated Immune Responses

Immunization

Active and Passive Immunity

Antibodies as Tools

Immune Rejection

Concept 47.4 Disruptions in immune system function can elicit or exacerbate disease

Exaggerated, Self-Directed, and Diminished Immune Responses

Evolutionary Adaptations of Pathogens That Underlie Immune System Avoidance

Cancer and Immunity

48 Electrical Signals in Animals

Concept 48.1 Neuron structure and organization reflect function in information transfer

Neuron Structure and Function

Introduction to Information Processing

Concept 48.2 Ion pumps and ion channels establish the resting potential of a neuron

Formation of the Resting Potential

Modeling the Resting Potential

Concept 48.3 Action potentials are the signals conducted by axons



Hyperpolarization and Depolarization

Graded Potentials and Action Potentials

Generation of Action Potentials: A Closer Look

Conduction of Action Potentials

Concept 48.4 Neurons communicate with other cells at synapses

Generation of Postsynaptic Potentials

Summation of Postsynaptic Potentials

Termination of Neurotransmitter Signaling

Modulated Signaling at Synapses

Neurotransmitters

49 Neural Regulation in Animals

Concept 49.1 Nervous systems consist of circuits of neurons and supporting cells

Organization of the Vertebrate Nervous System

The Peripheral Nervous System

Glia

Concept 49.2 The vertebrate brain is regionally specialized

Arousal and Sleep

Biological Clock Regulation

Emotions

Functional Imaging of the Brain

Concept 49.3 The cerebral cortex controls voluntary movement and cognitive functions

Information Processing

Language and Speech

Lateralization of Cortical Function

Frontal Lobe Function

Evolution of Cognition in Vertebrates

Concept 49.4 Changes in synaptic connections underlie memory and learning

Neuronal Plasticity

Memory and Learning

Long-Term Potentiation

Concept 49.5 Many nervous system disorders can now be explained in molecular terms

Schizophrenia

Depression

The Brains Reward System and Drug Addiction

Alzheimers Disease

Parkinsons Disease

Future Directions in Brain Research

50 Sensation and Movement in Animals

Concept 50.1 Sensory receptors transduce stimulus energy and transmit signals to the central nervous system



Sensory Reception and Transduction

Transmission

Perception

Amplification and Adaptation

Types of Sensory Receptors

Concept 50.2 In hearing and equilibrium, mechanoreceptors detect moving fluid or settling particles

Sensing of Gravity and Sound in Invertebrates

Hearing and Equilibrium in Mammals

Hearing and Equilibrium in Other Vertebrates

Concept 50.3 The diverse visual receptors of animals depend on lightabsorbing pigments

Evolution of Visual Perception

The Vertebrate Visual System

Concept 50.4 The senses of taste and smell rely on similar sets of sensory receptors

Taste in Mammals

Smell in Humans

Concept 50.5 The physical interaction of protein filaments is required for muscle function

Vertebrate Skeletal Muscle

Other Types of Muscle

Concept 50.6 Skeletal systems transform muscle contraction into locomotion

Types of Skeletal Systems

Types of Locomotion

Unit 8 The Ecology of Life

51 An Overview of Ecology

Concept 51.1 Earths climate varies by latitude and season and is changing rapidly

Global Climate Patterns

Regional and Local Effects on Climate

Effects of Vegetation on Climate

Microclimate

Global Climate Change

Concept 51.2 The distribution of terrestrial biomes is controlled by climate and disturbance

Climate and Terrestrial Biomes

General Features of Terrestrial Biomes

Disturbance and Terrestrial Biomes

Concept 51.3 Aquatic biomes are diverse and dynamic systems that cover most of Earth

Zonation in Aquatic Biomes

Concept 51.4 Interactions between organisms and the environment limit the distribution of species

Dispersal and Distribution

Biotic Factors

Abiotic Factors

Concept 51.5 Ecological change and evolution affect one another over long and short periods



of time

52 Behavioral Ecology

Concept 52.1 Discrete sensory inputs can stimulate both simple and complex behaviors

Fixed Action Patterns

Migration

Behavioral Rhythms

Animal Signals and Communication

Concept 52.2 Learning establishes specific links between experience and behavior

Experience and Behavior

Learning

Concept 52.3 Selection for individual survival and reproductive success can explain diverse behaviors

Evolution of Foraging Behavior

Mating Behavior and Mate Choice

Concept 52.4 Genetic analyses and the concept of inclusive fitness provide a basis for studying the evolution of behavior

Genetic Basis of Behavior

Genetic Variation and the Evolution of Behavior

Altruism

Inclusive Fitness

Evolution and Human Culture

53 Populations and Life History Traits

Concept 53.1 Biotic and abiotic factors affect population density, dispersion, and demographics

Density and Dispersion

Demographics

Concept 53.2 The exponential model describes population growth in an idealized, unlimited environment

Changes in Population Size

Exponential Growth

Concept 53.3 The logistic model describes how a population grows more slowly as it nears its carrying capacity

The Logistic Growth Model

The Logistic Model and Real Populations

Concept 53.4 Life history traits are products of natural selection

Diversity of Life Histories

Trade-offs and Life Histories

Concept 53.5 Density-dependent factors regulate population growth

Population Change and Population Density

Mechanisms of Density-Dependent Population Regulation

Population Dynamics

Concept 53.6 The human population is no longer growing exponentially but is still increasing extremely



rapidly

The Global Human Population

Global Carrying Capacity

54 Biodiversity and Communities

Concept 54.1 Interactions between species can help, harm, or have no effect on the individuals involved

Competition

Exploitation

Positive Interactions

Concept 54.2 Diversity and trophic structure characterize biological communities

Species Diversity

Diversity and Community Stability

Trophic Structure

Species with a Large Impact

Bottom-Up and Top-Down Controls

Concept 54.3 Disturbance influences species diversity and composition

Characterizing Disturbance

Ecological Succession

Human Disturbance

Concept 54.4 Biogeographic factors affect community diversity

Latitudinal Gradients

Area Effects

Island Equilibrium Model

Concept 54.5 Pathogens alter community structure locally and globally

Effects on Community Structure

Community Ecology and Zoonotic Diseases

55 Energy Flow and Chemical Cycling in Ecosystems

Concept 55.1 Physical laws govern energy flow and chemical cycling in ecosystems

Energy Flow and Chemical Cycling

Conservation of Energy

Conservation of Mass

Energy, Mass, and Trophic Levels

Concept 55.2 Energy and other limiting factors control primary production in ecosystems

Ecosystem Energy Budgets

Primary Production in Aquatic Ecosystems

Primary Production in Terrestrial Ecosystems

Effects of Climate Change on Production

Concept 55.3 Energy transfer between trophic levels is typically only 10% efficient

Production Efficiency

Trophic Efficiency and Ecological Pyramids

Concept 55.4 Biological and geochemical processes cycle nutrients and water in ecosystems



Decomposition and Nutrient Cycling Rates

Biogeochemical Cycles

Case Study: Nutrient Cycling in the Hubbard Brook Experimental Forest

Concept 55.5 Restoration ecologists return degraded ecosystems to a more natural state

Bioremediation

Biological Augmentation Ecosystems: A Review

56 Conservation and Global Ecology

Concept 56.1 Human activities threaten earths biodiversity

Three Levels of Biodiversity

Biodiversity and Human Welfare

Threats to Biodiversity

Can Extinct Species Be Resurrected?

Concept 56.2 Population conservation focuses on population size, genetic diversity, and critical habitat

Extinction Risks in Small Populations

Critical Habitat

Weighing Conflicting Demands

Concept 56.3 Landscape and regional conservation help sustain biodiversity

Landscape Structure and Biodiversity

Establishing Protected Areas

Urban Ecology

Concept 56.4 Earth is changing rapidly as a result of human actions

Nutrient Enrichment

Toxins in the Environment

Greenhouse Gases and Climate Change

Depletion of Atmospheric Ozone

Concept 56.5 Sustainable development can improve human lives while conserving biodiversity

Sustainable Development

The Future of the Biosphere

Appendix A

Appendix B

Appendix C

Appendix D

Credits

Glossary

Index

