Biology Study Guide Template

Course Information

- **Subject**: Biology
- **Grade Level**: High School / College Introductory
- **Academic Year**: 2025
- **Last Updated**: January 2025

Table of Contents

Cell Biology

Cell Structure and Function

Prokaryotic vs Eukaryotic Cells

- **Prokaryotic cells**: No membrane-bound nucleus or organelles
    - Examples: Bacteria, Archaea
    - DNA freely floating in cytoplasm
    - Ribosomes present but smaller (70S)
- **Eukaryotic cells**: Membrane-bound nucleus and organelles
    - Examples: Plants, animals, fungi, protists
    - DNA enclosed in nucleus
    - Larger ribosomes (80S)

Major Cell Organelles

Nucleus

- Control center of the cell
- Contains DNA and nucleolus
- Surrounded by nuclear envelope with pores

Mitochondria

- Powerhouse of the cell
- Site of cellular respiration
- Has its own DNA (maternal inheritance)
- Double membrane structure

Endoplasmic Reticulum (ER)

- Rough ER: Has ribosomes, protein synthesis
- Smooth ER: No ribosomes, lipid synthesis, detoxification

Golgi Apparatus

- Modifies, packages, and ships proteins
- Consists of flattened sacs called cisternae

Ribosomes

- Protein synthesis
- Free ribosomes or attached to ER

Cell Membrane Structure

- **Phospholipid bilayer**
- **Fluid mosaic model**
- **Membrane proteins**: Integral and peripheral
- **Cholesterol**: Maintains membrane fluidity

Transport Across Membranes

Passive Transport

- **Diffusion**: Movement from high to low concentration
- **Osmosis**: Water movement across semi-permeable membrane
- **Facilitated diffusion**: Uses protein channels

Active Transport

- **Primary active transport**: Uses ATP directly
- **Secondary active transport**: Uses electrochemical gradient
- **Endocytosis**: Cell engulfs materials

- **Exocytosis**: Cell expels materials

Genetics

DNA Structure and Function

DNA Composition

- **Nucleotides**: Phosphate, sugar (deoxyribose), nitrogenous base
- **Bases**: Adenine (A), Thymine (T), Guanine (G), Cytosine (C)
- **Base pairing**: A-T, G-C
- **Double helix structure**

DNA Replication

1. **Initiation**: DNA helicase unwinds double helix
2. **Elongation**: DNA polymerase adds nucleotides
3. **Termination**: Formation of two identical DNA molecules

- **Semi-conservative replication**
- **Leading and lagging strands**
- **Okazaki fragments**

Gene Expression

Transcription

- **Location**: Nucleus (eukaryotes), cytoplasm (prokaryotes)
- **Enzyme**: RNA polymerase
- **Product**: mRNA, tRNA, rRNA
- **Steps**: Initiation, elongation, termination

Translation

- **Location**: Ribosomes
- **Process**: mRNA → protein
- **Genetic code**: Triplet codons
- **Steps**: Initiation, elongation, termination

Mendelian Genetics

Basic Principles

- **Law of segregation**: Alleles separate during gamete formation
- **Law of independent assortment**: Genes on different chromosomes assort independently

- **Dominance**: Complete, incomplete, codominance

Inheritance Patterns

- **Autosomal dominant**
- **Autosomal recessive**
- **X-linked inheritance**
- **Multiple alleles**
- **Polygenic inheritance**

Evolution

Mechanisms of Evolution

Natural Selection

- **Variation**: Individuals differ in traits
- **Inheritance**: Traits are heritable
- **Selection**: Differential survival and reproduction
- **Time**: Changes accumulate over generations

Types of Selection

- **Directional selection**: Favors one extreme
- **Stabilizing selection**: Favors average traits
- **Disruptive selection**: Favors extremes over average

Other Evolutionary Forces

- **Genetic drift**: Random changes in allele frequencies
- **Gene flow**: Movement of alleles between populations
- **Mutation**: Source of new genetic variation
- **Non-random mating**: Affects genotype frequencies

Evidence for Evolution

- **Fossil record**: Transitional forms, time progression
- **Comparative anatomy**: Homologous structures
- **Molecular evidence**: DNA/protein similarities
- **Biogeography**: Species distribution patterns
- **Direct observation**: Bacterial resistance, industrial melanism

Speciation

- **Allopatric speciation**: Geographic isolation
- **Sympatric speciation**: No geographic isolation
- **Adaptive radiation**: Rapid diversification
- **Convergent evolution**: Similar traits in unrelated species

---

Ecology

Levels of Organization

1. **Individual**: Single organism
2. **Population**: Same species in same area
3. **Community**: All species in same area
4. **Ecosystem**: Community + abiotic factors
5. **Biosphere**: All ecosystems on Earth

Population Ecology

Population Growth

- **Exponential growth**: Unlimited resources
- **Logistic growth**: Limited by carrying capacity
- **r-selected species**: High reproductive rate, unstable environment
- **K-selected species**: Low reproductive rate, stable environment

Population Regulation

- **Density-dependent factors**: Competition, predation, disease
- **Density-independent factors**: Natural disasters, climate

Community Interactions

- **Competition**: (-/-)
- **Predation**: (+/-)
- **Mutualism**: (+/+)
- **Commensalism**: (+/0)
- **Parasitism**: (+/-)

Energy Flow and Nutrient Cycling

Energy Flow

- **Primary producers**: Photosynthesis, chemosynthesis
- **Primary consumers**: Herbivores
- **Secondary consumers**: Carnivores

- **Decomposers**: Bacteria, fungi
- **Energy pyramid**: 10% rule

Biogeochemical Cycles

- **Carbon cycle**: Photosynthesis, respiration, combustion
- **Nitrogen cycle**: Fixation, nitrification, denitrification
- **Phosphorus cycle**: No atmospheric component
- **Water cycle**: Evaporation, transpiration, precipitation

Human Biology

Body Systems Overview

Circulatory System

- **Heart**: Four chambers, double circulation
- **Blood vessels**: Arteries, veins, capillaries
- **Blood**: Red cells, white cells, platelets, plasma
- **Functions**: Transport oxygen, nutrients, waste

Respiratory System

- **Structure**: Nose, trachea, bronchi, lungs, alveoli
- **Gas exchange**: Oxygen in, carbon dioxide out
- **Breathing**: Diaphragm and intercostal muscles
- **Regulation**: Medulla oblongata responds to CO_2 levels

Digestive System

- **Mechanical digestion**: Chewing, churning
- **Chemical digestion**: Enzymes break down food
- **Absorption**: Small intestine
- **Elimination**: Large intestine

Nervous System

- **Central nervous system**: Brain and spinal cord
- **Peripheral nervous system**: All other nerves
- **Neurons**: Cell body, dendrites, axon
- **Synapse**: Gap between neurons

Endocrine System

- **Hormones**: Chemical messengers

- **Major glands**: Pituitary, thyroid, adrenals, pancreas
- **Feedback mechanisms**: Positive and negative feedback

Homeostasis

- **Definition**: Maintaining internal balance
- **Examples**: Temperature, blood sugar, pH
- **Mechanisms**: Negative feedback loops

Plant Biology

Plant Structure

Roots

- **Functions**: Absorption, anchorage, storage
- **Types**: Taproot, fibrous root
- **Zones**: Meristematic, elongation, maturation

Stems

- **Functions**: Support, transport, storage
- **Structure**: Nodes, internodes, buds
- **Growth**: Primary (length) and secondary (width)

Leaves

- **Functions**: Photosynthesis, gas exchange
- **Structure**: Blade, petiole, veins
- **Tissues**: Epidermis, mesophyll, vascular bundles

Plant Physiology

Photosynthesis

- **Overall equation**: $6CO_2 + 6H_2O + \text{light} \rightarrow C_6H_{12}O_6 + 6O_2$
- **Light reactions**: Occur in thylakoids, produce ATP and NADPH
- **Calvin cycle**: Occurs in stroma, fixes carbon into glucose

Plant Transport

- **Water transport**: Xylem, transpiration-cohesion theory
- **Sugar transport**: Phloem, pressure-flow hypothesis
- **Transpiration**: Water loss through stomata

Plant Hormones

- **Auxins**: Cell elongation, apical dominance
- **Gibberellins**: Stem elongation, seed germination
- **Cytokinins**: Cell division, delay senescence
- **Abscisic acid**: Stress response, stomatal closure
- **Ethylene**: Fruit ripening, leaf abscission

Molecular Biology

Enzymes

Enzyme Structure and Function

- **Active site**: Specific binding region
- **Substrate**: Molecule enzyme acts upon
- **Product**: Result of enzymatic reaction
- **Induced fit model**: Enzyme changes shape upon binding

Factors Affecting Enzyme Activity

- **Temperature**: Higher temperature increases rate until denaturation
- **pH**: Each enzyme has optimal pH range
- **Concentration**: More enzyme or substrate increases rate
- **Inhibitors**: Competitive and non-competitive

Cellular Respiration

Overview

- **Purpose**: Extract energy from glucose
- **Location**: Cytoplasm and mitochondria
- **Net result**: 36-38 ATP molecules per glucose

Stages

1. **Glycolysis**: Glucose → 2 pyruvate (cytoplasm)
2. **Krebs cycle**: Pyruvate breakdown (mitochondrial matrix)
3. **Electron transport**: ATP synthesis (inner mitochondrial membrane)

Fermentation

- **Lactic acid fermentation**: Muscle cells during exercise
- **Alcoholic fermentation**: Yeast, brewing, baking

Key Terms and Definitions

Allele: Alternative form of a gene

ATP (Adenosine Triphosphate): Universal energy currency of cells

Biodiversity: Variety of life in ecosystems

Chromosome: Structure containing DNA and proteins

Ecosystem: Community of organisms and their environment

Gene: Unit of heredity coding for a trait

Homeostasis: Maintenance of stable internal conditions

Mitosis: Cell division producing identical diploid cells

Meiosis: Cell division producing genetically diverse gametes

Osmosis: Movement of water across semi-permeable membranes

Phenotype: Observable characteristics of an organism

Photosynthesis: Process converting light energy to chemical energy

Protein: Large molecule made of amino acids

RNA (Ribonucleic Acid): Nucleic acid involved in protein synthesis

Species: Group of organisms that can interbreed

Stimulus: Change in environment that causes response

Taxonomy: Classification of living organisms

Trait: Characteristic of an organism

Variation: Differences among individuals in a population

Zygote: Fertilized egg cell

Study Tips

Effective Study Strategies

1. **Active reading**: Take notes, ask questions

2. **Concept mapping**: Connect related ideas
3. **Practice problems**: Apply knowledge
4. **Group study**: Discuss concepts with peers
5. **Regular review**: Spaced repetition

Exam Preparation

- **Understand, don't memorize**: Focus on concepts
- **Use multiple resources**: Textbook, notes, online materials
- **Practice past exams**: Familiarize with question format
- **Manage time**: Don't spend too long on difficult questions
- **Stay calm**: Deep breathing, positive mindset

Laboratory Skills

- **Safety first**: Know safety procedures
- **Accurate measurements**: Use proper tools
- **Record observations**: Detailed lab notebook
- **Data analysis**: Graphs, calculations, conclusions
- **Error analysis**: Identify sources of uncertainty

Additional Resources

Recommended Reading

- Campbell Biology (Textbook)
- Khan Academy Biology
- Crash Course Biology (YouTube)
- Nature Education

Online Tools

- PhET Simulations
- BioInteractive (HHMI)
- Molecular Workbench
- Virtual Labs

Study Apps

- Anki (Flashcards)
- Quizlet
- Forest (Focus timer)
- Notion (Note organization)

This study guide provides a comprehensive overview of key biology concepts. Use it as a foundation for deeper study and always refer to your course materials and instructor for specific requirements.