MCAT Study Guide

Test Breakdown:

- **Section 1: Biological and Biochemical Foundations of Living Systems** ........................................... pg. 3 – 22
  - Foundational Concept 1 - Biomolecules have unique properties that determine how they contribute to the structure and function of cells and how they participate in the processes necessary to maintain life.
  - Foundational Concept 2 - Highly-organized assemblies of molecules, cells, and organs interact to carry out the functions of living organisms.
  - Foundational Concept 3 - Complex systems of tissues and organs sense the internal and external environments of multicellular organisms, and through integrated functioning, maintain a stable internal environment within an ever-changing external environment.

- **Section 2: Chemical and Physical Foundations of Biological Systems** ............................................. pg. 23 – 40
  - Foundational Concept 4 - Complex living organisms transport materials, sense their environment, process signals, and respond to changes using processes understood in terms of physical principles.
  - Foundational Concept 5 - The principles that govern chemical interactions and reactions form the basis for a broader understanding of the molecular dynamics of living systems.

- **Section 3: Psychological, Social, and Biological Foundations of Behavior** ........................................ pg. 41 – 57
  - Foundational Concept 6 - Biological, psychological, and sociocultural factors influence the ways that individuals perceive, think about, and react to the world.
  - Foundational Concept 7 - Biological, psychological, and sociocultural factors influence behavior and behavior change.
  - Foundational Concept 8 - Psychological, sociocultural, and biological factors influence the way we think about ourselves and others, as well as how we interact with others.
  - Foundational Concept 9 - Cultural and social differences influence well-being.
  - Foundational Concept 10 - Social stratification and access to resources influence well-being.

- **Section 4: Critical Analysis and Reasoning Skills** ............................................................................. pg. 58
Section 1: Biological and Biochemical Foundations of Living Systems

<table>
<thead>
<tr>
<th># of questions</th>
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<tr>
<td>59 (passage-based and discrete questions)</td>
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Discipline:
- 25% First-semester biochemistry
- 65% Introductory biology
- 5% General chemistry
- 5% Organic chemistry

Foundational Concepts:
- 55% Foundational Concept 1 - Biomolecules have unique properties that determine how they contribute to the structure and function of cells and how they participate in the processes necessary to maintain life.
- 20% Foundational Concept 2 - Highly-organized assemblies of molecules, cells, and organs interact to carry out the functions of living organisms
- 25% Foundational Concept 3 - Complex systems of tissues and organs sense the internal and external environments of multicellular organisms, and through integrated functioning, maintain a stable internal environment within an ever-changing external environment

Scientific Inquiry and Reasoning Skill:
- 35% Skill 1 - Knowledge of Scientific Concepts and Principles
  - Demonstrating understanding of scientific concepts and principles
  - Identifying the relationships between closely-related concepts
- 45% Skill 2 - Scientific Reasoning and Problem Solving
  - Reasoning about scientific principles, theories, and models
  - Analyzing and evaluating scientific explanations and predictions
- 10% Skill 3 - Reasoning about the Design and Execution of Research
  - Demonstrating understanding of important components of scientific research
  - Reasoning about ethical issues in research
- 10% Skill 4 - Data-Based and Statistical Reasoning
  - Interpreting patterns in data presented in tables, figures, and graphs
  - Reasoning about data and drawing conclusions from them

# of questions: 59
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Section 1: Biological and Biochemical Foundations of Living Systems

Foundational Concepts

Foundational Concept 1 (55%): Biomolecules have unique properties that determine how they contribute to the structure and function of cells and how they participate in the processes necessary to maintain life.

Foundational Concept 1 includes:

- Content Category 1A: Structure and function of proteins and their constituent amino acids
- Content Category 1B: Transmission of genetic information from the gene to the protein
- Content Category 1C: Transmission of heritable information from generation to generation and the processes that increase genetic diversity
- Content Category 1D: Principles of bioenergetics and fuel molecule metabolism

Content Category 1A: Structure and function of proteins and their constituent amino acids

This section requires knowledge of:

Amino Acids (BC, OC)

- Description
  - Absolute configuration at the α position
  - Amino acids as dipolar ions
  - Classifications
    - Acidic or basic
    - Hydrophobic or hydrophilic
  - Reactions
    - Sulfur linkage for cysteine and cystine
    - Peptide linkage: polypeptides and proteins
    - Hydrolysis

Protein Structure (BIO, BC, OC)

- Structure
  - 1° structure of proteins
  - 2° structure of proteins
  - 3° structure of proteins; role of proline, cystine, hydrophobic bonding
  - 4° structure of proteins (BIO, BC)
- Conformational stability
  - Denaturing and folding
  - Hydrophobic interactions
  - Solvation layer (entropy) (BC)
- Separation techniques
  - Isoelectric point
  - Electrophoresis
Non-Enzymatic Protein Function (BIO, BC)
- Binding (BC)
- Immune system
- Motors

Enzyme Structure and Function (BIO, BC)
- Function of enzymes in catalyzing biological reactions
- Enzyme classification by reaction type
- Reduction of activation energy
- Substrates and enzyme specificity
- Active Site Model
- Induced-fit Model
- Mechanism of catalysis
  - Cofactors
  - Coenzymes
  - Water-soluble vitamins
- Effects of local conditions on enzyme activity

Control of Enzyme Activity (BIO, BC)
- Kinetics
  - General (catalysis)
  - Michaelis–Menten
  - Cooperativity
- Feedback regulation
- Inhibition – types
  - Competitive
  - Non-competitive
  - Mixed (BC)
  - Uncompetitive (BC)
- Regulatory enzymes
  - Allosteric enzymes
  - Covalently-modified enzymes
  - Zymogen
Content Category 1B: Transmission of genetic information from the gene to the protein

This section requires knowledge of:

Nucleic Acid Structure and Function (BIO, BC)
- Description
- Nucleotides and nucleosides
  - Sugar phosphate backbone
  - Pyrimidine, purine residues
- Deoxyribonucleic acid (DNA): double helix, Watson–Crick model of DNA structure
- Base pairing specificity: A with T, G with C
- Function in transmission of genetic information (BIO)
- DNA denaturation, reannealing, hybridization

DNA Replication (BIO)
- Mechanism of replication: separation of strands, specific coupling of free nucleic acids
- Semi-conservative nature of replication
- Specific enzymes involved in replication
- Origins of replication, multiple origins in eukaryotes
- Replicating the ends of DNA molecules

Repair of DNA (BIO)
- Repair during replication
- Repair of mutations

Genetic Code (BIO)
- Central Dogma: DNA to RNA to protein
- The triplet code
- Codon–anticodon relationship
- Degenerate code, wobble pairing
- Missense, nonsense codons
- Initiation, termination codons
- Messenger RNA (mRNA)

Transcription (BIO)
- Transfer RNA (tRNA); ribosomal RNA (rRNA)
- Mechanism of transcription mRNA processing in eukaryotes, introns, exons
- Ribozymes, spliceosomes, small nuclear ribonucleoproteins (snRNPs), small nuclear RNAs (snRNAs)
- Functional and evolutionary importance of introns

Translation (BIO)
- Roles of mRNA, tRNA, rRNA
- Role and structure of ribosomes
- Initiation, termination co-factors
- Post-translational modification of proteins
Eukaryotic Chromosome Organization (BIO)
- Chromosomal proteins
- Single copy vs. repetitive DNA
- Supercoiling
- Heterochromatin vs. euchromatin
- Telomeres, centromeres

Control of Gene Expression in Prokaryotes (BIO)
- Operon Concept, Jacob–Monod Model
- Gene repression in bacteria
- Positive control in bacteria

Control of Gene Expression in Eukaryotes (BIO)
- Transcriptional regulation
- DNA binding proteins, transcription factors
- Gene amplification and duplication
- Post-transcriptional control, basic concept of splicing (introns, exons)
- Cancer as a failure of normal cellular controls, oncogenes, tumor suppressor genes
- Regulation of chromatin structure
- DNA methylation
- Role of non-coding RNAs

Recombinant DNA and Biotechnology (BIO)
- Gene cloning
- Restriction enzymes
- DNA libraries
- Generation of cDNA
- Hybridization
- Expressing cloned genes
- Polymerase chain reaction
- Gel electrophoresis and Southern blotting
- DNA sequencing
- Analyzing gene expression
- Determining gene function
- Stem cells
- Practical applications of DNA technology: medical applications, human gene therapy, pharmaceuticals, forensic evidence, environmental cleanup, agriculture
- Safety and ethics of DNA technology
Content Category 1C: Transmission of heritable information from generation to generation and the processes that increase genetic diversity

This section requires knowledge of:

Evidence that DNA is Genetic Material (BIO)

Mendelian Concepts (BIO)
- Phenotype and genotype
- Gene
- Locus
- Allele: single and multiple
- Homozygosity and heterozygosity
- Wild-type
- Recessiveness
- Complete dominance
- Co-dominance
- Incomplete dominance, leakage, penetrance, expressivity
- Hybridization: viability
- Gene pool

Meiosis and Other Factors Affecting Genetic Variability (BIO)
- Significance of meiosis
- Important differences between meiosis and mitosis
- Segregation of genes
  - Independent assortment
  - Linkage
  - Recombination
    - Single crossovers
    - Double crossovers
    - Synaptonemal complex
    - Tetrad
  - Sex-linked characteristics
  - Very few genes on Y chromosome
  - Sex determination
  - Cytoplasmic/extranuclear inheritance
- Mutation
  - General concept of mutation — error in DNA sequence
  - Types of mutations: random, translation error, transcription error, base substitution, inversion, addition, deletion, translocation, mispairing
  - Advantageous vs. deleterious mutation
  - Inborn errors of metabolism
  - Relationship of mutagens to carcinogens
- Genetic drift
- Synapsis or crossing-over mechanism for increasing genetic diversity
Analytic Methods (BIO)
- Hardy–Weinberg Principle
- Testcross (Backcross; concepts of parental, F1, and F2 generations)
- Gene mapping: crossover frequencies
- Biometry: statistical methods

Evolution (BIO)
- Natural selection
  - Fitness concept
  - Selection by differential reproduction
  - Concepts of natural and group selection
  - Evolutionary success as increase in percent representation in the gene pool of the next generation
- Speciation
  - Polymorphism
  - Adaptation and specialization
  - Inbreeding
  - Outbreeding
  - Bottlenecks
- Evolutionary time as measured by gradual random changes in genome
Content Category 1D: Principles of bioenergetics and fuel molecule metabolism

This section requires knowledge of:

Principles of Bioenergetics (BC, GC)
- Bioenergetics/thermodynamics
  - Free energy
    - Equilibrium constant
    - Relationship of the equilibrium constant and delta G
  - Concentration
    - Le Châtelier’s Principle
  - Endothermic/exothermic reactions
  - Free energy: G
  - Spontaneous reactions
- Phosphoryl group transfers and ATP
  - ATP hydrolysis delta G << 0
  - ATP group transfers
- Biological oxidation-reduction
  - Half-reactions
  - Soluble electron carriers
  - Flavoproteins

Carbohydrates (BC, OC)
- Description
  - Nomenclature and classification, common names
  - Absolute configuration
  - Cyclic structure and conformations of hexoses
  - Epimers and anomers
  - Hydrolysis of the glycoside linkage
- Monosaccharides
- Disaccharides
- Polysaccharides

Glycolysis, Gluconeogenesis, and the Pentose Phosphate Pathway (BIO, BC)
- Glycolysis (aerobic), substrates and products
  - Feeder pathways: glycogen, starch metabolism
- Fermentation (anaerobic glycolysis)
- Gluconeogenesis (BC)
- Pentose phosphate pathway (BC)
- Net molecular and energetic results of respiration processes

Principles of Metabolic Regulation (BC)
- Regulation of metabolic pathways (BIO, BC)
  - Maintenance of a dynamic steady state
- Regulation of glycolysis and gluconeogenesis
- Metabolism of glycogen
- Regulation of glycogen synthesis and breakdown
  - Allosteric and hormonal control
- Analysis of metabolic control
Citric Acid Cycle (BIO, BC)
- Acetyl-CoA production (BC)
- Reactions of the cycle, substrates and products
- Regulation of the cycle
- Net molecular and energetic results of respiration processes

Metabolism of Fatty Acids and Proteins (BIO, BC)
- Description of fatty acids (BC)
- Digestion, mobilization, and transport of fats
- Oxidation of fatty acids
  - Saturated fats
  - Unsaturated fats
- Ketone bodies (BC)
- Anabolism of fats (BIO)
- Non-template synthesis: biosynthesis of lipids and polysaccharides (BIO)
- Metabolism of proteins (BIO)

Oxidative Phosphorylation (BIO, BC)
- Electron transport chain and oxidative phosphorylation, substrates and products, general features of the pathway
- Electron transfer in mitochondria
  - NADH, NADPH
  - Flavoproteins
  - Cytochromes
- ATP synthase, chemiosmotic coupling
  - Proton motive force
- Net molecular and energetic results of respiration processes
- Regulation of oxidative phosphorylation
- Mitochondria, apoptosis, oxidative stress (BC)

Hormonal Regulation and Integration of Metabolism (BC)
- Higher level integration of hormone structure and function
- Tissue specific metabolism
- Hormonal regulation of fuel metabolism
- Obesity and regulation of body mass
Foundational Concept 2 (20%): Highly-organized assemblies of molecules, cells, and organs interact to carry out the functions of living organisms.

Foundational Concept 2 includes:

- Content Category 2A: focuses on the assemblies of molecules, cells, and groups of cells within single cellular and multicellular organisms that function to execute the processes necessary to maintain life.
- Content Category 2B: focuses on the structure, growth, physiology, and genetics of prokaryotes, and the structure and life cycles of viruses.
- Content Category 2C: focuses on the processes of cell and nuclear division, and the mechanisms governing cell differentiation and specialization.

Content Category 2A: focuses on the assemblies of molecules, cells, and groups of cells within single cellular and multicellular organisms that function to execute the processes necessary to maintain life.

This section requires knowledge of:

**Plasma Membrane (BIO, BC)**

- General function in cell containment
- Composition of membranes
  - Lipid components (BIO, BC, OC)
    - Phospholipids (and phosphatids)
    - Steroids
    - Waxes
  - Protein components
  - Fluid mosaic model
- Membrane dynamics
- Solute transport across membranes
  - Thermodynamic considerations
  - Osmosis
    - Colligative properties; osmotic pressure (GC)
  - Passive transport
  - Active transport
    - Sodium/potassium pump
- Membrane channels
- Membrane potential
- Membrane receptors
- Exocytosis and endocytosis
- Intercellular junctions (BIO)
  - Gap junctions
  - Tight junctions
  - Desmosomes
Membrane-Bound Organelles and Defining Characteristics of Eukaryotic Cells (BIO)

- Defining characteristics of eukaryotic cells: membrane bound nucleus, presence of organelles, mitotic division
- Nucleus
  - Compartmentalization, storage of genetic information
  - Nucleolus: location and function
  - Nuclear envelope, nuclear pores
- Mitochondria
  - Site of ATP production
  - Inner and outer membrane structure (BIO, BC)
  - Self-replication
- Lysosomes: membrane-bound vesicles containing hydrolytic enzymes
- Endoplasmic reticulum
  - Rough and smooth components
  - Rough endoplasmic reticulum site of ribosomes
  - Double membrane structure
  - Role in membrane biosynthesis
  - Role in biosynthesis of secreted proteins
- Golgi apparatus: general structure and role in packaging and secretion
- Peroxisomes: organelles that collect peroxides

Cytoskeleton (BIO)

- General function in cell support and movement
- Microfilaments: composition and role in cleavage and contractility
- Microtubules: composition and role in support and transport
- Intermediate filaments, role in support
- Composition and function of cilia and flagella
- Centrioles, microtubule organizing centers

Tissues Formed From Eukaryotic Cells (BIO)

- Epithelial cells
- Connective tissue cells
Content Category 2B: focuses on the structure, growth, physiology, and genetics of prokaryotes, and the structure and life cycles of viruses.

This section requires knowledge of:

Cell Theory (BIO)
- History and development
- Impact on biology

Classification and Structure of Prokaryotic Cells (BIO)
- Prokaryotic domains
  - Archaea
  - Bacteria
- Major classifications of bacteria by shape
  - Bacilli (rod-shaped)
  - Spirilli (spiral-shaped)
  - Cocci (spherical)
- Lack of nuclear membrane and mitotic apparatus
- Lack of typical eukaryotic organelles
- Presence of cell wall in bacteria
- Flagellar propulsion, mechanism

Growth and Physiology of Prokaryotic Cells (BIO)
- Reproduction by fission
- High degree of genetic adaptability, acquisition of antibiotic resistance
- Exponential growth
- Existence of anaerobic and aerobic variants
- Parasitic and symbiotic
- Chemotaxis

Genetics of Prokaryotic Cells (BIO)
- Existence of plasmids, extragenomic DNA
- Transformation: incorporation into bacterial genome of DNA fragments from external medium
- Conjugation
- Transposons (also present in eukaryotic cells)

Virus Structure (BIO)
- General structural characteristics (nucleic acid and protein, enveloped and nonenveloped)
- Lack organelles and nucleus
- Structural aspects of typical bacteriophage
- Genomic content — RNA or DNA
- Size relative to bacteria and eukaryotic cells

Viral Life Cycle (BIO)
- Self-replicating biological units that must reproduce within specific host cell
- Generalized phage and animal virus life cycles
  - Attachment to host, penetration of cell membrane or cell wall, and entry of viral genetic material
  - Use of host synthetic mechanism to replicate viral components
  - Self-assembly and release of new viral particles
- Transduction: transfer of genetic material by viruses
- Retrovirus life cycle: integration into host DNA, reverse transcriptase, HIV
- Prions and viroids: subviral particles
Content Category 2C: focuses on the processes of cell and nuclear division, and the mechanisms governing cell differentiation and specialization.

This section requires knowledge of:

Mitosis (BIO)
- Mitotic process: prophase, metaphase, anaphase, telophase, interphase
- Mitotic structures
  - Centrioles, asters, spindles
  - Chromatids, centromeres, kinetochores
  - Nuclear membrane breakdown and reorganization
- Phases of cell cycle: G0, G1, S, G2, M
- Growth arrest
- Control of cell cycle
- Loss of cell cycle controls in cancer cells

Biosignalling (BC)
- Oncogenes, apoptosis

Reproductive System (BIO)
- Gametogenesis by meiosis
- Ovum and sperm
  - Differences in formation
  - Differences in morphology
  - Relative contribution to next generation
- Reproductive sequence: fertilization; implantation; development; birth

Embryogenesis (BIO)
- Stages of early development (order and general features of each)
  - Fertilization
  - Cleavage
  - Blastula formation
  - Gastrulation
    - First cell movements
    - Formation of primary germ layers (endoderm, mesoderm, ectoderm)
  - Neurulation
- Major structures arising out of primary germ layers
- Neural crest
- Environment–gene interaction in development

Mechanisms of Development (BIO)
- Cell specialization
  - Determination
  - Differentiation
  - Tissue types
- Cell–cell communication in development
- Cell migration
- Pluripotency: stem cells
- Gene regulation in development
- Programmed cell death
- Existence of regenerative capacity in various species
- Senescence and aging
Foundational Concept 3 (25%): Complex systems of tissues and organs sense the internal and external environments of multicellular organisms, and through integrated functioning, maintain a stable internal environment within an ever-changing external environment.

Foundational Concept 3 includes:

- Content Category 3A: focuses on the structure and functions of the nervous and endocrine systems, and the ways in which the systems work together to coordinate the responses of other body systems to both external and internal stimuli.
- Content Category 3B: focuses on the structure and functions of the organ systems — circulatory, respiratory, digestive, immune, lymphatic, muscular, skeletal, and reproductive — and the ways these systems interact to fulfill their concerted roles in the maintenance and continuance of the living organism.

Content Category 3A: focuses on the structure and functions of the nervous and endocrine systems, and the ways in which the systems work together to coordinate the responses of other body systems to both external and internal stimuli.

This section requires knowledge of:

Nervous System: Structure and Function (BIO)

- Major Functions
  - High level control and integration of body systems
  - Adaptive capability to external influences
- Organization of vertebrate nervous system
- Sensor and effector neurons
- Sympathetic and parasympathetic nervous systems: antagonistic control
- Reflexes
  - Feedback loop, reflex arc
  - Role of spinal cord and supraspinal circuits
- Integration with endocrine system: feedback control

Nerve Cell (BIO)

- Cell body: site of nucleus, organelles
- Dendrites: branched extensions of cell body
- Axon: structure and function
- Myelin sheath, Schwann cells, insulation of axon
- Nodes of Ranvier: propagation of nerve impulse along axon
- Synapse: site of impulse propagation between cells
- Synaptic activity: transmitter molecules
- Resting potential: electrochemical gradient
- Action potential
  - Threshold, all-or-none
  - Sodium/potassium pump
- Excitatory and inhibitory nerve fibers: summation, frequency of firing
- Glial cells, neuroglia

Electrochemistry (GC)

- Concentration cell: direction of electron flow, Nernst equation
Biosignalling (BC)
- Gated ion channels
  - Voltage gated
  - Ligand gated
- Receptor enzymes
- G protein-coupled receptors

Lipids (BC, OC)
- Description; structure
  - Steroids
  - Terpenes and terpenoids

Endocrine System: Hormones and Their Sources (BIO)
- Function of endocrine system: specific chemical control at cell, tissue, and organ level
- Definitions of endocrine gland, hormone
- Major endocrine glands: names, locations, products
- Major types of hormones
- Neuroendocrinology — relation between neurons and hormonal systems

Endocrine System: Mechanisms of Hormone Action (BIO)
- Cellular mechanisms of hormone action
- Transport of hormones: blood supply
- Specificity of hormones: target tissue
- Integration with nervous system: feedback control
- Regulation by second messengers ©
Content Category 3B: focuses on the structure and functions of the organ systems — circulatory, respiratory, digestive, immune, lymphatic, muscular, skeletal, and reproductive — and the ways these systems interact to fulfill their concerted roles in the maintenance and continuance of the living organism.

This section requires knowledge of:

Respiratory System (BIO)

- General function
  - Gas exchange, thermoregulation
  - Protection against disease: particulate matter
- Structure of lungs and alveoli
- Breathing mechanisms
  - Diaphragm, rib cage, differential pressure
  - Resiliency and surface tension effects
- Thermoregulation: nasal and tracheal capillary beds; evaporation, panting
- Particulate filtration: nasal hairs, mucus/cilia system in lungs
- Alveolar gas exchange
  - Diffusion, differential partial pressure
  - Henry’s Law (GC)
- pH control
- Regulation by nervous control
  - CO₂ sensitivity

Circulatory System (BIO)

- Functions: circulation of oxygen, nutrients, hormones, ions and fluids, removal of metabolic waste
- Role in thermoregulation
- Four-chambered heart: structure and function
- Endothelial cells
- Systolic and diastolic pressure
- Pulmonary and systemic circulation
- Arterial and venous systems (arteries, arterioles, venules, veins)
  - Structural and functional differences
  - Pressure and flow characteristics
- Capillary beds
  - Mechanisms of gas and solute exchange
  - Mechanism of heat exchange
  - Source of peripheral resistance
- Composition of blood
  - Plasma, chemicals, blood cells
  - Erythrocyte production and destruction; spleen, bone marrow
  - Regulation of plasma volume
- Coagulation, clotting mechanisms
- Oxygen transport by blood
  - Hemoglobin, hematocrit
  - Oxygen content
  - Oxygen affinity
- Carbon dioxide transport and level in blood
- Nervous and endocrine control
Lymphatic System (BIO)
- Structure of lymphatic system
- Major functions
  - Equalization of fluid distribution
  - Transport of proteins and large glycerides
  - Production of lymphocytes involved in immune reactions
  - Return of materials to the blood

Immune System (BIO)
- Innate (non-specific) vs. adaptive (specific) immunity
- Adaptive immune system cells
  - T-lymphocytes
  - B-lymphocytes
- Innate immune system cells
  - Macrophages
  - Phagocytes
- Tissues
  - Bone marrow
  - Spleen
  - Thymus
  - Lymph nodes
- Concept of antigen and antibody
- Antigen presentation
- Clonal selection
- Antigen-antibody recognition
- Structure of antibody molecule
- Recognition of self vs. non-self, autoimmune diseases
- Major histocompatibility complex

Digestive System (BIO)
- Ingestion
  - Saliva as lubrication and source of enzymes
  - Ingestion; esophagus, transport function
- Stomach
  - Storage and churning of food
  - Low pH, gastric juice, mucal protection against self-destruction
  - Production of digestive enzymes, site of digestion
  - Structure (gross)
- Liver
  - Structural relationship of liver within gastrointestinal system
  - Production of bile
  - Role in blood glucose regulation, detoxification
- Bile
  - Storage in gall bladder
  - Function
- Pancreas
  - Production of enzymes
  - Transport of enzymes to small intestine
- Small Intestine
  - Absorption of food molecules and water
• Function and structure of villi
  • Production of enzymes, site of digestion
  • Neutralization of stomach acid
  • Structure (anatomic subdivisions)

• Large Intestine
  • Absorption of water
  • Bacterial flora
  • Structure (gross)

• Rectum: storage and elimination of waste, feces

• Muscular control
  • Peristalsis

• Endocrine control
  • Hormones
  • Target tissues

• Nervous control: the enteric nervous system

Excretory System (BIO)

• Roles in homeostasis
  • Blood pressure
  • Osmoregulation
  • Acid–base balance
  • Removal of soluble nitrogenous waste

• Kidney structure
  • Cortex
  • Medulla

• Nephron structure
  • Glomerulus
  • Bowman’s capsule
  • Proximal tubule
  • Loop of Henle
  • Distal tubule
  • Collecting duct

• Formation of urine
  • Glomerular filtration
  • Secretion and reabsorption of solutes
  • Concentration of urine
  • Counter-current multiplier mechanism

• Storage and elimination: ureter, bladder, urethra

• Osmoregulation: capillary reabsorption of H 2 O

• Muscular control: sphincter muscle

Reproductive System (BIO)

• Male and female reproductive structures and their functions
  • Gonads
  • Genitalia
  • Differences between male and female structures

• Hormonal control of reproduction
  • Male and female sexual development
  • Female reproductive cycle
  • Pregnancy, parturition, lactation
  • Integration with nervous control
Muscle System (BIO)
• Important functions
  o Support: mobility
  o Peripheral circulatory assistance
  o Thermoregulation (shivering reflex)
• Structure of three basic muscle types: striated, smooth, cardiac
• Muscle structure and control of contraction
  o T-tubule system
  o Contractile apparatus
  o Sarcoplasmic reticulum
  o Fiber type
  o Contractile velocity of different muscle types
• Regulation of cardiac muscle contraction
• Oxygen debt: fatigue
• Nervous control
  o Motor neurons
  o Neuromuscular junction, motor end plates
  o Sympathetic and parasympathetic innervation
  o Voluntary and involuntary muscles

Specialized Cell - Muscle Cell (BIO)
• Structural characteristics of striated, smooth, and cardiac muscle
• Abundant mitochondria in red muscle cells: ATP source
• Organization of contractile elements: actin and myosin filaments, crossbridges, sliding filament model
• Sarcomeres: “I” and “A” bands, “M” and “Z” lines, “H” zone
• Presence of troponin and tropomyosin
• Calcium regulation of contraction

Skeletal System (BIO)
• Functions
  o Structural rigidity and support
  o Calcium storage
  o Physical protection
• Skeletal structure
  o Specialization of bone types, structures
  o Joint structures
  o Endoskeleton vs. exoskeleton
• Bone structure
  o Calcium/protein matrix
  o Cellular composition of bone
• Cartilage: structure and function
• Ligaments, tendons
• Endocrine control
Skin System (BIO)

• Structure
  o Layer differentiation, cell types
  o Relative impermeability to water

• Functions in homeostasis and osmoregulation

• Functions in thermoregulation
  o Hair, erectile musculature
  o Fat layer for insulation
  o Sweat glands, location in dermis
  o Vasoconstriction and vasodilation in surface capillaries

• Physical protection
  o Nails, calluses, hair
  o Protection against abrasion, disease organisms

• Hormonal control: sweating, vasodilation, and vasoconstriction
Section 2: Chemical and Physical Foundations of Biological Systems

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- 30% General chemistry
- 15% Organic chemistry
- 25% Introductory physics

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  - Interpreting patterns in data presented in tables, figures, and graphs
  - Reasoning about data and drawing conclusions from them
Section 2: Chemical and Physical Foundations of Biological Systems

Foundational Concepts

Foundational Concept 4 (40%): Complex living organisms transport materials, sense their environment, process signals, and respond to changes using processes understood in terms of physical principles.

Foundational Concept 4 includes:

- Content Category 4A focuses on motion and its causes, and various forms of energy and their interconversions.
- Content Category 4B focuses on the behavior of fluids, which is relevant to the functioning of the pulmonary and circulatory systems.
- Content Category 4C emphasizes the nature of electrical currents and voltages; how energy can be converted into electrical forms that can be used to perform chemical transformations or work; and how electrical impulses can be transmitted over long distances in the nervous system.
- Content Category 4D focuses on the properties of light and sound; how the interactions of light and sound with matter can be used by an organism to sense its environment; and how these interactions can also be used to generate structural information or images.
- Content Category 4E focuses on sub-atomic particles, the atomic nucleus, nuclear radiation, the structure of the atom, and how the configuration of any particular atom can be used to predict its physical and chemical properties.

Content Category 4A focuses on motion and its causes, and various forms of energy and their interconversions.

This section requires knowledge of:

Translational Motion (PHY)
- Units and dimensions
- Vectors, components
- Vector addition
- Speed, velocity (average and instantaneous)
- Acceleration

Force (PHY)
- Newton’s First Law, inertia
- Newton’s Second Law Capital F equals m times A
- Newton’s Third Law, forces equal and opposite
- Friction, static and kinetic
- Center of mass
Equilibrium (PHY)
- Vector analysis of forces acting on a point object
- Torques, lever arms

Work (PHY)
- Work done by a constant force: \( W = Fd \cos \theta \)
- Mechanical advantage
- Work Kinetic Energy Theorem
- Conservative forces

Energy of Point Object Systems (PHY)
- *Kinetic Energy, \( K \ E \) equals \( m \ times \ v \ squared \ divided \ by \ two \ and \ its \ units \)
- Potential Energy
  - \( PE = mgh \) (gravitational, local)
  - \( PE = \frac{1}{2} kx^2 \) (spring)
- Conservation of energy
- Power, units

Periodic Motion (PHY)
- Amplitude, frequency, phase
- Transverse and longitudinal waves: wavelength and propagation speed
Content Category 4B focuses on the behavior of fluids, which is relevant to the functioning of the pulmonary and circulatory systems.

This section requires knowledge of:

Fluids (PHY)

- Density, specific gravity
- Buoyancy, Archimedes’ Principle
- Hydrostatic pressure
  - Pascal’s Law
  - Hydrostatic pressure; $P=\rho gh$ (pressure vs. depth)
- Viscosity: Poiseuille Flow
- Continuity equation ($A\cdot v=\text{constant}$)
- Concept of turbulence at high velocities
- Surface tension
- Bernoulli’s equation
- Venturi effect, pitot tube

Circulatory System (BIO)

- Arterial and venous systems; pressure and flow characteristics

Gas Phase (GC, PHY)

- Absolute temperature, (K) Kelvin Scale
- Pressure, simple mercury barometer
- Molar volume at $0^\circ C$ and $1$ atm $= 22.4 \text{ L/mol}$
- Ideal gas
  - Definition
  - Ideal Gas Law: $PV=nRT$
  - Boyle’s Law: $PV=\text{constant}$
  - Charles’ Law: $V/T=\text{constant}$
  - Avogadro’s Law: $V/n=\text{constant}$
- Kinetic Molecular Theory of Gases
  - Heat capacity at constant volume and at constant pressure (PHY)
  - Boltzmann’s Constant (PHY)
- Deviation of real gas behavior from Ideal Gas Law
  - Qualitative
  - Quantitative (Van der Waals’ Equation)
- Partial pressure, mole fraction
- Dalton’s Law relating partial pressure to composition
Content Category 4C emphasizes the nature of electrical currents and voltages; how energy can be converted into electrical forms that can be used to perform chemical transformations or work; and how electrical impulses can be transmitted over long distances in the nervous system.

This section requires knowledge of:

**Electrostatics (PHY)**
- Charge, conductors, charge conservation
- Insulators
- Coulomb’s Law
- Electric field $E$
  - Field lines
  - Field due to charge distribution
- Electrostatic energy, electric potential at a point in space

**Circuit Elements (PHY)**
- Current $I=\Delta Q/\Delta t$, sign conventions, units
- Electromotive force, voltage
- Resistance
  - Ohm’s Law: $I=V/R$
  - Resistors in series
  - Resistors in parallel
  - Resistivity: $\rho=R\cdot A/L$
- Capacitance Parallel plate capacitor
  - Energy of charged capacitor
  - Capacitors in series
  - Capacitors in parallel
  - Dielectrics
- Conductivity
  - Metallic
  - Electrolytic
- Meters

**Magnetism (PHY)**
- Definition of magnetic field $B$
- Motion of charged particles in magnetic fields; Lorentz force

**Electrochemistry (GC)**
- Electrolytic cell
  - Electrolysis
  - Anode, cathode
  - Electrolyte
  - Faraday’s Law relating amount of elements deposited (or gas liberated) at an electrode to current
  - Electron flow; oxidation, and reduction at the electrodes
- Galvanic or Voltaic cells
  - Reduction potentials; cell potential
  - Direction of electron flow
  - Half-Reactions
- Concentration cell
• Batteries
  o Electromotive force, Voltage
  o Lead-storage batteries
  o Nickel-cadmium batteries

Specialized Cell - Nerve Cell (BIO)
• Myelin sheath, Schwann cells, insulation of axon
• Nodes of Ranvier: propagation of nerve impulse along axon
Content Category 4D focuses on the properties of light and sound; how the interactions of light and sound with matter can be used by an organism to sense its environment; and how these interactions can also be used to generate structural information or images.

This section requires knowledge of:

**Sound (PHY)**
- Production of sound
- Relative speed of sound in solids, liquids, and gases
- Intensity of sound, decibel units, log scale
- Attenuation (Damping)
- Doppler Effect: moving sound source or observer, reflection of sound from a moving object
- Pitch
- Resonance in pipes and strings
- Ultrasound
- Shock waves

**Light, Electromagnetic Radiation (PHY)**
- Concept of Interference; Young Double-slit Experiment
- Thin films, diffraction grating, single-slit diffraction
- Other diffraction phenomena, X-ray diffraction
- Polarization of light: linear and circular
- Properties of electromagnetic radiation
  - Velocity equals constant $c$, in vacuo
  - Electromagnetic radiation consists of perpendicularly oscillating electric and magnetic fields; direction of propagation is perpendicular to both
- Classification of electromagnetic spectrum, photon energy $E=hf$
- Visual spectrum, color

**Molecular Structure and Absorption Spectra (OC)**
- Infrared region
  - Intramolecular vibrations and rotations
  - Recognizing common characteristic group absorptions, fingerprint region
- Visible region (GC)
  - Absorption in visible region gives complementary color (e.g., carotene)
  - Effect of structural changes on absorption (e.g., indicators)
- Ultraviolet region
  - $\pi$-Electron and non-bonding electron transitions
  - Conjugated systems
- NMR spectroscopy
  - Protons in a magnetic field; equivalent protons
  - Spin-spin splitting
Geometrical Optics (PHY)

- Reflection from plane surface: angle of incidence equals angle of reflection
- Refraction, refractive index $n$; Snell’s law: $n_1 \sin \theta_1 = n_2 \sin \theta_2$
- Dispersion, change of index of refraction with wavelength
- Conditions for total internal reflection
  - Spherical mirrors
  - Center of curvature
  - Focal length
  - Real and virtual images
- Thin lenses
  - Converging and diverging lenses
  - Use of formula $1/p + 1/q = 1/f$, with sign conventions
  - Lens strength, diopters
- Combination of lenses
- Lens aberration
- Optical Instruments, including the human eye
Content Category 4E focuses on sub-atomic particles, the atomic nucleus, nuclear radiation, the structure of the atom, and how the configuration of any particular atom can be used to predict its physical and chemical properties.

This section requires knowledge of:

Atomic Nucleus (PHY, GC)
- Atomic number, atomic weight
- Neutrons, protons, isotopes
- Nuclear forces, binding energy
- Radioactive decay
  - $\alpha$, $\beta$, $\gamma$ decay
  - Half-life, exponential decay, semi-log plots
- Mass spectrometer

Electronic Structure (PHY, GC)
- Orbital structure of hydrogen atom, principal quantum number $n$, number of electrons per orbital (GC)
- Ground state, excited states
- Absorption and emission line spectra
- Use of Pauli Exclusion Principle
- Paramagnetism and diamagnetism
- Conventional notation for electronic structure (GC)
- Bohr atom
- Heisenberg Uncertainty Principle
- Effective nuclear charge (GC)
- Photoelectric effect

The Periodic Table - Classification of Elements into Groups by Electronic Structure (GC)
- Alkali metals
- Alkaline earth metals: their chemical characteristics
- Halogens: their chemical characteristics
- Noble gases: their physical and chemical characteristics
- Transition metals
- Representative elements
- Metals and non-metals
- Oxygen group

The Periodic Table - Variations of Chemical Properties with Group and Row (GC)
- Valence electrons
- First and second ionization energy
  - Definition
  - Prediction from electronic structure for elements in different groups or rows
- Electron affinity
  - Definition
  - Variation with group and row
- Electronegativity
  - Definition
  - Comparative values for some representative elements and important groups
- Electron shells and the sizes of atoms
- Electron shells and the sizes of ions
Stoichiometry (GC)

- Molecular weight
- Empirical versus molecular formula
- Metric units commonly used in the context of chemistry
- Description of composition by percent mass
- Mole concept, Avogadro’s number $NA$
- Definition of density
- Oxidation number
  - Common oxidizing and reducing agents
  - Disproportionation reactions
- Description of reactions by chemical equations
  - Conventions for writing chemical equations
  - Balancing equations, including redox equations
  - Limiting reactants
  - Theoretical yields
Foundational Concept 5 (60%): The principles that govern chemical interactions and reactions form the basis for a broader understanding of the molecular dynamics of living systems.

Foundational Concept 5 includes:
- Content Category 5A emphasizes the nature of solution formation, factors that affect solubility, and the properties and behavior of aqueous solutions, with special emphasis on the acid-base behavior of dissolved solutes.
- Content Category 5B focuses on molecular structure and how it affects the strength of intermolecular interactions.
- Content Category 5C emphasizes how differential intermolecular interactions can be used to effect chemical separations.
- Content Category 5D emphasizes the varied nature of biologically-relevant molecules, and how patterns of covalent bonding can be used to predict the chemical reactivity of these molecules and their structure and function within a living system.
- Content Category 5E emphasizes how relative energy dictates the overall favorability of chemical processes and the rate at which these processes can occur.

Content Category 5A emphasizes the nature of solution formation, factors that affect solubility, and the properties and behavior of aqueous solutions, with special emphasis on the acid-base behavior of dissolved solutes.

This section requires knowledge of:

Acid/Base Equilibria (GC, BC)
- Bronsted-Lowry definition of acid, base
- Ionization of water
  - $K_w$, its approximate value ($K_w = [H^+][OH^-] = 10^{-14}$ at 25°C, 1atm)
  - Definition of $pH$: pH of pure water
- Conjugate acids and bases (e.g., $NH_4^+$ and $NH_3$)
- Strong acids and bases (e.g., nitric, sulfuric)
- Weak acids and bases (e.g., acetic, benzoic) Dissociation of weak acids and bases with or without added salt
- Hydrolysis of salts of weak acids or bases
- Calculation of pH of solutions of salts of weak acids or bases
- Equilibrium $K_a$ and $K_b$: $pK_a$, $pK_b$
- Buffers
  - Definition and concepts (common buffer systems)
  - Influence on titration curves

Ions in Solutions (GC, BC)
- Anion, cation: compound names, formulas and charges for familiar ions (e.g., $NH_4^+$ ammonium, $PO_4^{3-}$ phosphate, $SO_4^{2-}$ sulfate)
- Hydration, the hydrogen ion

Solubility (GC)
- Units of concentration (e.g., molarity)
- Solubility product constant; the equilibrium expression $K_{sp}$
- Common-ion effect, its use in laboratory separations
  - Complex ion formation
  - Complex ions and solubility
  - Solubility and pH
Titration (GC)

- Indicators
- Neutralization
- Interpretation of the titration curves
- Redox titration
Content Category 5B focuses on molecular structure and how it affects the strength of intermolecular interactions. Content Category 5C emphasizes how differential intermolecular interactions can be used to effect chemical separations.

This section requires knowledge of:

Covalent Bond (GC)
- Lewis Electron Dot formulas
  - Resonance structures
  - Formal charge
  - Lewis acids and bases
- Partial ionic character
  - Role of electronegativity in determining charge distribution
  - Dipole Moment
- σ and π bonds
  - Hybrid orbitals: \( sp^3 \), \( sp^2 \), \( sp \) and respective geometries
  - Valence shell electron pair repulsion and the prediction of shapes of molecules (e.g., \( \text{NH}_3 \), \( \text{H}_2\text{O} \), \( \text{CO}_2 \))
  - Structural formulas for molecules involving H, C, N, O, F, S, P, Si, Cl
  - Delocalized electrons and resonance in ions and molecules
- Multiple bonding
  - Effect on bond length and bond energies
  - Rigidity in molecular structure
- Stereochemistry of covalently bonded molecules (OC)
  - Isomers
    - Structural isomers
    - Stereoisomers (e.g., diastereomers, enantiomers, cis/trans isomers)
    - Conformational isomers
  - Polarization of light, specific rotation
  - Absolute and relative configuration
    - Conventions for writing \( R \) and \( S \) forms
    - Conventions for writing \( E \) and \( Z \) forms

Liquid Phase - Intermolecular Forces (GC)
- Hydrogen bonding
- Dipole Interactions
- Van der Waals’ Forces (London dispersion forces)
Content Category 5D emphasizes the varied nature of biologically-relevant molecules, and how patterns of covalent bonding can be used to predict the chemical reactivity of these molecules and their structure and function within a living system.

This section requires knowledge of:

Nucleotides and Nucleic Acids (BC, BIO)
- Nucleotides and nucleosides: composition
  - Sugar phosphate backbone
  - Pyrimidine, purine residues
- Deoxyribonucleic acid: DNA; double helix
- Chemistry (BC)
- Other functions (BC)

Amino Acids, Peptides, Proteins (OC, BC)
- Amino acids: description
  - Absolute configuration at the α position
  - Dipolar ions
  - Classification
    - Acidic or basic
    - Hydrophilic or hydrophobic
  - Synthesis of α-amino acids (OC)
    - Strecker Synthesis
    - Gabriel Synthesis
- Peptides and proteins: reactions
  - Sulfur linkage for cysteine and cystine
  - Peptide linkage: polypeptides and proteins
  - Hydrolysis (BC)
- General Principles
  - Primary structure of proteins
  - Secondary structure of proteins
  - Tertiary structure of proteins
  - Isoelectric point

The Three-Dimensional Protein Structure (BC)
- Conformational stability
  - Hydrophobic interactions
  - Solvation layer (entropy)
- Quaternary structure
- Denaturing and Folding

Non-Enzymatic Protein Function (BC)
- Binding
- Immune system
- Motor
Lipids (BC, OC)
- Description, Types
  - Storage
    - Triacyl glycerols
    - Free fatty acids: saponification
  - Structural
    - Phospholipids and phosphatids
    - Sphingolipids (BC)
    - Waxes
  - Signals/cofactors
    - Fat-soluble vitamins
    - Steroids
    - Prostaglandins (BC)

Carbohydrates (OC)
- Description
  - Nomenclature and classification, common names
  - Absolute configuration
  - Cyclic structure and conformations of hexoses
  - Epimers and anomers
- Hydrolysis of the glycoside linkage
- Keto-enol tautomerism of monosaccharides
- Disaccharides (BC)
- Polysaccharides (BC)

Aldehydes and Ketones (OC)
- Description
  - Nomenclature
  - Physical properties
- Important reactions
  - Nucleophilic addition reactions at C=O bond
    - Acetal, hemiacetal
    - Imine, enamine
    - Hydride reagents
    - Cyanohydrin
  - Oxidation of aldehydes
  - Reactions at adjacent positions: enolate chemistry
    - Keto-enol tautomerism (α-racemization)
    - Aldol condensation, retro-aldol
    - Kinetic versus thermodynamic enolate
- General principles
  - Effect of substituents on reactivity of C=O; steric hindrance
  - Acidity of α-H; carbanions
Alcohols (OC)
- Description
  - Nomenclature
  - Physical properties (acidity, hydrogen bonding)
- Important reactions
  - Oxidation
  - Substitution reactions: SN1 or SN2
  - Protection of alcohols
  - Preparation of mesylates and tosylates

Carboxylic Acids (OC)
- Description
  - Nomenclature
  - Physical properties
- Important reactions
  - Carboxyl group reactions
    - Amides (and lactam), esters (and lactone), anhydride formation
    - Reduction
    - Decarboxylation
  - Reactions at 2-position, substitution

Acid Derivatives (Anhydrides, Amides, Esters) (OC)
- Description
  - Nomenclature
  - Physical properties
- Important reactions
  - Nucleophilic substitution
  - Transesterification
  - Hydrolysis of amides
- General principles
  - Relative reactivity of acid derivatives
  - Steric effects
  - Electronic effects
  - Strain (e.g., β-lactams)

Phenols (OC, BC)
- Oxidation and reduction (e.g., hydroquinones, ubiquinones): biological 2e− redox centers

Polycyclic and Heterocyclic Aromatic Compounds (OC, BC)
- Biological aromatic heterocycles
Content Category 5E emphasizes how relative energy dictates the overall favorability of chemical processes and the rate at which these processes can occur.

This section requires knowledge of:

**Enzymes (BC, BIO)**
- Classification by reaction type
- Mechanism
  - Substrates and enzyme specificity
  - Active site model
  - Induced-fit model
  - Cofactors, coenzymes, and vitamins
- Kinetics
  - General (catalysis)
  - Michaelis–Menten
  - Cooperativity
  - Effects of local conditions on enzyme activity
- Inhibition
- Regulatory enzymes
  - Allosteric
  - Covalently modified

**Principles of Bioenergetics (BC)**
- Bioenergetics/thermodynamics
  - Free energy/Keq
  - Concentration
- Phosphorylation/ATP
  - ATP hydrolysis $\Delta G < 0$
  - ATP group transfers
- Biological oxidation–reduction
  - Half-reactions
  - Soluble electron carriers
  - Flavoproteins

**Energy Changes in Chemical Reactions – Thermochemistry, Thermodynamics (GC, PHY)**
- Thermodynamic system – state function
- Zeroth Law – concept of temperature
- First Law – conservation of energy in thermodynamic processes
- $PV$ diagram: work done = area under or enclosed by curve (PHY)
- Second Law – concept of entropy
  - Entropy as a measure of “disorder”
  - Relative entropy for gas, liquid, and crystal states
- Measurement of heat changes (calorimetry), heat capacity, specific heat
- Heat transfer – conduction, convection, radiation (PHY)
- Endothermic/exothermic reactions (GC)
  - Enthalpy, $H$, and standard heats of reaction and formation
  - Hess’ Law of Heat Summation
- Bond dissociation energy as related to heats of formation (GC)
- Free energy: $G$ (GC)
- Spontaneous reactions and $\Delta G^\circ$ (GC)
- Coefficient of expansion (PHY)
- Heat of fusion, heat of vaporization
- Phase diagram: pressure and temperature
Rate Processes in Chemical Reactions - Kinetics and Equilibrium (GC)

- Reaction rate
- Dependence of reaction rate on concentration of reactants
  - Rate law, rate constant
  - Reaction order
- Rate-determining step
- Dependence of reaction rate upon temperature
  - Activation energy
    - Activated complex or transition state
    - Interpretation of energy profiles showing energies of reactants, products, activation energy, and ΔH for the reaction
  - Use of the Arrhenius Equation
- Kinetic control versus thermodynamic control of a reaction
- Catalysts
- Equilibrium in reversible chemical reactions
- Law of Mass Action
- Equilibrium Constant
- Application of Le Châtelier’s Principle
- Relationship of the equilibrium constant and ΔG°
Section 3: Psychological, Social, and Biological Foundations of Behavior

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Discipline:
- 65% Introductory psychology
- 30% Introductory sociology
- 5% Introductory biology

Foundational Concepts:
- 25% Foundational Concept 6 - Biological, psychological, and sociocultural factors influence the ways that individuals perceive, think about, and react to the world.
- 35% Foundational Concept 7 - Biological, psychological, and sociocultural factors influence behavior and behavior change.
- 20% Foundational Concept 8 - Psychological, sociocultural, and biological factors influence the way we think about ourselves and others, as well as how we interact with others.
- 15% Foundational Concept 9 - Cultural and social differences influence well-being.
- 5% Foundational Concept 10 - Social stratification and access to resources influence well-being.

Scientific Inquiry and Reasoning Skill:
- 35% Skill 1 - Knowledge of Scientific Concepts and Principles
  - Demonstrating understanding of scientific concepts and principles
  - Identifying the relationships between closely-related concepts
- 45% Skill 2 - Scientific Reasoning and Problem Solving
  - Reasoning about scientific principles, theories, and models
  - Analyzing and evaluating scientific explanations and predictions
- 10% Skill 3 - Reasoning about the Design and Execution of Research
  - Demonstrating understanding of important components of scientific research
  - Reasoning about ethical issues in research
- 10% Skill 4 - Data-Based and Statistical Reasoning
  - Interpreting patterns in data presented in tables, figures, and graphs
  - Reasoning about data and drawing conclusions from them
Section 3: Psychological, Social, and Biological Foundations of Behavior

Foundational Concepts

Foundational Concept 6 (25%): Biological, psychological, and sociocultural factors influence the ways that individuals perceive, think about, and react to the world.

Foundational Concept 6 includes:

- Content Category 6A focuses on the detection and perception of sensory information.
- Content Category 6B focuses on cognition, including our ability to attend to the environment, think about and remember what we experience, and use language to communicate with others.
- Content Category 6C focuses on how we process and experience emotion and stress.

Category 6A focuses on the detection and perception of sensory information.

This section requires knowledge of:

Sensory Processing (PSY, BIO)
- Sensation Threshold
  - Weber’s Law (PSY)
  - Signal detection theory (PSY)
  - Sensory adaptation
  - Psychophysics
- Sensory receptors
  - Sensory pathways
  - Types of sensory receptor

Vision (PSY, BIO)
- Structure and function of the eye
  - Visual processing Visual pathways in the brain
  - Parallel processing (PSY)
  - Feature detection (PSY)

Hearing (PSY, BIO)
- Structure and function of the ear
- Auditory processing (e.g., auditory pathways in the brain)
- Sensory reception by hair cells
Other Senses (PSY, BIO)
- Somatosensation (e.g., pain perception)
- Taste (e.g., taste buds/chemoreceptors that detect specific chemicals)
- Smell
  - Olfactory cells/chemoreceptors that detect specific chemicals
  - Pheromones (BIO)
  - Olfactory pathways in the brain (BIO)
- Kinesthetic sense (PSY)
- Vestibular sense

Perception (PSY)
- Bottom-up/Top-down processing
- Perceptual organization (e.g., depth, form, motion, constancy)
- Gestalt principles
Category 6B focuses on cognition, including our ability to attend to the environment, think about and remember what we experience, and use language to communicate with others.

This section requires knowledge of:

Attention (PSY)
- Selective attention
- Divided attention

Cognition (PSY)
- Information-processing model
- Cognitive development
  - Piaget’s stages of cognitive development
  - Cognitive changes in late adulthood
  - Role of culture in cognitive development
  - Influence of heredity and environment on cognitive development
- Biological factors that affect cognition (PSY, BIO)
- Problem solving and decision making
  - Types of problem solving
  - Barriers to effective problem solving
  - Approaches to problem solving
  - Heuristics and biases (e.g., overconfidence, belief perseverance)
- Intellectual functioning
  - Theories of intelligence
  - Influence of heredity and environment on intelligence
  - Variations in intellectual ability

Consciousness (PSY)
- States of consciousness
  - Alertness (PSY, BIO)
  - Sleep
    - Stages of sleep
    - Sleep cycles and changes to sleep cycles
    - Sleep and circadian rhythms (PSY, BIO)
    - Dreaming
    - Sleep–wake disorders
  - Hypnosis and meditation
- Consciousness-altering drugs
  - Types of consciousness-altering drugs and their effects on the nervous system and behavior
  - Drug addiction and the reward pathway in the brain
Memory (PSY)

- Encoding
  - Process of encoding information
  - Processes that aid in encoding memories

- Storage
  - Types of memory storage (e.g., sensory, working, long-term)
  - Semantic networks and spreading activation

- Retrieval
  - Recall, recognition, and relearning
  - Retrieval cues
  - The role of emotion in retrieving memories (PSY, BIO)
  - Processes that aid retrieval

- Forgetting
  - Aging and memory
  - Memory dysfunctions (e.g., Alzheimer’s disease, Korsakoff’s syndrome)
  - Decay
  - Interference
  - Memory construction and source monitoring

- Changes in synaptic connections underlie memory and learning (PSY, BIO)
  - Neural plasticity
  - Memory and learning
  - Long-term potentiation

Language (PSY)

- Theories of language development (e.g., learning, Nativist, Interactionist)
- Influence of language on cognition
- Brain areas that control language and speech (PSY, BIO)
Category 6C focuses on how we process and experience emotion and stress.

This section requires knowledge of:

**Emotion (PSY)**
- Three components of emotion (i.e., cognitive, physiological, behavioral)
- Universal emotions (i.e., fear, anger, happiness, surprise, joy, disgust, and sadness)
- Adaptive role of emotion
- Theories of emotion
  - James–Lange theory
  - Cannon–Bard theory
  - Schachter–Singer theory
- The role of biological processes in perceiving emotion (PSY, BIO)
  - Brain regions involved in the generation and experience of emotions
  - The role of the limbic system in emotion
  - Emotion and the autonomic nervous system
  - Physiological markers of emotion (signatures of emotion)

**Stress (PSY)**
- The nature of stress
  - Appraisal
  - Different types of stressors (e.g., cataclysmic events, personal)
  - Effects of stress on psychological functions
- Stress outcomes/response to stressors
  - Physiological (PSY, BIO)
  - Emotional
  - Behavioral
- Managing stress (e.g., exercise, relaxation, spirituality)
Foundational Concept 7 (35%): Biological, psychological, and sociocultural factors influence behavior and behavior change.

Foundational Concept 7 includes:

- Content Category 7A focuses on the individual psychological and biological factors that affect behavior.
- Content Category 7B focuses on how social factors, such as groups and social norms, affect behavior.
- Content Category 7C focuses on how learning affects behavior, as well as the role of attitude theories in behavior and behavior change.

Category 7A focuses on the individual psychological and biological factors that affect behavior.

This section requires knowledge of:

**Biological Bases of Behavior (PSY, BIO)**

- The nervous system
  - Neurons (e.g., the reflex arc)
  - Neurotransmitters
  - Structure and function of the peripheral nervous system
  - Structure and function of the central nervous system
    - The brain
    - Forebrain
    - Midbrain
    - Hindbrain
    - Lateralization of cortical functions
    - Methods used in studying the brain
  - The spinal cord
- Neuronal communication and its influence on behavior (PSY)
- Influence of neurotransmitters on behavior (PSY)
- The endocrine system
  - Components of the endocrine system
  - Effects of the endocrine system on behavior
- Behavioral genetics
  - Genes, temperament, and heredity
  - Adaptive value of traits and behaviors
  - Interaction between heredity and environmental influences
- Influence of genetic and environmental factors on the development of behaviors
  - Experience and behavior (PSY)
  - Regulatory genes and behavior (BIO)
  - Genetically based behavioral variation in natural populations
- Human physiological development (PSY)
  - Prenatal development
  - Motor development
  - Developmental changes in adolescence
Personality (PSY)
- Theories of personality
  - Psychoanalytic perspective
  - Humanistic perspective
  - Trait perspective
  - Social cognitive perspective
  - Biological perspective
  - Behaviorist perspective
- Situational approach to explaining behavior

Psychological Disorders (PSY)
- Understanding psychological disorders
  - Biomedical vs. biopsychosocial approaches
  - Classifying psychological disorders
  - Rates of psychological disorders
- Types of psychological disorders
- Anxiety disorders
  - Obsessive–compulsive disorder
  - Trauma- and stressor-related disorders
  - Somatic symptom and related disorders
  - Bipolar and related disorders
  - Depressive disorders
  - Schizophrenia
  - Dissociative disorders
  - Personality disorders
- Biological bases of nervous system disorders (PSY, BIO)
  - Schizophrenia
  - Depression
  - Alzheimer’s disease
  - Parkinson’s disease
  - Stem cell-based therapy to regenerate neurons in the central nervous system (BIO)

Motivation (PSY)
- Factors that influence motivation
  - Instinct
  - Arousal
  - Drives (e.g., negative feedback systems) (PSY, BIO)
  - Needs
- Theories that explain how motivation affects human behavior
  - Drive reduction theory
  - Incentive theory
  - Other theories (e.g., cognitive, need-based)
- Biological and sociocultural motivators that regulate behavior (e.g., hunger, sex drive, substance addiction)

Attitudes (PSY)
- Components of attitudes (i.e., cognitive, affective, and behavioral)
- The link between attitudes and behavior
  - Processes by which behavior influences attitudes (e.g., foot-in-the-door phenomenon, role-playing effects)
  - Processes by which attitudes influence behavior
  - Cognitive dissonance theory
Category 7B focuses on how social factors, such as groups and social norms, affect behavior.

This section requires knowledge of:

**How the Presence of Others Affects Individual Behavior (PSY)**
- Social facilitation
- Deindividuation
- Bystander effect
- Social loafing
- Social control (SOC)
- Peer pressure (PSY, SOC)
- Conformity (PSY, SOC)
- Obedience (PSY, SOC)

**Group Decision-making Processes (PSY, SOC)**
- Group polarization (PSY)
- Groupthink

**Normative and Non-normative Behavior (SOC)**
- Social norms (PSY, SOC)
  - Sanctions (SOC)
  - Folkways, mores, and taboos (SOC)
  - Anomie (SOC)
- Deviance
  - Perspectives on deviance (e.g., differential association, labeling theory, strain theory)
- Aspects of collective behavior (e.g., fads, mass hysteria, riots)

**Socialization (PSY, SOC)**
- Agents of socialization (e.g., the family, mass media, peers, workplace)
Category 7C focuses on how learning affects behavior, as well as the role of attitude theories in behavior and behavior change.

This section requires knowledge of:

Habituation and Dishabituation (PSY)

Associative Learning (PSY)
- Classical conditioning (PSY, BIO) ooo
  - Neutral, conditioned, and unconditioned stimuli
  - Conditioned and unconditioned response
  - Processes: acquisition, extinction, spontaneous recovery, generalization, discrimination
- Operant conditioning (PSY, BIO) ooooo
  - Processes of shaping and extinction
  - Types of reinforcement: positive, negative, primary, conditional
  - Reinforcement schedules: fixed-ratio, variable-ratio, fixed-interval, variable-interval
  - Punishment
  - Escape and avoidance learning
- The role of cognitive processes in associative learning
- Biological processes that affect associative learning (e.g., biological predispositions, instinctive drift) (PSY, BIO)

Observational Learning (PSY)
- Modeling
- Biological processes that affect observational learning
  - Mirror neurons
  - Role of the brain in experiencing vicarious emotions
- Applications of observational learning to explain individual behavior

Theories of Attitude and Behavior Change (PSY)
- Elaboration likelihood model
- Social cognitive theory
- Factors that affect attitude change (e.g., changing behavior, characteristics of the message and target, social factors)
Foundational Concept 8 (20%): Psychological, sociocultural, and biological factors influence the way we think about ourselves and others, as well as how we interact with others.

Foundational Concept 8 includes:

- Content Category 8A focuses on the notion of self and identity formation.
- Content Category 8B focuses on the attitudes and beliefs that affect social interaction.
- Content Category 8C focuses on the actions and processes underlying social interactions.

Category 8A focuses on the notion of self and identity formation.

This section requires knowledge of:

Self-Concept, Self-identity, and Social Identity (PSY, SOC)
- The role of self-esteem, self-efficacy, and locus of control in self-concept and self-identity (PSY)
- Different types of identities (e.g., race/ethnicity, gender, age, sexual orientation, class)

Formation of Identity (PSY, SOC)
- Theories of identity development (e.g., gender, moral, psychosexual, social)
- Influence of social factors on identity formation
  - Influence of individuals (e.g., imitation, looking-glass self, role-taking)
  - Influence of groups (e.g., reference group)
- Influence of culture and socialization on identity formation
Category 8B focuses on the attitudes and beliefs that affect social interaction.

This section requires knowledge of:

Attributing Behavior to Persons or Situations (PSY)
- Attributional processes (e.g., fundamental attribution error, role of culture in attributions)
- How self-perceptions shape our perceptions of others
- How perceptions of the environment shape our perceptions of others

Prejudice and Bias (PSY, SOC)
- Processes that contribute to prejudice
  - Power, prestige, and class (SOC)
  - The role of emotion in prejudice (PSY)
  - The role of cognition in prejudice (PSY)
- Stereotypes
- Stigma (SOC)
- Ethnocentrism (SOC)
  - Ethnocentrism vs. cultural relativism

Processes Related to Stereotypes (PSY)
- Self-fulfilling prophecy
- Stereotype threat
Category 8C focuses on the actions and processes underlying social interactions.

This section requires knowledge of:

**Elements of Social Interaction (PSY, SOC)**
- Status (SOC)
  - Types of status (e.g., achieved, ascribed)
- Role
  - Role conflict and role strain (SOC)
  - Role exit (SOC)
- Groups
  - Primary and secondary groups (SOC)
  - In-group vs. out-group
  - Group size (e.g., dyads, triads) (SOC)
- Networks (SOC)
- Organizations (SOC)
  - Formal organization
  - Bureaucracy
    - Characteristics of an ideal bureaucracy
    - Perspectives on bureaucracy (e.g., iron law of oligarchy, McDonaldization)

**Self-presentation and Interacting with Others (PSY, SOC)**
- Expressing and detecting emotion
  - The role of gender in the expression and detection of emotion
  - The role of culture in the expression and detection of emotion
- Presentation of self
  - Impression management
  - Front stage vs. back stage self (Dramaturgical approach) (SOC)
- Verbal and nonverbal communication
- Animal signals and communication (PSY, BIO)

**Social Behavior (PSY)**
- Attraction
- Aggression
- Attachment
- Altruism
- Social support (PSY, SOC)
- Biological explanations of social behavior in animals (PSY, BIO)
  - Foraging behavior (BIO)
  - Mating behavior and mate choice
  - Applying game theory (BIO)
  - Altruism
  - Inclusive fitness (BIO)

**Discrimination (PSY, SOC)**
- Individual vs. institutional discrimination (SOC)
- The relationship between prejudice and discrimination
- How power, prestige, and class facilitate discrimination (SOC)
Foundational Concept 9 (15%): Cultural and social differences influence well-being

Foundational Concept 9 includes:
- Content Category 9A focuses on the link between social structures and human interactions.
- Content Category 9B focuses on the demographic characteristics and processes that define a society.

Category 9A focuses on the link between social structures and human interactions.

*This section requires knowledge of:*

**Theoretical Approaches (SOC)**
- Microsociology vs. macrosociology
- Functionalism
- Conflict theory
- Symbolic interactionism
- Social constructionism
- Exchange-rational choice
- Feminist theory

**Social Institutions (SOC)**
- Education
  - Hidden curriculum
  - Teacher expectancy
  - Educational segregation and stratification
- Family (PSY, SOC)
  - Forms of kinship (SOC)
  - Diversity in family forms
  - Marriage and divorce
  - Violence in the family (e.g., child abuse, elder abuse, spousal abuse) (SOC)
- Religion
  - Religiosity
  - Types of religious organizations (e.g., churches, sects, cults)
  - Religion and social change (e.g., modernization, secularization, fundamentalism)
- Government and economy
  - Power and authority
  - Comparative economic and political systems
  - Division of labor
- Health and medicine
  - Medicalization
  - The sick role
  - Delivery of health care
  - Illness experience
  - Social epidemiology
Culture (PSY, SOC)

- Elements of culture (e.g., beliefs, language, rituals, symbols, values)
- Material vs. symbolic culture (SOC)
- Culture lag (SOC)
- Culture shock (SOC)
- Assimilation (SOC)
- Multiculturalism (SOC)
- Subcultures and countercultures (SOC)
- Mass media and popular culture (SOC)
- Evolution and human culture (PSY, BIO)
- Transmission and diffusion (SOC)
Category 9B focuses on the demographic characteristics and processes that define a society.

This section requires knowledge of:

**Demographic Structure of Society (PSY, SOC)**
- Age
  - Aging and the life course
  - Age cohorts (SOC)
  - Social significance of aging
- Gender
  - Sex versus gender
  - The social construction of gender (SOC)
  - Gender segregation (SOC)
- Race and ethnicity (SOC)
  - The social construction of race
  - Racialization
  - Racial formation
- Immigration status (SOC)
  - Patterns of immigration
  - Intersections with race and ethnicity
- Sexual orientation

**Demographic Shifts and Social Change (SOC)**
- Theories of demographic change (i.e., Malthusian theory and demographic transition)
- Population growth and decline (e.g., population projections, population pyramids)
- Fertility, migration, and mortality
  - Fertility and mortality rates (e.g., total, crude, age-specific)
  - Patterns in fertility and mortality
  - Push and pull factors in migration
- Social movements
  - Relative deprivation
  - Organization of social movements
  - Movement strategies and tactics
- Globalization
  - Factors contributing to globalization (e.g., communication technology, economic interdependence)
  - Perspectives on globalization
  - Social changes in globalization (e.g., civil unrest, terrorism)
- Urbanization
  - Industrialization and urban growth
  - Suburbanization and urban decline
  - Gentrification and urban renewal
Foundational Concept 10 (5%): Social stratification and access to resources influence well-being.

Foundational Concept 10 includes:
- Category 10A focuses on a broad understanding of social class, including theories of stratification, social mobility, and poverty

Category 10A focuses on a broad understanding of social class, including theories of stratification, social mobility, and poverty.

This section requires knowledge of:

Spatial Inequality (SOC)
- Residential segregation
- Neighborhood safety and violence
- Environmental justice (location and exposure to health risks)

Social Class (SOC)
- Aspects of social stratification
  - Social class and socioeconomic status
  - Class consciousness and false consciousness
  - Cultural capital and social capital
  - Social reproduction
  - Power, privilege, and prestige
  - Intersectionality (e.g., race, gender, age)
  - Socioeconomic gradient in health
  - Global inequalities
- Patterns of social mobility
  - Intergenerational and intragenerational mobility
  - Vertical and horizontal mobility
  - Meritocracy
- Poverty
  - Relative and absolute poverty
  - Social exclusion (segregation and isolation)

Health Disparities (SOC) (e.g., class, gender, and race inequalities in health)

Healthcare Disparities (SOC) (e.g., class, gender, and race inequalities in health care)
Section 4: Critical Analysis and Reasoning Skills

<table>
<thead>
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<th># of questions</th>
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<td>53 (passage-based questions)</td>
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Passage Content:
- 50% Humanities
- 50% Social Sciences

**Humanities (50%):** Passages in the humanities are drawn from a variety of disciplines, including (but not limited to):
  - Architecture
  - Art
  - Dance
  - Ethics
  - Literature
  - Music
  - Philosophy
  - Popular Culture
  - Religion
  - Theater
  - Studies of Diverse Cultures

**Social Sciences (50%):** Social sciences passages are also drawn from a variety of disciplines, including (but not limited to):
  - Anthropology
  - Archaeology
  - Economics
  - Education
  - Geography
  - History
  - Linguistics
  - Political Science
  - Population Health
  - Psychology
  - Sociology
  - Studies of Diverse Cultures

Critical Analysis and Reasoning Skill:
- 35% Skill 1 - Foundations of Comprehension
  - Understanding the basic components of the text
  - Inferring meaning from rhetorical devices, word choice, and text structure
- 30% Skill 2 - Reasoning Within the Text
  - Integrating different components of the text to increase comprehension
- 40% Skill 3 - Reasoning Beyond the Text
  - Applying or extrapolating ideas from the passage to new contexts
  - Assessing the impact of introducing new factors, information, or conditions to ideas from the passage