

GLOBAL
EDITION 

3rd Edition Campbell
BIOLOGY IN FOCUS

Urry • Cain • Wasserman • Minorsky



CAMPBELL BIOLOGY IN FOCUS

THIRD EDITION
GLOBAL EDITION



Lisa A. Urry

Mills College, Oakland, California

Michael L. Cain

New Mexico State University

Steven A. Wasserman

University of California, San Diego

Peter V. Minorsky

Mercy College, Dobbs Ferry, New York

Rebecca B. Orr

Collin College, Plano, Texas



Campbell Biology in Focus, eBook, Global Edition

Table of Contents

Front Cover

Title Page

Copyright Page

About the Authors

Preface

Organization and New Content

Featured Figures

Acknowledgments

Brief Contents

Detailed Contents

Introduction: Evolution and the Foundations of Biology

Overview Inquiring About Life

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: Organisms Interact with Other Organisms and the Physical Environment

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

Classifying the Diversity of Life

Unity in 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 Discovery

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

Science as a Social Process

Unit 1 Chemistry and Cells

2 The Chemical Context of Life

Overview The Importance of Chemistry to Life

Table of Contents

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

- Elements and Compounds
- The Elements of Life
- 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

Concept 2.3 The formation and function of molecules 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

Concept 2.5 Hydrogen bonding gives water properties that help make life possible on Earth

- Cohesion of Water Molecules
- Moderation of Temperature by Water
- Floating of Ice on Liquid Water
- Water: The Solvent of Life
- Acids and Bases

3 Carbon and the Molecular Diversity of Life

Overview Carbon Compounds and Life

Concept 3.1 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
- The Chemical Groups Most Important to Life
- ATP: An Important Source of Energy for Cellular Processes

Concept 3.2 Macromolecules are polymers, built from monomers

- The Synthesis and Breakdown of Polymers
- The Diversity of Polymers

Concept 3.3 Carbohydrates serve as fuel and building material

- Sugars
- Polysaccharides

Concept 3.4 Lipids are a diverse group of hydrophobic molecules

- Fats
- Phospholipids
- Steroids

Concept 3.5 Proteins include a diversity of structures, resulting in a wide range of functions

- Amino Acid Monomers

Table of Contents

Polypeptides (Amino Acid Polymers)

Protein Structure and Function

Concept 3.6 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 3.7 Genomics and proteomics have transformed biological inquiry and applications

DNA and Proteins as Tape Measures of Evolution

4 A Tour of the Cell

Overview The Fundamental Units of Life

Concept 4.1 Biologists use microscopes and biochemistry to study cells

Microscopy

Cell Fractionation

Concept 4.2 Eukaryotic cells have internal membranes that compartmentalize their functions

Comparing Prokaryotic and Eukaryotic Cells

A Panoramic View of the Eukaryotic Cell

Concept 4.3 The eukaryotic cells genetic instructions are housed in the nucleus and carried out by the ribosomes

The Nucleus: Information Central

Ribosomes: Protein Factories

Concept 4.4 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 Compartments

The Endomembrane System: A Review

Concept 4.5 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 4.6 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 4.7 Extracellular components and connections between cells help coordinate cellular activities

Cell Walls of Plants

The Extracellular Matrix (ECM) of Animal Cells

Cell Junctions

Concept 4.8 A cell is greater than the sum of its parts

Table of Contents

5 Membrane Transport and Cell Signaling

Overview Life at the Edge

Concept 5.1 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 5.2 Membrane structure results in selective permeability

The Permeability of the Lipid Bilayer

Transport Proteins

Concept 5.3 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 5.4 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 5.5 Bulk transport across the plasma membrane occurs by exocytosis and endocytosis

Exocytosis

Endocytosis

Concept 5.6 The plasma membrane plays a key role in most cell signaling

Local and Long-Distance Signaling

The Three Stages of Cell Signaling: A preview

Reception, the Binding of a Signaling Molecule to a Receptor Protein

Transduction by Cascades of Molecular Interactions

Response: Regulation of Transcription or Cytoplasmic Activities

6 Introduction to Metabolism

Overview The Energy of 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 (ΔG), 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

Table of Contents

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
Organization of Enzymes Within the Cell

7 Cellular Respiration and Fermentation

Overview Life Is Work

Concept 7.1 Catabolic pathways yield energy by oxidizing organic fuels

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

Concept 7.2 Glycolysis harvests chemical energy by oxidizing glucose to pyruvate

Concept 7.3 After pyruvate is oxidized, the citric acid cycle completes the energy-yielding oxidation of organic molecules

Concept 7.4 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 7.5 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 7.6 Glycolysis and the citric acid cycle connect to many other metabolic pathways

The Versatility of Catabolism
Biosynthesis (Anabolic Pathways)

8 Photosynthesis

Overview The Process That Feeds the Biosphere

Concept 8.1 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 8.2 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

Table of Contents

A Comparison of Chemiosmosis in Chloroplasts and Mitochondria

Concept 8.3 The calvin cycle uses the chemical energy of ATP and NADPH to reduce CO₂ to sugar

Evolution of Alternative Mechanisms of Carbon Fixation in Hot, Arid Climates

Concept 8.4 Life depends on photosynthesis

9 The Cell Cycle

Overview The Key Roles of Cell Division

Concept 9.1 Most cell division results in genetically identical daughter cells

Cellular Organization of the Genetic Material

Distribution of Chromosomes During Eukaryotic Cell Division

Concept 9.2 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 9.3 The eukaryotic cell cycle is regulated by a molecular control system

Evidence for Cytoplasmic Signals

Checkpoints of the Cell Cycle Control System

Loss of Cell Cycle Controls in Cancer Cells

Unit 2 Genetics

10 Meiosis and Sexual Life Cycles

Overview Variations on a Theme

Concept 10.1 Offspring acquire genes from parents by inheriting chromosomes

Inheritance of Genes

Comparison of Asexual and Sexual Reproduction

Concept 10.2 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 10.3 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 10.4 Genetic variation produced in sexual life cycles contributes to evolution

Origins of Genetic Variation Among Offspring

The Evolutionary Significance of Genetic Variation Within Populations

11 Mendel and the Gene Idea

Overview Drawing from the Deck of Genes

Concept 11.1 Mendel used the scientific approach to identify two laws of inheritance

Mendel's Experimental, Quantitative Approach

Table of Contents

The Law of Segregation

The Law of Independent Assortment

Concept 11.2 Probability laws govern mendelian inheritance

The Multiplication and Addition Rules Applied to Monohybrid Crosses

Solving Complex Genetics Problems with the Rules of Probability

Concept 11.3 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 11.4 Many human traits follow mendelian patterns of inheritance

Pedigree Analysis

Recessively Inherited Disorders

Dominantly Inherited Disorders

Multifactorial Disorders

Genetic Counseling Based on Mendelian Genetics

12 The Chromosomal Basis of Inheritance

Overview Locating Genes Along Chromosomes

Concept 12.1 Morgan showed that mendelian inheritance has its physical basis in the behavior of chromosomes: Scientific Inquiry

Morgans Choice of Experimental Organism

Correlating Behavior of a Genes Alleles with Behavior of a Chromosome Pair

Concept 12.2 Sex-linked genes exhibit unique patterns of inheritance

The Chromosomal Basis of Sex

Inheritance of X-Linked Genes

X Inactivation in Female Mammals

Concept 12.3 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 12.4 Alterations of chromosome number or structure cause some genetic disorders

Abnormal Chromosome Number

Alterations of Chromosome Structure

Human Disorders Due to Chromosomal Alterations

13 The Molecular Basis of Inheritance

Overview Lifes Operating Instructions

Concept 13.1 DNA is the genetic material

The Search for the Genetic Material: Scientific Inquiry

Building a Structural Model of DNA: Scientific Inquiry

Concept 13.2 Many proteins work together in DNA replication and repair

The Basic Principle: Base Pairing to a Template Strand

DNA Replication: A Closer Look

Table of Contents

Proofreading and Repairing DNA

Evolutionary Significance of Altered DNA Nucleotides

Replicating the Ends of DNA Molecules

Concept 13.3 A chromosome consists of a DNA molecule packed together with proteins

Concept 13.4 Understanding DNA structure and replication makes genetic engineering possible

DNA Cloning: 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 Cloning

DNA Sequencing

Editing Genes and Genomes

14 Gene Expression: From Gene To Protein

Overview The Flow of Genetic Information

Concept 14.1 Genes specify proteins via transcription and translation

Evidence from Studying Metabolic Defects

Basic Principles of Transcription and Translation

The Genetic Code

Concept 14.2 Transcription is the DNA-directed synthesis of RNA: A Closer Look

Molecular Components of Transcription

Synthesis of an RNA Transcript

Concept 14.3 Eukaryotic cells modify RNA after transcription

Alteration of mRNA Ends

Split Genes and RNA Splicing

Concept 14.4 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 14.5 Mutations of one or a few nucleotides can affect protein structure and function

Types of Small-Scale Mutations

New Mutations and Mutagens

What Is a Gene? Revisiting the Question

15 Regulation of Gene Expression

Overview Beauty in the Eye of the Beholder

Concept 15.1 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 15.2 Eukaryotic gene expression is regulated at many stages

Differential Gene Expression

Regulation of Transcription Initiation

Table of Contents

Regulation of Chromatin Structure

Mechanisms of Post-transcriptional Regulation

Concept 15.3 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 Noncoding RNAs

Concept 15.4 Researchers can monitor expression of specific genes

Studying the Expression of Single Genes

Studying the Expression of Groups of Genes

16 Development, Stem Cells, and Cancer

Overview Orchestrating Life's Processes

Concept 16.1 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

Genetic Analysis of Early Development: Scientific Inquiry

Concept 16.2 Cloning of organisms showed that differentiated cells could be reprogrammed and ultimately led to the production of stem cells

Cloning Plants: Single-Cell Cultures

Cloning Animals: Nuclear Transplantation

Stem Cells of Animals

Concept 16.3 Abnormal regulation of genes that affect the cell cycle can lead to cancer

Types of Genes Associated with Cancer

Interference with Cell-Signaling Pathways

The Multistep Model of Cancer Development

Inherited Predisposition and Other Factors Contributing to Cancer

17 Viruses

Overview A Borrowed Life

Concept 17.1 A virus consists of a nucleic acid surrounded by a protein coat

Viral Genomes

Capsids and Envelopes

Concept 17.2 Viruses replicate only in host cells

General Features of Viral Replicative Cycles

Replicative Cycles of Phages

Bacterial Defenses Against Phages

Replicative Cycles of Animal Viruses

Evolution of Viruses

Concept 17.3 Viruses and prions are formidable pathogens in animals and plants

Viral Diseases in Animals

Emerging Viruses

Viral Diseases in Plants

Prions: Proteins as Infectious Agents

18 Genomes and Their Evolution

Table of Contents

Overview Mining the Genome

Concept 18.1 The human genome project fostered development of faster, less expensive sequencing techniques

Concept 18.2 Scientists use bioinformatics to analyze genomes and their functions

- Centralized Resources for Analyzing Genome Sequences

- Understanding the Functions of Protein-Coding Genes

- Understanding Genes and Gene Expression at the Systems Level

Concept 18.3 Genomes vary in size, number of genes, and gene density

- Genome Size

- Number of Genes

- Gene Density and Noncoding DNA

Concept 18.4 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 18.5 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 18.6 Comparing genome sequences provides clues to evolution and development

- Comparing Genomes

- Widespread Conservation of Developmental Genes Among Animals

Unit 3 Evolution

19 Descent with Modification

Overview Endless Forms Most Beautiful

Concept 19.1 The darwinian revolution challenged traditional views of a young earth inhabited by unchanging species

- Scala Naturae and Classification of Species

- Ideas About Change over Time

- Lamarcks Hypothesis of Evolution

Concept 19.2 Descent with modification by natural selection explains the adaptations of organisms and the unity and diversity of life

- Darwins Research

- The Voyage of the Beagle

- Darwins Focus on Adaptation

- Ideas from The Origin of Species

- Artificial Selection, Natural Selection, and Adaptation

Concept 19.3 Evolution is supported by an overwhelming amount of scientific evidence

Table of Contents

- Direct Observations of Evolutionary Change
- Homology
- The Fossil Record
- Biogeography
- What Is Theoretical About Darwins View of Life?

20 Phylogeny

Overview Investigating the Evolutionary History of Life

Concept 20.1 Phylogenies show evolutionary relationships

- Binomial Nomenclature
- Hierarchical Classification
- Linking Classification and Phylogeny
- What We Can and Cannot Learn from Phylogenetic Trees
- Applying Phylogenies

Concept 20.2 Phylogenies are inferred from morphological and molecular data

- Morphological and Molecular Homologies
- Sorting Homology from Analogy
- Evaluating Molecular Homologies

Concept 20.3 Shared characters are used to construct phylogenetic trees

- Cladistics
- Phylogenetic Trees with Proportional Branch Lengths
- Maximum Parsimony
- Phylogenetic Trees as Hypotheses

Concept 20.4 Molecular clocks help track evolutionary time

- Molecular Clocks
- Applying a Molecular Clock: Dating the Origin of Hiv

Concept 20.5 New information continues to revise our understanding of evolutionary history

- From Two Kingdoms to Three Domains
- The Important Role of Horizontal Gene Transfer

21 The Evolution of Populations

Overview The Smallest Unit of Evolution

Concept 21.1 Genetic variation makes evolution possible

- Genetic Variation
- Sources of Genetic Variation

Concept 21.2 The hardy-Weinberg equation can be used to test whether a population is evolving

- Gene Pools and Allele Frequencies
- The Hardy-Weinberg Equation

Concept 21.3 Natural selection, genetic drift, and gene flow can alter allele frequencies in a population

- Natural Selection
- Genetic Drift
- Gene Flow

Concept 21.4 Natural selection is the only mechanism that consistently causes adaptive evolution

Table of Contents

- Natural Selection: A Closer Look
- The Key Role of Natural Selection in Adaptive Evolution
- Balancing Selection
- Sexual Selection
- Why Natural Selection Cannot Fashion Perfect Organisms

22 The Origin of Species

- Overview That Mystery of Mysteries
- Concept 22.1 The biological species concept emphasizes reproductive isolation
 - The Biological Species Concept
 - Other Definitions of Species
- Concept 22.2 Speciation can take place with or without geographic separation
 - Allopatric (Other Country) Speciation
 - Sympatric (Same Country) Speciation
 - Allopatric and Sympatric Speciation: A Review
- Concept 22.3 Hybrid zones reveal factors that cause reproductive isolation
 - Patterns Within Hybrid Zones
 - Hybrid Zones and Environmental Change
 - Hybrid Zones over Time
- Concept 22.4 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

23 Broad Patterns of Evolution

- Overview A Surprise in the Desert
- Concept 23.1 The fossil record documents life's history
 - The Fossil Record
 - How Rocks and Fossils Are Dated
 - Fossils Frame the Geologic Record
 - The Origin of New Groups of Organisms
- Concept 23.2 The rise and fall of groups of organisms reflect differences in speciation and extinction rates
 - Plate Tectonics
 - Mass Extinctions
 - Adaptive Radiations
- Concept 23.3 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 23.4 Evolution is not goal oriented
 - Evolutionary Novelty
 - Evolutionary Trends

Unit 4 The Evolutionary History of Life

- 24 Early Life and the Diversification of Prokaryotes
 - Overview The First Cells

Table of Contents

Concept 24.1 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

Fossil Evidence of Early Life

Concept 24.2 Diverse structural and metabolic adaptations have evolved in prokaryotes

Cell-Surface Structures

Motility

Internal Organization and DNA

Nutritional and Metabolic Adaptations

Reproduction

Adaptations of Prokaryotes: A Summary

Concept 24.3 Rapid reproduction, mutation, and genetic recombination promote genetic diversity in prokaryotes

Rapid Reproduction and Mutation

Genetic Recombination

Concept 24.4 Prokaryotes have radiated into a diverse set of lineages

An Overview of Prokaryotic Diversity

Bacteria

Archaea

Concept 24.5 Prokaryotes play crucial roles in the biosphere

Chemical Recycling

Ecological Interactions

Impact on Humans

25 The Origin and Diversification of Eukaryotes

Overview Shape Changers

Concept 25.1 Eukaryotes arose by endosymbiosis more than 1.8 billion years ago

The Fossil Record of Early Eukaryotes

Endosymbiosis in Eukaryotic Evolution

Concept 25.2 Multicellularity has originated several times in eukaryotes

Multicellular Colonies

Independent Origins of Complex Multicellularity

Steps in the Origin of Multicellular Animals

Concept 25.3 Four supergroups of eukaryotes have been proposed based on morphological and molecular data

Four Supergroups of Eukaryotes

Excavates

SAR: Stramenopiles, Alveolates, and Rhizarians

Archaeplastids

Unikonts

Concept 25.4 Single-Celled eukaryotes play key roles in ecological communities and affect human health

Structural and Functional Diversity in Protists

Photosynthetic Protists

Table of Contents

Symbiotic Protists

Effects on Human Health

26 The Colonization of Land

Overview The Greening of Earth

Concept 26.1 Fossils show that plants colonized land more than 470 million years ago

Evidence of Algal Ancestry

Adaptations Enabling the Move to Land

Derived Traits of Plants

Early Plants

Concept 26.2 Though not closely related to plants, fungi played a key role in the colonization of land

The Origin of Fungi

Fungal Adaptations for Life on Land

Diversification of Fungi

Concept 26.3 Early plants radiated into a diverse set of lineages

Bryophytes: A Collection of Basal Plant Lineages

Seedless Vascular Plants: The First Plants to Grow Tall

Concept 26.4 Seeds and pollen grains are key adaptations for life on land

Terrestrial Adaptations in Seed Plants

Early Seed Plants and the Rise of Gymnosperms

The Origin and Diversification of Angiosperms

Concept 26.5 Plants and fungi fundamentally changed chemical cycling and biotic interactions

Physical Environment and Chemical Cycling

Biotic Interactions

27 The Rise of Animal Diversity

Overview Life Becomes Dangerous

Concept 27.1 Animals originated more than 700 million years ago

Fossil and Molecular Evidence

Early-Diverging Animal Groups

Concept 27.2 The diversity of large animals increased dramatically during the Cambrian explosion

Evolutionary Change in the Cambrian Explosion

Dating the Origin of Bilaterians

Concept 27.3 Diverse animal groups radiated in aquatic environments

Animal Body Plans

The Diversification of Animals

Bilaterian Radiation I: Diverse Invertebrates

Concept 27.4 Vertebrates have been the oceans dominant predators for more than 400 million years

Bilaterian Radiation II: Aquatic Vertebrates

Summary: Effects of Bilaterian Radiations I and II

Concept 27.5 Several animal groups had features facilitating their colonization of land

Table of Contents

Early Land Animals

Colonization of Land by Arthropods

Terrestrial Vertebrates

Concept 27.6 Amniotes have key adaptations for life in a wide range of terrestrial environments

Terrestrial Adaptations in Amniotes

The Origin and Radiation of Amniotes

Human Evolution

Concept 27.7 Animals have transformed ecosystems and altered the course of evolution

Ecological Effects of Animals

Evolutionary Effects of Animals

Unit 5 Plant Form and Function

28 Vascular Plant Structure and Growth

Overview Beauty Through Repetition

Concept 28.1 Plants have a hierarchical organization consisting of organs, tissues, and cells

The Three Basic Plant Organs: Roots, Stems, and Leaves

Dermal, Vascular, and Ground Tissue

Common Types of Plant Cells

Concept 28.2 Different meristems generate new cells for primary and secondary growth

Gene Expression and Control of Cell Differentiation

Meristematic Control of the Transition to Flowering and the Life Spans of Plants

Concept 28.3 Primary growth lengthens roots and shoots

Primary Growth of Roots

Primary Growth of Shoots

Concept 28.4 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

29 Resource Acquisition, Nutrition, and Transport in Vascular Plants

Overview A Whole Lot of Shaking Going on

Concept 29.1 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 29.2 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 29.3 Plant roots absorb many types of essential elements from the soil

Macronutrients and Micronutrients

Table of Contents

Symptoms of Mineral Deficiency

Soil Management

The Living, Complex Ecosystem of Soil

Concept 29.4 Plant nutrition often involves relationships with other organisms

Bacteria and Plant Nutrition

Fungi and Plant Nutrition

Epiphytes, Parasitic Plants, and Carnivorous Plants

Concept 29.5 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 29.6 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 29.7 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

30 Reproduction and Domestication of Flowering Plants

Overview Getting Hooked

Concept 30.1 Flowers, double fertilization, and fruits are unique features of the angiosperm life cycle

Flower Structure and Function

Flower Formation

The Angiosperm Life Cycle: an Overview

Pollination: A Closer Look

Seed Development and Structure

Germination, Growth, and Flowering

Fruit Structure and Function

Concept 30.2 Flowering plants reproduce sexually, asexually, or both

Mechanisms of Asexual Reproduction

Advantages and Disadvantages of Asexual Versus Sexual Reproduction

Mechanisms That Prevent Self-Fertilization

Totipotency, Vegetative Reproduction, and Tissue Culture

Concept 30.3 People modify crops through breeding and genetic engineering

Plant Breeding

Plant Biotechnology and Genetic Engineering

The Debate over Plant Biotechnology

31 Plant Responses to Internal and External Signals

Overview Stimuli and a Stationary Life

Concept 31.1 Plant hormones help coordinate growth, development, and responses

Table of Contents

to stimuli

The Discovery of Plant Hormones

A Survey of Plant Hormones

Concept 31.2 Responses to light are critical for plant success

Photomorphogenesis

Biological Clocks and Circadian Rhythms

Photoperiodism and Responses to Seasons

Concept 31.3 Plants respond to a wide variety of stimuli other than light

Gravity

Mechanical Stimuli

Environmental Stresses

Concept 31.4 Plants respond to attacks by herbivores and pathogens

Defenses Against Herbivores

Defenses Against Pathogens

Unit 6 Animal Form and Function

32 The Internal Environment of Animals: Organization and Regulation

Overview Diverse Forms, Common Challenges

Concept 32.1 Animal form and function are correlated at all levels of organization

Concept 32.2 The endocrine and nervous systems act individually and together in regulating animal physiology

An Overview of Coordination and Control

Endocrine Glands and Hormones

Regulation of Endocrine Signaling

Simple Endocrine Pathways

Neuroendocrine Signaling

Hormone Solubility

Multiple Effects of Hormones

Concept 32.3 Feedback control maintains the internal environment in many animals

Regulating and Conforming

Homeostasis

Thermoregulation: A Closer Look

Concept 32.4 A shared system mediates osmoregulation and excretion in many animals

Osmosis and Osmolarity

Osmoregulatory Challenges and Mechanisms

Nitrogenous Wastes

Excretory Processes

Concept 32.5 The mammalian kidney's ability to conserve water is a key terrestrial adaptation

From Blood Filtrate to Urine: A Closer Look

Concentrating Urine in the Mammalian Kidney

Adaptations of the Vertebrate Kidney to Diverse Environments

Homeostatic Regulation of the Kidney

33 Animal Nutrition

Table of Contents

Overview The Need to Feed

Concept 33.1 An animals diet must supply chemical energy, organic building blocks, and essential nutrients

Essential Nutrients

Dietary Deficiencies

Concept 33.2 Food processing involves ingestion, digestion, absorption, and elimination

Digestive Compartments

Concept 33.3 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 33.4 Evolutionary adaptations of vertebrate digestive systems correlate with diet

Dental Adaptations

Stomach and Intestinal Adaptations

Mutualistic Adaptations in Humans

Mutualistic Adaptations in Herbivores

Concept 33.5 Feedback circuits regulate digestion, energy allocation, and appetite

Regulation of Digestion

Energy Allocation

Regulation of Appetite and Consumption

34 Circulation and Gas Exchange

Overview Trading Places

Concept 34.1 Circulatory systems link exchange surfaces with cells throughout the body

Open and Closed Circulatory Systems

Organization of Vertebrate Circulatory Systems

Concept 34.2 Coordinated cycles of heart contraction drive double circulation in mammals

Mammalian Circulation

The Mammalian Heart: A Closer Look

Maintaining the Hearts Rhythmic Beat

Concept 34.3 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 34.4 Blood components function in exchange, transport, and defense

Blood Composition and Function

Table of Contents

Cardiovascular Disease

Concept 34.5 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 34.6 Breathing ventilates the lungs

How a Mammal Breathes

Control of Breathing in Humans

Concept 34.7 Adaptations for gas exchange include pigments that bind and transport gases

Coordination of Circulation and Gas Exchange

Respiratory Pigments

Carbon Dioxide Transport

Respiratory Adaptations of Diving Mammals

35 The Immune System

Overview Recognition and Response

Concept 35.1 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 35.2 In adaptive immunity, receptors provide pathogen-specific recognition

Antigen Recognition by B Cells and Antibodies

Antigen Recognition by T Cells

B Cell and T Cell Development

Concept 35.3 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

Disruptions in Immune System Function

Cancer and Immunity

36 Reproduction and Development

Overview Let Me Count the Ways

Concept 36.1 Both asexual and sexual reproduction occur in the animal kingdom

Mechanisms of Asexual Reproduction

Sexual Reproduction: An Evolutionary Enigma

Table of Contents

Reproductive Cycles

Variation in Patterns of Sexual Reproduction

External and Internal Fertilization

Ensuring the Survival of Offspring

Concept 36.2 Reproductive organs produce and transport gametes

Variation in Reproductive Systems

Human Male Reproductive Anatomy

Human Female Reproductive Anatomy

Gametogenesis

Concept 36.3 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 36.4 Development of an egg into a mature embryo requires fertilization, cleavage, gastrulation, and organogenesis

Fertilization

Cleavage

Gastrulation

Conception, Cleavage, and Embryo Implantation in Humans

Embryonic Development in Humans

Fetal Development and Birth

Contraception

Infertility and in Vitro Fertilization

37 Neurons, Synapses, and Signaling

overview Lines of Communication

Concept 37.1 Neuron structure and organization reflect function in information transfer

Neuron Structure and Function

Introduction to Information Processing

Concept 37.2 Ion pumps and ion channels establish the resting potential of a neuron

Formation of the Resting Potential

Modeling the Resting Potential

Concept 37.3 Action potentials are the signals conducted by axons

Hyperpolarization and Depolarization

Graded Potentials and Action Potentials

Generation of Action Potentials:

Conduction of Action Potentials

Concept 37.4 Neurons communicate with other cells at synapses

Generation of Postsynaptic Potentials

Summation of Postsynaptic Potentials

Modulated Signaling at Synapses

Neurotransmitters

38 Nervous and Sensory Systems

Table of Contents

Overview Command and Control Center

Concept 38.1 Nervous systems consist of circuits of neurons and supporting cells

Glia

Organization of the Vertebrate Nervous System

The Peripheral Nervous System

Concept 38.2 The vertebrate brain is regionally specialized

Functional Imaging of the Brain

Arousal and Sleep

Biological Clock Regulation

Emotions

The Brains Reward System and Drug Addiction

Concept 38.3 The cerebral cortex controls voluntary movement and cognitive functions

Language and Speech

Lateralization of Cortical Function

Information Processing

Frontal Lobe Function

Evolution of Cognition in Vertebrates

Neuronal Plasticity

Memory and Learning

Future Directions in Brain Research

Concept 38.4 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 38.5 In hearing and equilibrium, mechanoreceptors detect moving fluid or settling particles

Sensing of Gravity and Sound in Invertebrates

Hearing and Equilibrium in Mammals

Concept 38.6 The diverse visual receptors of animals depend on light-absorbing pigments

Evolution of Visual Perception

The Vertebrate Visual System

39 Motor Mechanisms and Behavior

Overview The How and Why of Animal Activity

Concept 39.1 The physical interaction of protein filaments is required for muscle function

Vertebrate Skeletal Muscle

Other Types of Vertebrate Muscle

Concept 39.2 Skeletal systems transform muscle contraction into locomotion

Types of Skeletal Systems

Types of Locomotion

Concept 39.3 Discrete sensory inputs can stimulate both simple and complex

Table of Contents

behaviors

Fixed Action Patterns

Migration

Behavioral Rhythms

Animal Signals and Communication

Concept 39.4 Learning establishes specific links between experience and behavior

Experience and Behavior

Learning

Concept 39.5 Selection for individual survival and reproductive success can explain diverse behaviors

Evolution of Foraging Behavior

Mating Behavior and Mate Choice

Concept 39.6 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

Unit 7 Ecology

40 Population Ecology and the Distribution of Organisms

Overview Discovering Ecology

Concept 40.1 Earth's climate influences the distribution of terrestrial biomes

Global Climate Patterns

Regional and Local Effects on Climate

Climate and Terrestrial Biomes

General Features of Terrestrial Biomes

Concept 40.2 Aquatic biomes are diverse and dynamic systems that cover most of earth

Concept 40.3 Interactions between organisms and the environment limit the distribution of species

Dispersal and Distribution

Biotic Factors

Abiotic Factors

Concept 40.4 Biotic and abiotic factors affect population density, dispersion, and demographics

Density and Dispersion

Demographics

Concept 40.5 The exponential and logistic models describe the growth of populations

Changes in Population Size

Exponential Growth

Carrying Capacity

The Logistic Growth Model

The Logistic Model and Real Populations

Concept 40.6 Population dynamics are influenced strongly by life history traits

Table of Contents

and population density

Trade-Offs and Life Histories

Population Change and Population Density

Mechanisms of Density-Dependent Population Regulation

Population Dynamics

41 Ecological Communities

Overview Communities in Motion

Concept 41.1 Interactions between species may help, harm, or have no effect on the individuals involved

Competition

Exploitation

Positive Interactions

Concept 41.2 Biological communities can be characterized by their diversity and trophic structure

Species Diversity

Diversity and Community Stability

Trophic Structure

Species with a Large Impact

Bottom-Up and Top-Down Controls

Concept 41.3 Disturbance influences species diversity and composition

Characterizing Disturbance

Ecological Succession

Human Disturbance

Concept 41.4 Biogeographic factors affect community diversity

Latitudinal Gradients

Area Effects

Concept 41.5 Pathogens alter community structure locally and globally

Effects on Community Structure

Community Ecology and Zoonotic Diseases

42 Ecosystems and Energy

Overview Transformed to Tundra

Concept 42.1 Physical laws govern energy flow and chemical cycling in ecosystems

Conservation of Energy

Conservation of Mass

Energy, Mass, and Trophic Levels

Concept 42.2 Energy and other limiting factors control primary production in ecosystems

Ecosystem Energy Budgets

Primary Production in Aquatic Ecosystems

Primary Production in Terrestrial Ecosystems

Concept 42.3 Energy transfer between trophic levels is typically only 10% efficient

Production Efficiency

Trophic Efficiency and Ecological Pyramids

Concept 42.4 Biological and geochemical processes cycle nutrients and water in

Table of Contents

ecosystems

Decomposition and Nutrient Cycling Rates

Biogeochemical Cycles

Case Study: Nutrient Cycling in the Hubbard Brook Experimental Forest

Concept 42.5 Restoration ecologists return degraded ecosystems to a more natural state

Bioremediation

Biological Augmentation

Ecosystems: A Review

43 Conservation Biology and Global Change

Overview Psychedelic Treasure

Concept 43.1 Human activities threaten earths biodiversity

Three Levels of Biodiversity

Biodiversity and Human Welfare

Threats to Biodiversity

Concept 43.2 Population conservation focuses on population size, genetic diversity, and critical habitat

Small-Population Approach

Declining-Population Approach

Weighing Conflicting Demands

Concept 43.3 Landscape and regional conservation help sustain biodiversity

Landscape Structure and Biodiversity

Establishing Protected Areas

Concept 43.4 Earth is changing rapidly as a result of human actions

Nutrient Enrichment

Toxins in the Environment

Greenhouse Gases and Climate Change

Concept 43.5 The human population is no longer growing exponentially but is still increasing rapidly

The Global Human Population

Global Carrying Capacity

Concept 43.6 Sustainable development can improve human lives while conserving biodiversity

Sustainable Development

The Future of the Biosphere

Appendix A Answers

Appendix B Periodic Table of the Elements

Appendix C The Metric System

Appendix D A Comparison of the Light Microscope and the Electron Microscope

Appendix E Classification of Life

Appendix F Scientific Skills Review

Credits

Glossary

Table of Contents

Index

Back Cover