AAMC'S COMPLETE LIST OF
CHEMICAL AND PHYSICAL FOUNDATIONS OF BIOLOGICAL SYSTEMS

BIO/BIOCHEM FOUNDATIONS OF LIVING SYSTEMS

1A. Structure and function of proteins and amino acids
1B. Transmission of genetic information from the gene to the protein
1C. Transmission of heritable information and the processes of genetic diversity
1D. Principles of bioenergetics and fuel molecule metabolism
2A. Assemblies of molecules, cells, and groups of cells within organisms
2B. The structure, growth, physiology, and genetics of prokaryotes and viruses
2C. Processes of cell division, differentiation, and specialization
3A. The nervous and endocrine systems and their coordinations of the organ systems
3B. Structure and integrative functions of the main organ systems

DETAILED BREAKDOWN ON SUBSEQUENT PAGES OF THIS DOC

1A. STRUCTURE AND FUNCTION OF PROTEINS AND AMINO ACIDS

Amino Acids: Absolute configuration at the α position; Amino acids as dipolar ions
Classifications (Acidic or basic, hydrophobic or hydrophilic)
Amino Acid Reactions: Sulfur linkage [cysteine and cystine]; peptide linkage in proteins, hydrolysis
Protein Structure (1st, 2nd, 3rd, and 4th degree structures)
Roles of proline, cystine, hydrophobic bonding in 3rd degree protein structures
Conformational stability (denaturing and folding, hydrophobic interactions, solvation layer [entropy])
Separation techniques (Isoelectric point, Electrophoresis)
Non-Enzymatic Protein Function (Binding, immune system, motors)
Enzyme classification by reaction type, function of enzymes in catalyzing biological reactions
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
Kinetics (general/catalyst, Michaelis-Menten, cooperativity)
Feedback regulation
Inhibition (competitive, noncompetitive, mixed, uncompetitive)
Regulatory enzymes (allosteric enzymes, covalently-modified enzymes, zymogen)

1B. TRANSMISSION OF GENETIC INFORMATION FROM GENE TO THE PROTEIN

Nucleotides and nucleosides (sugar, phosphate backbone, pyrimidine, purine residues)
Deoxyribonucleic acid, double helix, Watson-Crick model of DNA
Base pairing specificity: A with T, G with C
DNA denaturation, reannealing, hybridization
Mechanism of DNA 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
DNA Repair during replication, repair of DNA mutations
Central Dogma: DNA → RNA → protein, the triplet code
Codon–anticodon relationship, degenerate code, wobble pairing
Codons: missense, nonsense, initiation, termination codons
Messenger RNA (mRNA), transcription/mechanisms of transcription
Transfer RNA (tRNA); ribosomal RNA (rRNA)
mRNA processing in eukaryotes, introns, exons
Ribozymes, spliceosomes, snRNPs, snRNAs
Functional and evolutionary importance of introns
Translation: Roles of mRNA, tRNA, rRNA, role and structure of ribosomes
Initiation, termination cofactors
Post-translational modification of proteins
Eukaryotic chromosomal proteins, single copy vs. repetitive DNA, supercoiling
Heterochromatin vs. euchromatin
Telomeres, centromeres
Control of Gene Expression in Prokaryotes
Operon Concept, Jacob–Monod Model
Gene repression in bacteria, positive control in bacteria
Gene Expression in Eukaryotes (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 (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
Practical applications of stem cells and DNA technology: medical applications, human gene therapy, pharmaceuticals, forensic evidence, environmental cleanup, agriculture
Safety and ethics of DNA technology

1C. TRANSMISSION OF HERITABLE INFORMATION ACROSS GENERATIONS AND THE PROCESSES THAT INCREASE GENETIC DIVERSITY

Mendelian Concepts, 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
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, sex determination (few genes on Y chromosome,extranuclear inheritance)
General types of mutation, DNA sequencing, advantageous vs deleterious mutation
Types of mutations: random, translation error, transcription error, base substitution, inversion, addition, deletion, translocation, mispairing
Inborn errors of mutation , relationship of mutations to carcinogens
Genetic drift
Synapsis or crossing-over mechanism for increasing genetic diversity
Hardy–Weinberg Principle
Testcross (Backcross; concepts of parental, F1, and F2 generations)
Gene mapping: crossover frequencies, biometry: statistical methods
Natural selection Fitness concept (differential reproduction, group selection, evolutionary success)
Speciation (polymorphism, adaptation and specialization, inbreeding, outbreeding, bottlenecks)
Evolutionary time as measured by gradual random changes in genome

1D. STRUCTURE AND FUNCTION OF PROTEINS AND AMINO ACIDS

Bioenergetics/thermodynamics
Free energy/*K*eq, equilibrium constant, relationship of the equilibrium constant and $\Delta G°$
Concentration, Le Châtelier's Principle
Endothermic/exothermic reactions
Free energy: *G,* Spontaneous reactions and $\Delta G°$
Phosphoryl group transfers and ATP (ATP hydrolysis $\Delta G << 0$; ATP group transfers)
Biological oxidation-reduction (half-reactions, soluble electron carriers, flavoproteins)
Carbohydrates: nomenclature and classification, common names, absolute configuration
Cyclic structure and conformations of carbohydrate hexoses
Epimers and anomers
Hydrolysis of the glycoside linkage
Monosaccharides, disaccharides, polysaccharides
Glycolysis, Gluconeogenesis, and the Pentose Phosphate Pathway
Glycolysis (aerobic), substrates and products, feeder pathways: glycogen, starch metabolism)
Fermentation (anaerobic glycolysis)
Gluconeogenesis pentose phosphate pathway, net molecular and energetic results of respiration
Principles of Metabolic Regulation
Regulation of metabolic pathways, maintenance of a dynamic steady state
Regulation of glycolysis and gluconeogenesis
Metabolism of glycogen, regulation of glycogen synthesis and breakdown
Allosteric and hormonal control
Citric Acid Cycle
Acetyl-CoA production, reactions of the cycle, substrates and products
Regulation of the cycle, net molecular and energetic results of respiration processes
Description and metabolism of fatty acids
Digestion, mobilization, and transport of fats
Oxidation of fatty acids
Saturated and unsaturated fats
Ketone bodies, anabolism of fats
Non-template synthesis: biosynthesis of lipids and polysaccharides
Metabolism of proteins
Oxidative Phosphorylation
Electron transport chain and oxidative phosphorylation, substrates and products, 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
Hormonal Regulation and Integration of Metabolism
Higher level integration of hormone structure and function
Tissue specific metabolism
Hormonal regulation of fuel metabolism
Obesity and regulation of body mass

2A. ASSEMBLIES OF MOLECULES, CELLS, AND GROUPS OF CELLS WITHIN SINGLE CELLULAR AND MULTICELLULAR ORGANISMS

Plasma Membrane, function in cell containment, composition of membranes
Lipid components (Phospholipids and phosphatides, Steroids, Waxes
Protein components, fluid mosaic model
Membrane dynamics, solute transport across membranes
Osmosis: Colligative properties; osmotic pressure
Passive and active transport; sodium/potassium pump
Membrane channels, potential, and receptors
Exocytosis and endocytosis
Intercellular junctions: gap junctions, tight junctions, desmosomes
Defining characteristics of eukaryotic cells: membrane bound nucleus, 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, self-replication
Lysosomes: membrane-bound vesicles containing hydrolytic enzymes
Endoplasmic reticulum: Rough and smooth components, rough endoplasmic reticulum site of ribosomes
Endoplasmic reticulum membrane: structure, membrane biosynthesis, secreted proteins
Golgi apparatus: general structure and role in packaging and secretion
Peroxisomes: organelles that collect peroxides
Cytoskeleton: 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: epithelial cells, connective tissue cells

2B. THE STRUCTURE, GROWTH, PHYSIOLOGY, AND GENETICS OF PROKARYOTES AND VIRUSES

Cell Theory: history and development, impact on biology
Classification and Structure of Prokaryotic Cells
Prokaryotic domains: archaea, bacteria
Major classifications of bacteria by shape: Bacilli, Spirilli, Cocci
Bacteria: lack of nuclear membrane and mitotic apparatus, and typical eukaryotic organelles
Presence of cell wall in bacteria, Flagellar propulsion, mechanism
Growth and Physiology of Prokaryotic Cells
Bacteria: Reproduction by fission, high degree of genetic adaptability, acquisition of antibiotic resistance
Bacteria: Exponential growth, existence of anaerobic and aerobic variants
Parasitic and symbiotic, Chemotaxis
Genetics of Prokaryotic Cells: plasmids, extragenomic DNA
Transformation: incorporation into bacterial genome of DNA fragments from external medium
Conjugation and Transposons in prokaryotic cells
Virus Structure: nucleic acid and protein, enveloped and nonenveloped
Viruses lack organelles and nucleus
Viruses: Structural aspects of typical bacteriophage
Viruses: Genomic content — RNA or DNA
Viruses: Size relative to bacteria and eukaryotic cells
Virus Life Cycle: Self-replicating biological units that must reproduce within specific host cell
Generalized phage and animal virus life cycles (attachment to host, replication, release)
Transduction: transfer of genetic material by viruses
Retrovirus life cycle: integration into host DNA, reverse transcriptase, HIV
Prions and viroids: subviral particles

2C. PROCESSES OF CELL DIVISION, DIFFERENTIATION, AND SPECIALIZATION

Mitotic process: prophase, metaphase, anaphase, telophase, interphase
Mitotic structures: (Centrioles, asters, spindles, Chromatids, centromeres, kinetochores)
Nuclear membrane breakdown and reorganization
Mechanisms of chromosome movement
Phases of cell cycle: G0, G1, S, G2, M
Loss of cell cycle controls in cancer cells
Oncogenes, apoptosis
Gametogenesis by meiosis (ovum and sperm: formation, morphology, genetic contributions)
Reproductive sequence: fertilization; implantation; development; birth
Embryogenesis: Stages of early development (order and general features of each)
Formation of primary germ layers (endoderm, mesoderm, ectoderm)
Neurulation, Neural crest
Environment–gene interaction in germ layer development
Cell specialization: (determination, differentiation, tissue types)
Cell–cell communication in development
Pluripotency: stem cells
Gene regulation in development
Programmed cell death
Existence of regenerative capacity in various species
Senescence and aging

3A. STRUCTURE AND FUNCTION OF PROTEINS AND AMINO ACIDS

Major Functions of nervous system: (integration of body systems, adaptive capability)
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 of nervous system with endocrine system: feedback control
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
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: Concentration cell: direction of electron flow, Nernst equation
Biosignalling
Gated ion channels (voltage, ligand)
Receptor enzymes
G protein-coupled receptors
Lipids (description, structure, steroids, terpenes, and terpenoids)
Function of endocrine system: specific chemical control at cell, tissue, and organ level
Definitions of endocrine gland, hormone
Major endocrine glands and types of hormones: names, locations, products
Neuroendrocrinology — relation between neurons and hormonal systems
Cellular mechanisms of hormone action
Transport of hormones: blood supply
Specificity of hormones: target tissue
Regulation by second messengers

3B. STRUCTURE AND FUNCTION OF THE MAIN ORGAN SYSTEMS

Respiratory System : Gas exchange, thermoregulation
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)
pH control
Circulatory System Functions: circulation of oxygen, nutrients, hormones, removal of metabolic waste)
Four-chambered heart: structure and function
Endothelial cells
Systolic and diastolic pressure
Pulmonary and systemic circulation
Arterial and venous systems (arteries, arterioles, venules, veins)
Capillary beds: (Mechanisms of gas and solute exchange, heat exchange, peripheral resistance)
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
Structure and functions of lymphatic system
Lymphatic transport of proteins and large glycerides
Production of lymphocytes involved in immune reactions
Immune System

- Innate (nonspecific) vs adaptive (specific) immunity
- Adaptive immune system cells: T-lymphocytes, B-lymphocytes
- Innate immune system cells (macrophages, phagocytes)
- Tissues & immune system (Bone marrow, Spleen, Thymus, Lymph nodes)
- Concept of antigen and antibody
- Antigen presentation, Clonal selection, Antigen-antibody recognition
- Recognition of self vs. non-self, autoimmune diseases
- Major histocompatibility complex

Digestive System
Ingestion: Saliva as lubrication and source of enzymes, Ingestion; esophagus, transport function)
Stomach: Structure, function, storage and churning of food
Stomach: Low pH, gastric juice, mucal protection against self-destruction
Stomach's production of digestive enzymes, site of digestion
Liver: Structure, production of bile, role in blood glucose regulation and detoxification)
Pancreas: enzymes and relationship to small intestines
Small Intestine: Function and structure of villi, enzymes, site of digestion, neutralization of stomach acid
Large Intestine: Absorption of water, Bacterial flora
Rectum: storage and elimination of waste, feces

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Digestion and muscular control, peristalsis
Digestion and nervous control: the enteric nervous system
Excretory System & homeostasis: (Blood pressure, Osmoregulation, Acid–base balance, nitrogenous waste)
Kidney structure, Cortex, Medulla
Nephron structure
Formation of urine: Glomerular filtration, Counter-current multiplier mechanism)
Storage and elimination: ureter, bladder, urethra
Osmoregulation: capillary reabsorption of H2O, amino acids, glucose, ions
Muscular control: sphincter muscle
Male and female reproductive structures and their functions
Hormonal control of reproduction
Male and female sexual development
Female reproductive cycle
Pregnancy, parturition, lactation
Muscle System: Important functions, Peripheral circulatory assistance, thermoregulation (shivering reflex)
Structure of three basic muscle types: striated, smooth, cardiac
Muscle structure & control of contractions: T-tubule system, contractile, apparatus, sarcoplasmic reticulum
Contractile velocity of different muscle types
Regulation of cardiac muscle contraction
Neuromuscular junction, motor end plates
Muscles and Sympathetic and parasympathetic innervation
Voluntary and involuntary muscles
Structural characteristics of striated, smooth, and cardiac muscle
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: functions: rigidity, support, calcium storage
Skeletal system: structure
Bone structure: Calcium/protein matrix, Cellular composition of bone
Cartilage and ligaments: structure and function
Skin: Structure and functions, Layer differentiation, cell types
Skin & functions in homeostasis, osmoregulation, and thermoregulation
Hair, erectile musculature
Sweat glands, location in dermis
Vasoconstriction and vasodilation in surface capillaries
Physical properties of nails, calluses, hair
Hormonal control: sweating, vasodilation, and vasoconstriction