CHAPTER 1: EXPLORING LIFE

KEY CONCEPTS:

1. Biologists explore life from the microscopic to the global scale.
2. Biological systems are much more than the sum of their parts.
3. Biologists explore life across its great diversity of species.
4. Evolution accounts for life's unity and diversity.
5. Biologists use various forms of inquiry to explore life.
6. A set of themes connects the concepts of biology.

OBJECTIVES:

Exploring Life on its Many Levels

1. Briefly describe the unifying themes that characterize the biological sciences.
2. Diagram the hierarchy of structural levels in biological organization.
3. Explain how the properties of life emerge from complex organization.
4. Distinguish between prokaryotic and eukaryotic cells.
5. Describe the basic structure and function of DNA.
6. Describe the dilemma of reductionism.
7. Discuss the goals and activities of systems biology. List the three research developments that have advanced systems biology.
8. Explain the importance of regulatory mechanisms in living things. Distinguish between positive and negative feedback.

Evolution, Unity and Diversity

9. Distinguish among the three domains of life. List and distinguish among the three kingdoms of multicellular, eukaryotic life.
10. Explain the phrase: "life's dual nature of unity and diversity".
11. Describe the observations and inferences that led Charles Darwin to his theory of evolution by natural selection.
12. Explain why diagrams of evolutionary relationships have a treelike form.

The Process of Science

13. Distinguish between discovery science and hypothesis-based science. Explain why both types of exploration contribute to our understanding of nature.
14. Distinguish between quantitative and qualitative data.
15. Distinguish between inductive and deductive reasoning.
16. Explain why hypotheses must be testable and falsifiable but are not provable.
17. Describe what is meant by a controlled experiment.
18. Distinguish between the everyday meaning of the term 'theory' and its meaning to scientists.
19. Explain how science is influenced by social and cultural factors.
20. Distinguish between science and technology. Explain how science and technology are interdependent.

KEY TERMS:

animalia
Archaea
Bacteria
bioinformatics

biology
biosphere
cell
community
controlled experiment
data
deductive reasoning
deoxyribonucleic acid (DNA)
discovery science
ecosystem
emergent properties
Eukarya
eukaryotic cell
Fungi
gene
genome
hypothesis
inductive reasoning
inquiry
model
molecule
natural selection
negative feedback
organ
organ system
organelle
organism
plantae
population
positive feedback
prokaryotic cell
reductionism
system
systems biology
technology
theory
tissue

CHAPTER 2: THE CHEMICAL CONTEXT OF LIFE

KEY CONCEPTS:

1. Matter consists of chemical elements in pure form and in combinations called compounds.
2. An element's properties depend on the structure of its atoms.
3. The formation and function of molecule depend on chemical bonding between atoms.
4. Chemical reactions make and break chemical bonds.

OBJECTIVES:

Elements and Compounds

1. Distinguish between an element and a compound.
2. Identify the four elements that make up 96% of living matter.
3. Define the term trace element and give an example.

Atoms and Molecules

4. Draw and label a simplified model of an atom. Explain how this model simplifies our understanding of atomic structure.
5. Distinguish between each of the following pairs of terms:

   neutron and proton

   atomic number and mass number

   atomic weight and mass number
6. Explain how the atomic number and mass number of an atom can be used to determine the number of neutrons.
7. Explain how two isotopes of an element are similar. Explain how they are different.
8. Describe two biological applications that use radioactive isotopes.
9. Define the terms energy and potential energy. Explain why electrons in the first electron shell have less potential energy than electrons in higher electron shells.
10. Distinguish among nonpolar covalent, polar covalent and ionic bonds.
11. Explain why strong covalent bonds and weak bonds are both essential in living organisms.
12. Distinguish between hydrogen bonds and van der Waals interactions.
13. Give an example that illustrates how a molecule's shape can determine its biological function.
14. Explain what is meant by a chemical equilibrium.

KEY TERMS:

anion
atom
atomic mass
atomic nucleus
atomic number
cation
chemical bond
chemical equilibrium
chemical reaction
compound
covalent bond
dalton
electron
electron shell
electronegativity
element
energy
energy level

hydrogen bond
ion
ionic bond
ionic compound
isotope
mass number
matter
molecular formula
molecule
neutron
nonpolar covalent bond
orbital
periodic table of the elements
polar covalent bond
potential energy
product
proton
radioactive isotope
reactant
salt
structural formula
trace element
valence
valence electron
valence shell
van der Waals interactions

CHAPTER 3: WATER AND THE FITNESS OF THE ENVIRONMENT

KEY CONCEPTS:

1. The polarity of water molecules results in hydrogen bonding.
2. Four emergent properties of water contribute to Earth's fitness for life.
3. Dissociation of water molecules leads to acidic and basic conditions that affect living organisms.

OBJECTIVES:

The Properties of Water

1. With the use of a diagram or diagrams, explain why water molecules are: polar and capable of hydrogen bonding with 4 neighboring water molecules

2. List four characteristics of water that are emergent properties resulting from hydrogen bonding.

3. Define cohesion and adhesion. Explain how water's cohesion and adhesion contribute to the movement of water from the roots to the leaves of a tree.

4. Distinguish between heat and temperature, using examples to clarify your definitions.

5. Explain the following observations by referring to the properties of water:

- Coastal areas have milder climates than adjacent inland areas.
- Ocean temperatures fluctuate much less than air temperatures on land.
- Insects like water striders can walk on the surface of a pond without breaking the surface.
- If you slightly overfill a water glass, the water will form a convex surface above the top of the glass.
- If you place a paper towel so that it touches spilled water, the towel will draw in the water.
- Ice floats on water.
- Humans sweat and dogs pant to cool themselves on hot days.

6. Distinguish among a solute, a solvent, and a solution.

7. Distinguish between hydrophobic and hydrophilic substances.

8. Explain how you would make up a one molar (1M) solution of ethyl alcohol.

The Dissociation of Water Molecules

9. Name the products of the dissociation of water and give their concentration in pure water.

10. Define acid, base, and pH.

11. Explain how acids and bases may directly or indirectly alter the hydrogen ion concentration of a solution.

12. Using the bicarbonate buffer system as an example, explain how buffers work.

13. Briefly explain the causes and effects of acid precipitation.

KEY TERMS:

acid
acid precipitation
adhesion
aqueous solution
base
buffer
calorie (cal)
Celsius scale
cohesion
colloid
evaporative cooling
heat
heat of vaporization
hydration shell

hydrogen ion
hydrophilic
hydrophobic
hydroxide ion
joule (J)
kilocalorie (kcal)
kinetic energy
molarity
mole (mol)
molecular mass
pH
polar molecule
solute
solution
solvent
specific heat
surface tension
temperature

CHAPTER 4: CARBON AND THE MOLECULAR DIVERSITY OF LIFE

KEY CONCEPTS:

1. Organic chemistry is the study of carbon compounds.
2. Carbon atoms can form diverse molecules by bonding to four other atoms.
3. Functional groups are the parts of molecules involved in chemical reactions.

OBJECTIVES:

The Importance of Carbon

1. Explain how carbon's electron configuration accounts for its ability to form large, complex, and diverse organic molecules.
2. Describe how carbon skeletons may vary, and explain how this variation contributes to the diversity and complexity of organic molecules.
3. Describe the basic structure of a hydrocarbon and explain why these molecules are hydrophobic.
4. Distinguish among the three types of isomers: structural, geometric, and enantiomer.

Functional Groups

5. Name the major functional groups found in organic molecules. Draw the basic chemical structure of each functional group and outline the chemical properties of the organic molecules in which they occur.

KEY TERMS:

amino group
carbonyl group
carboxyl group
cis
enantiomer
functional group
geometric isomer
hydrocarbon
hydroxyl group
isomer
organic chemistry
phosphate group
structural isomer
sulfhydryl group
trans

CHAPTER 5: THE STRUCTURE AND FUNCTION OF MACROMOLECULES

KEY CONCEPTS:

1. Most macromolecules are polymers, built from monomers.
2. Carbohydrates serve as fuel and building material.
3. Lipids are a diverse group of hydrophobic molecules.
4. Proteins have many structures, resulting in a wide range of functions.
5. Nucleic acids store and transmit heredity information.

OBJECTIVES:

The Principles of Polymers

1. List the four major classes of macromolecules.
2. Distinguish between monomers and polymers.
3. Draw diagrams to illustrate condensation and hydrolysis reactions.

Carbohydrates Serve as Fuel and Building Material

4. Distinguish between monosaccharides, disaccharides, and polysaccharides.
5. Describe the formation of a glycosidic linkage.
6. Distinguish between the glycosidic linkages found in starch and cellulose. Explain why the difference is biologically important.
7. Describe the role of symbiosis in cellulose digestion.

Lipids are a Diverse Group of Hydrophobic Molecules

8. Describe the building-block molecules, structure, and biological importance of fats, phospholipids, and steroids.
9. Identify an ester linkage and describe how it is formed.
10. Distinguish between saturated and unsaturated fats.
11. Name the principal energy storage molecules of plants and animals.

Proteins have Many Structures and Many Functions

12. Distinguish between a protein and a polypeptide.
13. Explain how a peptide bond forms between two amino acids.
14. List and describe the four major components of an amino acid. Explain how amino acids may be grouped according to the physical and chemical properties of the R group.
15. Explain what determines protein conformation and why it is important.
16. Explain how the primary structure of a protein is determined.
17. Name two types of secondary protein structure. Explain the role of hydrogen bonds in maintaining secondary structure.
18. Explain how weak interactions and disulfide bridges contribute to tertiary protein structure.
19. List four conditions under which proteins may be denatured.

Nucleic Acids Store and Transmit Hereditary Information

20. List the major components of a nucleotide, and describe how these monomers are linked to form a nucleic acid.
21. Distinguish between:

    pyrimidine and purine
    nucleotide and nucleoside
    ribose and deoxyribose
    5' end and 3' end of a nucleotide

22. Briefly describe the three-dimensional structure of DNA.

KEY TERMS:

alpha (a) helix
amino acid
antiparallel
beta (b) pleated sheet
carbohydrate
catalyst
cellulose
chaperonin
chitin
cholesterol
condensation reaction
dehydration reaction
denaturation
deoxyribonucleic acid (DNA)
deoxyribose
disaccharide
disulfide bridge
double helix
fat (triacylglycerol)
fatty acid
gene
glycogen
glycosidic linkage
hydrolysis
hydrophobic interaction
lipid
macromolecule
monomer
monosaccharide
nucleic acid
nucleotide
peptide bond
phospholipid
polymer
polynucleotide
polypeptide
polysaccharide
primary structure
protein
purine
pyrimidine
quaternary structure
ribonucleic acid (RNA)
ribose
saturated fatty acid
secondary structure
starch
steroid
tertiary structure
triacylglycerol
unsaturated fatty acid
X-ray crystallography

CHAPTER 6: A TOUR OF THE CELL

KEY CONCEPTS:

1. To study cells, biologists use microscopes and the tools of biochemistry.
2. Eukaryotic cells have internal membranes that compartmentalize their functions.
3. The eukaryotic cell's genetic instructions are housed in the nucleus and carried out by the ribosomes.
4. The endomembrane system regulates protein traffic and performs metabolic functions in the cell.
5. Mitochondria and chloroplasts change energy from one form to another.
6. The cytoskeleton is a network of fibers that organizes structures and activities in the cell.
7. Extracellular components and connections between the cells help coordinate cellular activities.

OBJECTIVES:

How We Study Cells

1. Distinguish between magnification and resolving power.
2. Describe the principles, advantages, and limitations of the light microscope, transmission electron microscope, and scanning electron microscope.
3. Describe the major steps of cell fractionation and explain why it is a useful technique.

A Panoramic View of the Cell

4. Distinguish between prokaryotic and eukaryotic cells.
5. Explain why there are both upper and lower limits to cell size.
6. Explain the advantages of compartmentalization in eukaryotic cells.

The Nucleus and Ribosomes

7. Describe the structure and function of the nuclear envelope, including the role of the pore complex.
8. Briefly explain how the nucleus controls protein synthesis in the cytoplasm.
9. Explain how the nucleolus contributes to protein synthesis.
10. Describe the structure and function of a eukaryotic ribosome.
11. Distinguish between free and bound ribosomes in terms of location and function.

The Endomembrane System

12. List the components of the endomembrane system, and describe the structure and functions of each component.
13. Compare the structure and functions of smooth and rough ER.
14. Explain the significance of the cis and trans sides of the Golgi apparatus.
15. Describe the cisternal maturation model of Golgi function.
16. Describe three examples of intracellular digestion by lysosomes.
17. Name three different kinds of vacuoles, giving the function of each kind.

Other Membranous Organelles

18. Briefly describe the energy conversions carried out by mitochondria and chloroplasts.
19. Describe the structure of a mitochondrion and explain the importance of compartmentalization in mitochondrial function.
20. Distinguish among amyloplasts, chromoplasts, and chloroplasts.
21. Identify the three functional compartments of a chloroplast. Explain the importance of compartmentalization in chloroplast function.
22. Describe the evidence that mitochondria and chloroplasts are semiautonomous organelles.
23. Explain the roles of peroxisomes in eukaryotic cells.

The Cytoskeleton

24. Describe the functions of the cytoskeleton.
25. Compare the structure, monomers, and functions of microtubules, microfilaments, and intermediate filaments.
26. Explain how the ultrastructure of cilia and flagella relates to their functions.

Cell Surfaces and Junctions

27. Describe the basic structure of a plant cell wall.
28. Describe the structure and list four functions of the extracellular matrix in animal cells.
29. Explain how the extracellular matrix may act to integrate changes inside and outside the cell.
30. Name the intercellular junctions found in plant and animal cells and list the function of each type of junction.

KEY TERMS:

actin
aminopeptidase
basal body
cell fractionation
cell wall
central vacuole
centriole
centrosome
chloroplast
chromatin
chromosome
cilium
collagen
contractile vacuole
crista
cytoplasm
cytoplasmic streaming
cytoskeleton
cytosol
desmosome
dynein
electron microscope (EM)
endomembrane system
eukaryotic cell
extracellular matrix (ECM)
fibronectin
flagellum
food vacuole
gap junction
glycoprotein
Golgi apparatus
granum
integrin
intermediate filament
light microscope (LM)
lysosome
microfilament
microtubule
middle lamella
mitochondrial matrix
mitochondrion
myosin
nuclear envelope
nuclear lamina

nucleoid
nucleolus
nucleus
organelle
peroxisome
phagocytosis
plasma membrane
plasmodesma
plastid
primary cell wall
prokaryotic cell
proteoglycan
pseudopodium
ribosome
rough ER
scanning electron microscope (SEM)
secondary cell wall
smooth ER
stroma
thylakoid
tight junction
tonoplast
transmission electron microscope (TEM)
transport vesicle
vesicle

CHAPTER 7: MEMBRANE STRUCTURE AND FUNCTION

KEY CONCEPTS:

1. Cellular membranes are fluid mosaics of lipids and proteins.
2. Membrane structure results in selective permeability.
3. Passive transport is diffusion of a substance across a membrane with no energy investment.
4. Active transport uses energy to move solutes against their gradients.
5. Bulk transport across the plasma membrane occurs by exocytosis and endocytosis.

OBJECTIVES:

Membrane Structure

1. Explain why phospholipids are amphipathic molecules.
2. Explain what freeze-fracture techniques reveal about the arrangement of proteins in membranes.
3. Describe the fluidity of the components of a cell membrane and explain how membrane fluidity is influenced by temperature and membrane composition.
4. Explain how cholesterol resists changes in membrane fluidity with temperature change.

Traffic Across Membranes

5. Distinguish between peripheral and integral membrane proteins.
6. List six major functions of membrane proteins.
7. Explain the role of membrane carbohydrates in cell-cell recognition.
8. Explain how hydrophobic molecules cross cell membranes.
9. Distinguish between channel proteins and carrier proteins.
10. Define diffusion. Explain why diffusion is a spontaneous process.
11. Explain why a concentration gradient of a substance across a membrane represents potential energy.
12. Distinguish among hypertonic, hypotonic, and isotonic solutions.
13. Define osmosis and predict the direction of water movement based on differences in solute concentrations.
14. Describe how living cells with and without cell walls regulate water balance.
15. Explain how transport proteins facilitate diffusion.
16. Distinguish among osmosis, facilitated diffusion, and active transport.
17. Describe the two forces that combine to produce an electrochemical gradient.
18. Explain how an electrogenic pump creates voltage across a membrane.
19. Describe the process of cotransport.
20. Explain how large molecules are transported across a cell membrane.
21. Distinguish between pinocytosis and receptor-mediated endocytosis.

KEY TERMS:

active transport
amphipathic molecule
aquaporin
concentration gradient
cotransport
diffusion
electrochemical gradient
electrogenic pump
endocytosis
exocytosis
facilitated diffusion

flaccid
fluid mosaic model
gated channel
glycolipid
glycoprotein
hypertonic
hypotonic
integral protein
ion channel
isotonic
ligand
membrane potential
osmoregulation
osmosis
passive transport
peripheral protein
phagocytosis
pinocytosis
plasmolysis
proton pump
receptor-mediated endocytosis
selective permeability
sodium-potassium pump
tonicity
transport protein
turgid

CHAPTER 8: AN INTRODUCTION TO METABOLISM

KEY CONCEPTS:

1. An organism's metabolism transforms matter and energy, subject to the laws of thermodynamics.
2. The free-energy change of a reaction tells us whether the reaction occurs spontaneously.
3. ATP powers cellular work by coupling exergonic reactions to endergonic reactions.
4. Enzymes speed up metabolic reactions by lowering energy barriers.
5. Regulation of enzyme activity helps control metabolism.

OBJECTIVES:

Metabolism, Energy, and Life

1. Explain the role of catabolic and anabolic pathways in cellular metabolism.
2. Distinguish between kinetic and potential energy.
3. Explain why an organism is considered an open system.
4. Explain the first and second laws of thermodynamics in your own words.
5. Explain why highly ordered living organisms do not violate the second law of thermodynamics.
6. Write and define each component of the equation for free-energy change.
7. Distinguish between exergonic and endergonic reactions in terms of free energy change.
8. Explain why metabolic disequilibrium is one of the defining features of life.
9. List the three main kinds of cellular work. Explain in general terms how cells obtain the energy to do cellular work.
10. Describe the structure of ATP and identify the major class of macromolecules to which ATP belongs.
11. Explain how ATP performs cellular work.

Enzymes are Catalytic Proteins

12. Describe the function of enzymes in biological systems.
13. Explain why an investment of activation energy is necessary to initiate a spontaneous reaction.
14. Explain how enzyme structure determines enzyme specificity.
15. Explain the induced-fit model of enzyme function.
16. Describe the mechanisms by which enzymes lower activation energy.
17. Explain how substrate concentration affects the rate of an enzyme-catalyzed reaction.
18. Explain how temperature, pH, cofactors, and enzyme inhibitors can affect enzyme activity.

The Control of Metabolism

19. Explain how metabolic pathways are regulated.
20. Explain how the location of enzymes in a cell may help order metabolism.

KEY WORDS:

activation energy
active site
allosteric regulation
anabolic pathway
ATP (adenosine triphosphate)
bioenergetics
catabolic pathway
catalyst
chemical energy
coenzyme
cofactor
competitive inhibitor

cooperativity
endergonic reaction
energy
energy coupling
entropy
enzyme
enzyme-substrate complex
exergonic reaction
feedback inhibition
first law of thermodynamics
free energy
free energy of activation
heat
induced fit
kinetic energy
metabolic pathway
metabolism
non-competitive inhibitor
phosphorylated
potential energy
second law of thermodynamics
substrate
thermal energy
thermodynamics

CHAPTER 9: CELLULAR RESPIRATIONHARVESTING CHEMICAL ENERGY

KEY CONCEPTS:

1. Catabolic pathways yield energy by oxidizing organic fuels.
2. Glycolysis harvests chemical energy by oxidizing glucose to pyruvate.
3. The citric acid cycle completes the energy-yielding oxidation of organic molecules.
4. During oxidative phosphorylation, chemiosmosis couples electron transport to ATP synthesis.
5. Fermentation enables some cells to produce ATP without the use of oxygen.
6. Glycolysis and the citric acid cycle connect to many other metabolic pathways.

OBJECTIVES:

The Principles of Energy Harvest

1. In general terms, distinguish between fermentation and cellular respiration.
2. Write the summary equation for cellular respiration. Write the specific chemical equation for the degradation of glucose.
3. Define oxidation and reduction.
4. Explain in general terms how redox reactions are involved in energy exchanges.
5. Describe the role of NAD+ in cellular respiration.
6. In general terms, explain the role of the electron transport chain in cellular respiration.

The Process of Cellular Respiration

7. Name the three stages of cellular respiration and state the region of the eukaryotic cell where each stage occurs.
8. Describe how the carbon skeleton of glucose changes as it proceeds through glycolysis.
9. Explain why ATP is required for the preparatory steps of glycolysis.
10. Identify where substrate-level phosphorylation and the reduction of NAD+ occur in glycolysis.
11. Describe where pyruvate is oxidized to acetyl CoA, what molecules are produced, and how this process links glycolysis to the citric acid cycle.
12. List the products of the citric acid cycle. Explain why it is called a cycle.
13. Describe the point at which glucose is completely oxidized during cellular respiration.
14. Distinguish between substrate level phosphorylation and oxidative phosphorylation.
15. In general terms, explain how the exergonic “slide” of electrons down the electron transport chain is coupled to the endergonic production of ATP by chemiosmosis.
16. Explain where and how the respiratory electron transport chain creates a proton gradient.
17. Describe the structure and function of the four subunits of ATP synthase.
18. Summarize the net ATP yield from the oxidation of a glucose molecule by constructing an ATP ledger.
19. Explain why it is not possible to state an exact number of ATP molecules generated by the oxidation of glucose.

Related Metabolic Processes

20. State the basic function of fermentation.
21. Compare the fate of pyruvate in alcohol fermentation and lactic acid fermentation.
22. Compare the processes of fermentation and cellular respiration.
23. Describe the evidence that suggests that glycolysis is an ancient metabolic pathway.
24. Describe how food molecules other than glucose can be oxidized to make ATP.
25. Explain how glycolysis and the citric acid cycle can contribute to anabolic pathways.
26. Explain how ATP production is controlled by the cell and describe the role that the allosteric enzyme phosphofructokinase plays in the process.

KEY TERMS:

acetyl CoA
aerobic
alcohol fermentation
anaerobic
ATP synthase
beta oxidation
cellular respiration
chemiosmosis
citric acid cycle
cytochrome
electron transport chain
facultative anaerobe
fermentation
glycolysis
lactic acid fermentation
NAD+
oxidation
oxidative phosphorylation
oxidizing agent
proton-motive force
redox reaction
reducing agent
reduction
substrate-level phosphorylation

CHAPTER 10: PHOTOSYNTHESIS

KEY CONCEPTS:

1. Photosynthesis converts light energy to the chemical energy of food.
2. The light reactions convert solar energy to the chemical energy of ATP and NADPH.
3. The Calvin cycle uses ATP and NADPH to convert CO_2 into sugar.
4. Alternative mechanisms of carbon fixation have evolved in hot, arid climates.

OBJECTIVES:

The Process That Feeds the Biosphere

1. Distinguish between autotrophic and heterotrophic nutrition.
2. Distinguish between photoautotrophs and chemoautotrophs.
3. Describe the structure of a chloroplast, listing all membranes and compartments.

The Pathways of Photosynthesis

4. Write a summary equation for photosynthesis.
5. Explain van Niel's hypothesis and describe how it contributed to our current understanding of photosynthesis. Explain the evidence that supported his hypothesis.
6. In general terms, explain the role of redox reactions in photosynthesis.
7. Describe the two main stages of photosynthesis in general terms.
8. Describe the relationship between an action spectrum and an absorption spectrum. Explain why the action spectrum for photosynthesis differs from the absorption spectrum for chlorophyll a.
9. Explain how carotenoids protect the cell from damage by light.
10. List the wavelengths of light that are most effective for photosynthesis.
11. Explain what happens when a solution of chlorophyll a absorbs photons. Explain what happens when chlorophyll a in an intact chloroplast absorbs photons.
12. List the components of a photosystem and explain the function of each component.
13. Trace the movement of electrons in noncyclic electron flow. Trace the movement of electrons in cyclic electron flow.
14. Explain the functions of cyclic and noncyclic electron flow.
15. Describe the similarities and differences in chemiosmosis between oxidative phosphorylation in mitochondria and photophosphorylation in chloroplasts.
16. State the function of each of the three phases of the Calvin cycle.
17. Describe the role of ATP and NADPH in the Calvin cycle.
18. Describe what happens to rubisco when O2 concentration is much higher than CO2 concentration.
19. Describe the major consequences of photorespiration. Explain why it is thought to be an evolutionary relict.
20. Describe two important photosynthetic adaptations that minimize photorespiration.
21. List the possible fates of photosynthetic products.

KEY TERMS:

absorption spectrum
action spectrum
autotroph
bundle-sheath cell
C3 plant
C4 plant
Calvin cycle
CAM plant
carbon fixation

carotenoid
chlorophyll
chlorophyll a
chlorophyll b
crassulacean acid metabolism (CAM)
cyclic electron flow
electromagnetic spectrum
glyceraldehyde-3-phosphate (G3P)
heterotroph
light reactions
light-harvesting complex
mesophyll
mesophyll cell
NADP+
non-cyclic electron flow
PEP carboxylase
photon
photophosphorylation
photorespiration
photosynthesis
photosystem
photosystem I
photosystem II
primary electron acceptor
reaction center
rubisco
spectrophotometer
stoma
stroma
thylakoid
visible light
wavelength

CHAPTER 12: THE CELL CYCLE

KEY CONCEPTS:

1. Cell division results in genetically identical daughter cells.
2. The mitotic phase alternates with interphase in the cell cycle.
3. The cell cycle is regulated by a molecular control system.

OBJECTIVES:

The Key Roles of Cell Division

1. Explain how cell division functions in reproduction, growth, and repair.
2. Describe the structural organization of a prokaryotic and eukaryotic genome.
3. Describe the major events of cell division that enable the genome of one cell to be passed on to two daughter cells.
4. Describe how the chromosome number changes throughout the human life cycle.

Mechanisms of the Cell Cycle

5. List the phases of the cell cycle and describe the sequence of events that occurs during each phase.
6. List the phases of mitosis and describe the events characteristic of each phase.
7. Recognize the phases of mitosis from diagrams and micrographs.
8. Draw or describe the spindle apparatus, including centrosomes, kinetochore microtubules, nonkinetochore microtubules, asters, and centrioles (in animal cells).
9. Describe what characteristic changes occur in the spindle apparatus during each phase of mitosis.
10. Explain the current models for poleward chromosomal movement and elongation of the cell's polar axis.
11. Compare cytokinesis in animals and plants.
12. Describe the process of binary fission in bacteria and explain how eukaryotic mitosis may have evolved from binary fission.

Regulation of the Cell Cycle

13. Describe the roles of checkpoints, cyclin, Cdk, and MPF in the cell cycle control system.
14. Describe the internal and external factors that influence the cell cycle control system.
15. Explain how the abnormal cell division of cancerous cells escapes normal cell cycle controls.
16. Distinguish between benign, malignant, and metastatic tumors.

KEY TERMS:

anaphase
anchorage dependence
aster
benign tumor
binary fission
cell cycle
cell cycle control system
cell division
cell plate
centromere
centrosome
checkpoint
chromatin
chromosome
cleavage
cleavage furrow
cyclin

cyclin-dependent kinase (Cdk)
cytokinesis
density-dependent inhibition
G0 phase
G1 phase
G2 phase
gamete
genome
growth factor
interphase
kinetochore
M phase
malignant tumor
meiosis
metaphase
metaphase plate
metastasis
mitosis
mitotic (M) phase
mitotic spindle
MPF
origin of replication
prometaphase
prophase
S phase
sister chromatids
somatic cell
telophase
transformation

CHAPTER 13: MEIOSIS AND SEXUAL LIFESTYLES

KEY CONCEPTS:

1. Offspring acquire genes from parents by inheriting chromosomes.
2. Fertilization and meiosis alternate in sexual life cycles.
3. Meiosis reduces the number of chromosome sets from diploid to haploid.
4. Genetic variation produced in sexual life cycles contributes to evolution.

OBJECTIVES:

The Basis of Heredity

1. Explain in general terms how traits are transmitted from parents to offspring.
2. Distinguish between asexual and sexual reproduction.

The Role of Meiosis in Sexual Life Cycles

3. Distinguish between the following pairs of terms:
4. Explain how haploid and diploid cells differ from each other. State which cells in the human body are diploid and which are haploid.
5. Explain why fertilization and meiosis must alternate in all sexual life cycles.
6. Distinguish among the three life-cycle patterns characteristic of eukaryotes, and name one organism that displays each pattern.
7. List the phases of meiosis I and meiosis II and describe the events characteristic of each phase.
8. Recognize the phases of meiosis from diagrams or micrographs.
9. Describe the process of synapsis during prophase I and explain how genetic recombination occurs.
10. Describe three events that occur during meiosis I but not during mitosis.

Origins of Genetic Variation

11. Explain how independent assortment, crossing over, and random fertilization contribute to genetic variation in sexually reproducing organisms.
12. Explain why heritable variation is crucial to Darwin‘s theory of evolution by natural selection.

KEY TERMS:

alternation of generations
asexual reproduction
autosome
chiasma
clone
crossing over
diploid cell
fertilization
gametophyte
gene
genetics
haploid cell
heredity
homologous chromosomes
karyotype
life cycle
locus
meiosis
meiosis I
meiosis II
recombinant chromosome

sex chromosome
sexual reproduction
spore
sporophyte
synapsis
tetrad
variation
zygote

CHAPTER 14: MENDEL AND THE GENE IDEA

KEY CONCEPTS:

1. Mendel used the scientific approach to identify two laws of inheritance.
2. The laws of probability govern Mendelian inheritance
3. Inheritance patterns are often more complex than predicted by Mendelian genetics.
4. Many human traits follow Mendelian patterns of inheritance.

OBJECTIVES:

Gregor Mendel's Discoveries

1. Explain how Mendel's particulate mechanism differed from the blending theory of inheritance.
2. Define the following terms: true-breeding, hybridization, monohybrid cross, P generation, F1 generation, and F2 generation.
3. List and explain the four components of Mendel's hypothesis that led him to deduce the law of segregation.
4. Use a Punnett square to predict the results of a monohybrid cross, stating the phenotypic and genotypic ratios of the F2 generation.
5. Distinguish between the following pairs of terms: dominant and recessive; heterozygous and homozygous; genotype and phenotype.
6. Explain how a testcross can be used to determine if an individual with the dominant phenotype is homozygous or heterozygous.
7. Use a Punnett square to predict the results of a dihybrid cross and state the phenotypic and genotypic ratios of the F2 generation.
8. State Mendel's law of independent assortment and describe how this law can be explained by the behavior of chromosomes during meiosis.
9. Use the rule of multiplication to calculate the probability that a particular F2 individual will be homozygous recessive or dominant.
10. Given a Mendelian cross, use the rule of addition to calculate the probability that a particular F2 individual will be heterozygous.
11. Use the laws of probability to predict, from a trihybrid cross between two individuals that are heterozygous for all three traits, what expected proportion of the offspring would be:
    - homozygous dominant for the three traits
    - heterozygous for all three traits
    - homozygous recessive for two specific traits and heterozygous for the third
12. Explain why it is important that Mendel used large sample sizes in his studies.

Extending Mendelian Genetics

13. Give an example of incomplete dominance and explain why it does not support the blending theory of inheritance.
14. Explain how phenotypic expression of the heterozygote differs with complete dominance, incomplete dominance, and codominance.
15. Explain why Tay-Sachs disease is considered recessive at the organismal level but codominant at the molecular level.
16. Explain why genetic dominance does not mean that a dominant allele subdues a recessive allele. Illustrate your explanation with the use of round versus wrinkled pea seed shape.
17. Explain why dominant alleles are not necessarily more common in a population. Illustrate your explanation with an example.
18. Describe the inheritance of the ABO blood system and explain why the I^A and I^B alleles are said to be codominant.

19. Define and give examples of pleiotropy and epistasis.
20. Describe a simple model for polygenic inheritance and explain why most polygenic characters are described in quantitative terms.
21. Describe how environmental conditions can influence the phenotypic expression of a character. Explain what is meant by “a norm of reaction.”
22. Distinguish between the specific and broad interpretations of the terms phenotype and genotype.

Mendelian Inheritance in Humans

23. Explain why studies of human inheritance are not as easily conducted as Mendel’s work with his peas.
24. Given a simple family pedigree, deduce the genotypes for some of the family members.
25. Explain how a lethal recessive allele can be maintained in a population.
26. Describe the inheritance and expression of cystic fibrosis, Tay-Sachs disease, and sickle-cell disease.
27. Explain why lethal dominant genes are much rarer than lethal recessive genes.
28. Give an example of a late-acting lethal dominant gene in humans and explain how it can escape elimination by natural selection.
29. Define and give examples of multifactorial disorders in humans.
30. Explain how carrier recognition, fetal testing, and newborn screening can be used in genetic screening and counseling.

KEY TERMS:

alleles
amniocentesis
carrier
character
chorionic villus sampling (CVS)
codominance
complete dominance
cystic fibrosis
dihybrid
dominant allele
epistasis
F1 generation
F2 generation
genotype
heterozygous
homozygous
Huntington’s disease
hybridization
incomplete dominance
law of independent assortment
law of segregation
monohybrid
multifactorial
norm of reaction
P generation
pedigree
phenotype
pleiotropy
polygenic inheritance
Punnett square
quantitative character
recessive allele

sickle-cell disease
Tay-Sachs disease
testcross
trait
true-breeding

CHAPTER 15: THE CHROMOSOMAL BASIS OF INHERITANCE

KEY CONCEPTS:

1. Mendelian inheritance has its physical basis in the behavior of chromosomes.
2. Linked genes tend to be inherited together because they are located near each other on the same chromosome.
3. Sex-linked genes exhibit unique patterns of inheritance.
4. Alterations of chromosome number or structure cause some genetic disorders.
5. Some inheritance patterns are exceptions to the standard chromosome theory.

OBJECTIVES:

Relating Mendelian Inheritance to the Behavior of Chromosomes

1. Explain how the observations of cytologists and geneticists provided the basis for the chromosome theory of inheritance.
2. Explain why Drosophila melanogaster is a good experimental organism for genetic studies.
3. Explain why linked genes do not assort independently.
4. Distinguish between parental and recombinant phenotypes.
5. Explain how crossing over can unlink genes.
6. Explain how Sturtevant created linkage maps.
7. Define a map unit.
8. Explain why Mendel did not find linkage between seed color and flower color, despite the fact that these genes are on the same chromosome.
9. Explain how genetic maps are constructed for genes located far apart on a chromosome.
10. Explain the effect of multiple crossovers between loci.
11. Explain what additional information cytogenetic maps provide.

Sex Chromosomes

12. Describe how sex is genetically determined in humans and explain the significance of the SRY gene.
13. Distinguish between linked genes and sex-linked genes.
14. Explain why sex-linked diseases are more common in human males.
15. Describe the inheritance patterns and symptoms of color blindness, Duchenne muscular dystrophy, and hemophilia.
16. Describe the process of X inactivation in female mammals. Explain how this phenomenon produces the tortoiseshell coloration in cats.

KEY TERMS:

aneuploidy
Barr body
chromosome theory of inheritance
crossing over
cytologenetic map
deletion
Down syndrome
Duchenne muscular dystrophy
duplication
genetic map
genetic recombination
genomic imprinting
hemophilia
inversion
linkage map
linked genes

map unit
monosomic
nondisjunction
parental type
polyploidy
recombinant
sex-linked gene
translocation
trisomic
wild type

CHAPTER 16: THE MOLECULAR BASIS OF INHERITANCE

KEY CONCEPTS:

1. DNA is the genetic material.
2. Many proteins work together in DNA replication and repair.

OBJECTIVES:

DNA as the Genetic Material

1. Explain why researchers originally thought protein was the genetic material.

2. Summarize the experiments performed by the following scientists that provided evidence that DNA is the genetic material:

Frederick Griffith

Oswald Avery, Maclyn McCarty, and Colin MacLeod

Alfred Hershey and Martha Chase

Erwin Chargaff

3. Explain how Watson and Crick deduced the structure of DNA and describe the evidence they used. Explain the significance of the research of Rosalind Franklin.

4. Describe the structure of DNA. Explain the base-pairing rule and describe its significance.

DNA Replication and Repair

5. Describe the semiconservative model of replication and the significance of the experiments of Matthew Meselson and Franklin Stahl.

6. Describe the process of DNA replication, including the role of the origins of replication and replication forks.

7. Explain the role of DNA polymerases in replication.

8. Explain what energy source drives the polymerization of DNA.

9. Define antiparallel and explain why continuous synthesis of both DNA strands is not possible.

10. Distinguish between the leading strand and the lagging strand.

11. Explain how the lagging strand is synthesized even though DNA polymerase can add nucleotides only to the 39 end. Describe the significance of Okazaki fragments.

12. Explain the roles of DNA ligase, primer, primase, helicase, topoisomerase, and single-strand binding proteins.

13. Explain why an analogy can be made comparing DNA replication to a locomotive made of DNA polymerase moving along a railroad track of DNA.

14. Explain the roles of DNA polymerase, mismatch repair enzymes, and nuclease in DNA proofreading and repair.

15. Describe the structure and function of telomeres.

16. Explain the possible significance of telomerase in germ cells and cancerous cells.

KEY TERMS:

bacteriophage
DNA ligase
DNA polymerase
double helix
helicase
lagging strand
leading strand
mismatch repair
nuclease
nucleotide excision repair

Okazaki fragment
origin of replication
phage
primase
primer
replication fork
semiconservative model
single-strand binding protein
telomerase
telomere
topoisomerase
transformation

CHAPTER 17: FROM GENE TO PROTEIN

KEY CONCEPTS:

1. Genes specify proteins via transcription and translation.
2. Transcription is the DNA-directed synthesis of RNA: a closer look.
3. Eukaryotic cells modify RNA after transcription.
4. Translation is the RNA-directed synthesis of a polypeptide: a closer look.
5. RNA plays multiple roles in the cell: a review.
6. Comparing gene expression in prokaryotes and eukaryotes reveals key differences.
7. Point mutations can affect protein structure and function.

OBJECTIVES: The Connection Between Genes and Proteins

1. Explain why dwarf peas have shorter stems than tall varieties.
2. Explain the reasoning that led Archibald Garrod to first suggest that genes dictate phenotypes through enzymes.
3. Describe Beadle and Tatum's experiments with Neurospora and explain the contribution they made to our understanding of how genes control metabolism.
4. Distinguish between the "one geneÐone enzyme" hypothesis and the "one geneÐone polypeptide" hypothesis and explain why the original hypothesis was changed.
5. Explain how RNA differs from DNA.
6. Briefly explain how information flows from gene to protein.
7. Distinguish between transcription and translation.
8. Compare where transcription and translation occur in prokaryotes and in eukaryotes.
9. Define codon and explain the relationship between the linear sequence of codons on mRNA and the linear sequence of amino acids in a polypeptide.
10. Explain the early techniques used to identify what amino acids are specified by the triplets UUU, AAA, GGG, and CCC.
11. Explain why polypeptides begin with methionine when they are synthesized.
12. Explain what it means to say that the genetic code is redundant and unambiguous.
13. Explain the significance of the reading frame during translation.
14. Explain the evolutionary significance of a nearly universal genetic code.

The Synthesis and Processing of RNA

15. Explain how RNA polymerase recognizes where transcription should begin. Describe the promoter, the terminator, and the transcription unit.
16. Explain the general process of transcription, including the three major steps of initiation, elongation, and termination.
17. Explain how RNA is modified after transcription in eukaryotic cells.
18. Define and explain the role of ribozyme.
19. Describe the functional and evolutionary significance of introns.

The Synthesis of Protein

20. Describe the structure and functions of tRNA.
21. Explain the significance of wobble.
22. Explain how tRNA is joined to the appropriate amino acid.
23. Describe the structure and functions of ribosomes.

24. Describe the process of translation (including initiation, elongation, and termination) and explain which enzymes, protein factors, and energy sources are needed for each stage.
25. Describe the significance of polyribosomes.
26. Explain what determines the primary structure of a protein and describe how a polypeptide must be modified before it becomes fully functional.
27. Describe what determines whether a ribosome will be free in the cytosol or attached to the rough endoplasmic reticulum.
28. Describe two properties of RNA that allow it to perform so many different functions.
29. Compare protein synthesis in prokaryotes and in eukaryotes.
30. Define point mutations. Distinguish between base-pair substitutions and base-pair insertions. Give examples of each and note the significance of such changes.
31. Describe several examples of mutagens and explain how they cause mutations.
32. Describe the historical evolution of the concept of a gene.

KEY TERMS:

5’ cap
A site
alternative RNA splicing
aminoacyl-tRNA synthetase
anticodon
base-pair substitution
codon
deletion
domain
E site
exon
frameshift mutation
insertion
intron
messenger RNA (mRNA)
missense mutation
mutagen
mutation
nonsense mutation
one gene–one polypeptide hypothesis
P site
point mutation
poly-A tail
polyribosome (polysome)
primary transcript
promoter
reading frame
ribosomal RNA (rRNA)
ribosome
ribozyme
RNA polymerase
RNA processing
RNA splicing
signal peptide
signal-recognition particle (SRP)
spliceosome
TATA box
template strand
terminator

transcription
transcription factor
transcription initiation complex
transcription unit
transfer RNA (tRNA)
translation
triplet code
wobble

CHAPTER 18: THE GENETICS OF VIRUSES AND BACTERIA

KEY CONCEPTS:

1. A virus has a genome but can reproduce only within a host cell.
2. Viruses, viroids and prions are formidable pathogens in animals and plants.
3. Rapid reproduction, mutation, and genetic recombination contribute to the genetic diversity of bacteria.
4. Individual bacteria respond to environmental change by regulating their gene expression.

OBJECTIVES: The Genetics of Viruses

1. Recount the history leading up to the discovery of viruses. Include the contributions of Adolf Mayer, Dimitri Ivanowsky, Martinus Beijerinck, and Wendell Stanley.
2. List and describe the structural components of viruses.
3. Explain why viruses are obligate intracellular parasites.
4. Explain how a virus identifies its host cell.
5. Describe bacterial defenses against phages.
6. Distinguish between the lytic and lysogenic reproductive cycles, using phage lambda as an example.
7. Describe the reproductive cycle of an enveloped virus. Explain the reproductive cycle of the herpesvirus.
8. Describe the reproductive cycle of retroviruses.
9. List some characteristics that viruses share with living organisms and explain why viruses do not fit our usual definition of life.
10. Describe the evidence that viruses probably evolved from fragments of cellular nucleic acids.
11. Define and describe mobile genetic elements.
12. Explain how viral infections in animals cause disease.
13. Describe the best current medical defenses against viruses. Explain how AZT helps to fight HIV infections.
14. Describe the mechanisms by which new viral diseases emerge.
15. Distinguish between the horizontal and vertical routes of viral transmission in plants.
16. Describe viroids and prions.
17. Explain how a non-replicating protein can act as a transmissible pathogen.

The Genetics of Bacteria

18. Describe the structure of a bacterial chromosome.
19. Compare the sources of genetic variation in bacteria and humans.
20. Compare the processes of transformation, transduction, and conjugation.
21. Distinguish between generalized and specialized transduction.
22. Define an episome. Explain why a plasmid can be an episome.
23. Explain how the F plasmid controls conjugation in bacteria.
24. Describe the significance of R plasmids. Explain how the widespread use of antibiotics contributes to R plasmid-related disease.
25. Explain how transposable elements may cause recombination of bacterial DNA.
26. Distinguish between an insertion sequence and a transposon.
27. Describe the role of transposase in the process of transposition.
28. Briefly describe two main strategies that cells use to control metabolism.
29. Explain the adaptive advantage of genes grouped into an operon.

30. Using the trp operon as an example, explain the concept of an operon and the function of the operator, repressor, and corepressor.

31. Distinguish between structural and regulatory genes.

32. Describe how the lac operon functions and explain the role of the inducer, allolactose.

33. Explain how repressible and inducible enzymes differ and how those differences reflect differences in the pathways they control.

34. Distinguish between positive and negative control and give examples of each from the lac operon.

35. Explain how cyclic AMP and catabolite activator protein are affected by glucose concentration.

KEY TERMS:

activator
AIDS (acquired immunodeficiency syndrome)
bacteriophage
capsid
conjugation
corepressor
cyclic AMP (cAMP)
episome
F factor
F plasmid
HIV (human immunodeficiency virus)
host range
inducer
insertion sequence
lysogenic cycle
lytic cycle
nucleoid
operator
operon
phage
plasmid
prion
prophage
provirus
R plasmid
regulatory gene
repressor
retrovirus
reverse transcriptase
temperate phage
transduction
transformation
transposable genetic element
transposon
vaccine
viral envelope
viroid
virulent phage