

Biology Study List for the MCAT

Molecular Biology

- Understand the basic functions and structures of the major chemical components of living cells and their surroundings: proteins, lipids, carbohydrates, nucleotides, water and minerals (in order of importance)

Enzymes:

- Understand the function and mode of action of enzymes
- Know the concept and mechanism of enzyme kinetics
- Memorize the relationship between enzyme reaction rates and environmental factors such as pH, temperature and substrate concentration
- Understand how enzymes are controlled and regulated - particular emphasis on feedback inhibition

Cellular Metabolism:

- Understand the process of glycolysis & its stages; memorize where it occurs and its substrate and end products (i.e. net yield of ATP, NADH etc)
- Know the difference between anaerobic vs. aerobic respiration and the location, substrates and end products of each
- Remember the difference between substrate level vs. oxidative phosphorylation
- Memorize the high-energy products (NADH, FADH₂, ATP) of glycolysis and Krebs cycle
- Understand how and where the electron transport chain works, and why is oxygen important for the process

Genes

- Know the central dogma of gene expression: DNA → RNA → protein

DNA structure and function:

- Be aware of the structure of DNA: polymer of nucleotides, double helix, helical twist, 5' → 3' direction, complimentary strands
- Know the composition of DNA: pyrimidines, purines, base-pair (bp) rules, number/type of bonds between bp, structure of nucleotide

DNA replication:

- Know the steps involved in DNA replication and the enzymes that play important roles (helicase, RNA/DNA polymerase etc)
- Memorize the kinetics and characteristics of DNA replication (fast, semicontinuous)

RNA:

- Be able to list all the differences between DNA and RNA
- Memorize the 3 major types of RNA and their function

Transcription:

- Know the steps and enzymes involved in the process of transcription in eukaryotes and prokaryotes
- Understand how the *lac* operon works
- Know the sequence of post-transcriptional processing modifications that occur

DNA technology:

- Understand the steps/enzymes involved in making recombinant DNA, cloning DNA
- Understand the concept of PCR and how it works
- Know the following experimental techniques and what they are used for: southern, northern and western blotting

Translation:

- Memorize the start and stop codons
- Understand the principle behind the genetic code formation: be able to understand how AA are coded by nucleotides
- Understand the process of translation (initiation, elongation and termination) and the role of mRNA, tRNA, rRNA

Mutations:

- Know the difference between gene vs. chromosomal mutation, somatic vs. germ line mutation, advantageous vs. deleterious mutations
- Know the different types of mutations: base pair vs. insertion/deletion, missense vs. nonsense, frameshift vs. non-frameshift mutation
- Understand how mutations lead to cancer

Chromosomes:

- Know the eukaryotic chromosomal arrangement (histone, nucleosome, chromatin)
- Know the terminology (diploid, homologues, haploid etc)

Cell cycle, mitosis, meiosis:

- Be able to list the phases of cell cycle and know what happens in each
- Know the basic conditions that define each phase of mitosis
- Know the names of cells at different stages and whether or not these cells are haploid/diploid
- Know the difference between mitosis and meiosis
- Understand the concept of gene segregation and sex-linked characteristics
- Be aware of developmental mechanisms involved in cell specialization, differentiation and gene regulation in development

Microbiology

Virus Structure:

- Know the structure of viruses: capsid, nucleic acid content, protein-envelope etc
- Be aware of differences in viruses and bacterium/eukaryotic cells in terms of size, life cycle, reproduction
- Know difference between lytic and lysogenic infection
- Know about viruses classified by nucleic acid content; virions; retrovirus life cycle
- Understand concept of antibiotics, drug resistance and vaccines

Prokaryotes:

- Know difference between archaea and bacteria
- Be aware of classification system based on 1) energy source 2) carbon source

- Know structural differences between prokaryotes vs. eukaryotes
- Know the major classification of bacteria based on shape, presence of cell wall type
- Understand how bacteria uses the flagella to move
- Memorize the 3 forms of genetic recombination used by bacteria (conjugation, transformation, transduction) and their mechanisms
- Understand the process of binary fission

Fungi:

- Memorize basics about fungi – eukaryotes or prokaryotes, energy source, nucleic acid content, method of reproduction

Membranes and membrane transport:

- Be familiar with the fluid mosaic model of membrane
- Know structure of phospholipid membrane
- Know the type and function of membrane bound proteins
- Understand and memorize the concept and characteristics of passive diffusion, facilitated diffusion and active transport
- Know the sodium/potassium pump

The Eukaryotic Cell; Nervous System

Eukaryotic cell:

- Memorize the characteristics of a eukaryotic cell and the membrane bound structures within along with their functions (endoplasmic reticulum, rough ER, smooth ER, Golgi apparatus, lysosomes, peroxisomes)
- Understand the basic concept of endocytosis and exocytosis
- Know difference between cytoskeletal filaments (microfilaments, microtubules, flagella and cilia)
- Remember the 3 types of cellular junctions
- Memorize the parts of the mitochondria and their purpose – connect structures with aerobic respiration
- Understand the concept of the extracellular matrix

Nervous System:

- Know the basic anatomy of a neuron and how signals travel through it
- Understand and memorize the dynamics of an action potential
- Understand the structure of a chemical synapse
- Recognize a second messenger system, G-protein coupled receptors, adenylate cyclase
- Know the general functions of support cells in the nervous tissue
- Be clear about the structure of the nervous system: CNS vs. PNS, sympathetic vs. parasympathetic nervous systems, somatic vs. autonomic
- Be very familiar with neurotransmitters such as acetylcholine, epinephrine, norepinephrine and their receptors
- Memorize reflexes esp. the reflex arc, feedback loop
- Understand the concept of sensory receptors and how they function

- Be aware of basic anatomy of the eye: understand how the lens of an eye works and the difference between cones and rods
- Be aware of the basic anatomy of the ear and their function

The Endocrine System

- Be aware of the difference between an endocrine system and nervous system
- Know about the 3 different types of hormones and where and how each of these types of hormones reacts and which gland produces them
- Memorize the peptide hormones produced by the anterior/posterior pituitary, parathyroid hormone, and pancreatic hormones: insulin and glucagons
- Memorize the steroid hormones and tyrosine hormones
- Understand clearly the process of negative feedback and how it works
- Know the hormones produced by the male and female reproductive systems and their functions

The Digestive System and the Excretory System

- Know digestion starts in mouth; the function of peristalsis
- Be aware of the different type of cells in the stomach and the primary function of stomach itself
- Know the pancreatic enzymes and their functions in the small intestine
- Understand the purpose of bile
- Know the function of small and large intestine and the concept of digestion
- Be aware of the process of carbohydrate, protein and fat digestion, absorption and metabolism – relate to glycolysis and Krebs cycle
- Be aware of the major functions of liver and kidney
- Know the function of each section of nephron, loop of Henle, distal tubule, collecting duct, and the overall function of kidney
- Understand the effect of ADH on kidney function
- Understand the mechanism of urine formation

The Cardiovascular System and the Respiratory System

Cardiovascular System:

- Know the function of the different parts of the heart, the pulmonary and systemic systems
- Be aware of the nerve innervating the heart and its effect (vagus)
- Understand how blood flows through an organism (arteries, veins, oxygenated vs. deoxygenated blood)
- Be aware of the relationship between blood pressure and volume and peripheral resistance
- Know the blood pressure formulas

Respiratory System:

- Know the basic anatomy and function of the respiratory system
- Understand the concept of gas exchange and the mechanisms involved
- Know the effects of temperature, pH and carbon dioxide pressure on hemoglobin

- Be able to read a dissociation curve and predict shifts
- Understand the relation between rate of breathing and carbon dioxide, pH, and oxygen levels in blood
- Know the effect nitrogen can have on body
- Be aware of the differential pressure involved in breathing: pressure of oxygen, carbon dioxide, alveolar and arterial pressure

Lymphatic System:

- Know the basic function of the lymphatic system and its structure

Blood System:

- Know the different components of blood and the function of each
- Understand the process of coagulation and what it requires to work
- Know the different blood types

Immune System:

- Memorize the type and function of the different cells of the immune system
- Know the steps involved in response to a bacterial inflammation
- Be aware of the tissues involved in immune system response
- Understand the concept of antigens, antibodies, cytokines, septic shock

Muscle, Bone and Skin

Muscle:

- Know the 3 types of muscles and their 4 possible functions
- Know how the concept of leverage applies to a biological system
- Be aware of the organization of contractile elements: actin, myosin filaments, cross-bridges, sliding filament model
- Know the structure of sarcomeres and the function of each and how it regulates muscle contraction
- Recognize importance of calcium in muscle contraction, of sarcoplasmic reticulum and T-tubules
- Know what is a motor unit
- Know the different types of skeletal muscles

Bone:

- Know the function of bones and the 4 types of cells it has
- Know function of osteoblasts, osteocytes and osteoclasts
- Understand the different types of joints in the body

Skin:

- Know the specific functions of skin and how it achieves its purposes
- Be aware of the structure of skin particularly layer differentiation

Populations

Mendelian Genetics:

- Memorize the terminology: dominant, recessive traits, F1 generation, homozygous, heterozygous, recessive traits, allele, locus, complete dominance etc
- Know the test-cross model and how to use the punnett square
- Know the concepts of inbreeding and outbreeding
- Know the laws and their applications

Evolution

- Be aware of the taxonomical classification system
- Understand how ontogeny shows phylogeny
- Know the concept of species, survival of the fittest, and relationships between species
- Be familiar with the Hardy-Weinberg Equilibrium
- Have a basic understanding of chordate features