**AP Biology Major Topics Review**

**Evolution**

* Natural selection
* The evolution of beneficial adaptations
* Hardy-Weinberg genetic equilibrium and equations
* Evidence of evolution
* Phylogenetic trees and cladograms
* Speciation

**Ecology**

* Exponential vs. Logistic population growth and their respective equations
* Population limiting factors and carrying capacity
* Ecosystem interdependence and balance
* Energy and biomass pyramids, 10% rule, 1st and 2nd laws of thermodynamics
* The important role of autotrophs and primary productivity in an ecosystem
* The biogeochemical cycles of matter through ecosystems (especially water, carbon, nitrogen, and phosphorous)

**Animal Behavior**

* Innate vs. Learned behaviors
* Photoperiod, nocturnal vs. diurnal behaviors, circadian (daily) rhythms vs. circannual (yearly) rhythms.

**Origins of Life**

* Miller and Urey experiment: simple, inorganic molecules can become complex, organic molecules
* RNA world hypothesis
* Characteristics shared by all forms of life: cell membrane, genetic material, enzymes, glycolysis.
* Cell membrane structure and function
* Endosymbiosis to form chloroplasts and mitochondria

**Enzymes**

* Protein structure: primary, secondary, tertiary, and quarternary
* The importance of protein shape and surface chemistry in determining function.
* An enzyme’s active site where the reaction with substrate occurs.
* Optimum conditions for enzyme function, especially temperature, pH, and the presence or absence of inhibitors.
* Enzyme denaturation.

**Cell Function**

* Properties of water due to its polarity and hydrogen bonding.
* Cell membranes are selectively permeable.
* Passive transport does not require energy: simple diffusion, facilitated diffusion, osmosis.
* Water potential and the water potential equations to determine the movement of water across a membrane via osmosis.
* Use of the terms isotonic, hypertonic, and hypotonic to compare the solute concentrations of two solutions.
* Active transport requires energy and uses protein “pumps” embedded in the membrane.
* Endocytosis and exocytosis.
* Structure of a neuron: dendrites, cell body, axon, axon terminals.
* Function of a neuron: action potentials and neurotransmitters. Electro-chemical signaling.

**Cell Communication**

* Signal 🡪 Receptor 🡪 Pathway 🡪 Response
* Short vs. long distance cell communication
* Types of receptors: cell membrane embedded vs. cytoplasmic
* Hormone signaling: use of chemical signals released into the bloodstream
* Positive and negative feedback for cell communication

**Photosynthesis**

* Autotrophic organisms can perform photosynthesis or chemosynthesis
* Chloroplast arose via endosymbiosis of photosynthetic bacteria
* Structure of a chloroplast: double membrane, thylakoid membranes, stroma, chlorophyll molecules embedded in photosystems, electron transport chain, ATP synthase, Calvin cycle enzymes
* The overall equation for photosynthesis: CO2 + H2O + Light energy 🡪 C6H12O6 + 02
* The light-dependent reactions of photosynthesis use light energy to create NADPH and ATP.
* The light-independent reactions of photosynthesis use the energy of NADPH and ATP and the enzymes of the Calvin Cycle to create sugars.

**Plant Transport and Transpiration**

* Leaves have many small openings for gas exchange called stomata.
* Transpiration is the loss of water vapor from plants primarily through stomata during gas exchange for photosynthesis.
* A plant uses xylem vessels to transport water and dissolved minerals from roots to stem to branches to leaves.
* A plant uses phloem vessels to transport dissolved sugars and nutrient-rich sap to all parts of the plant.

**Cell Energetics**

* Glycolysis is the first, fundamental step in converting sugars to ATP. Glycolysis produces 2 ATP molecules per sugar.
* Almost all forms of life perform glycolysis; it evolved very early.
* Fermentation (lactic acid fermentation and alcohol fermentation) increase the efficiency of glycolysis by regenerating NAD+ for glycolysis.
* Glycolysis and fermentation do not require oxygen.
* Aerobic respiration does use oxygen and typically takes place in the mitochondria.
* The overall equation of aerobic cellular respiration is: C6H12O6 + O2 🡪 CO2 + H2O + ATP
* Mitochondria arose by the endosymbiosis of aerobic bacteria.
* Structure of a mitochondria: outer and inner membranes, cristae folds, intermembrane space, and matrix.
* Mitochondria use the enzymes of the Krebs cycle (Citric acid cycle) to convert pyruvate from glycolysis into NADH, FADH2, and ATP.
* Mitochondria use the ETC and ATP synthase to convert NADH and FADH2 into even more ATP.
* Chemiosmosis is the use of a proton gradient created by the ETC to create ATP.
* Aerobic cellular respiration produces approximately 32 ATP per sugar.

**Gibbs Free Energy**

* The Gibbs free energy equation reveals whether a given chemical reaction is energetically favorable and spontaneous or energetically unfavorable and not spontaneous.
* In biology, generally speaking, biochemical reactions that build molecules (anabolic) and create or maintain order require free energy. Biochemical reactions that take molecules apart (catabolic) and create more disorder are spontaneous and favorable and release free energy.
* As a result, the energy released by catabolic reactions often drives anabolic reactions. Most notably, the hydrolysis of ATP is often used by cells to drive cell chemistry and make cell reactions favorable.

**Body Systems**

* The need to maintain homeostasis via positive and negative feedback mechanisms.
* Ectotherm vs. Endotherm body temperature regulation.
* Respiratory systems for gas exchange.
* Circulatory systems to circulate and transport materials throughout the body of an organism. The evolution of the circulatory system.
* Digestive systems to break down and absorb consumed nutrients.
* Excretory systems to eliminate nitrogenous waste from the body, but also to maintain the body’s salt and water balance (osmoregulation).
* Immune system to protect from pathogen infection. Non-specific defenses vs. specific defenses. Specific defenses include B cells and antibodies, Helper T cells, and Cytotoxic (killer) T cells.

**Asexual and Sexual Reproduction**

* The cell cycle: interphase (G1, S, G2), M phase, and cytokinesis.
* Cell cycle control using cyclins, CDKs, and check points.
* Loss of cell cycle control leads to tumor or cancer.
* The role of mitosis to carefully separate copied chromosomes to each daughter cell. Mitotic daughter cells are genetically identical.
* The structure of a nucleotide: phosphate, sugar, base.
* The structure of DNA: base-pairing, double helix, antiparallel strands, 5’ to 3’ directionality.
* Circular prokaryotic chromosomes vs. linear eukaryotic chromosomes
* DNA replication: semi-conservative process; the roles of helicase, DNA polymerase, and ligase; production of leading and lagging strands; Okazaki fragments.
* The role of meiosis to create genetically unique, haploid reproductive cells called gametes. Genetic diversity and variation created through crossing over, independent assortment, and fertilization.

**Inheritance and Genetics**

* Punnett squares: monohybrid and dihybrid crosses
* Genotype and phenotype
* Patterns of inheritance: dominant/recessive, incomplete dominant, codominant, sex-linked, and linked genes.
* Use of the Chi-Square test to statistically analyze observed vs. expected outcomes.

**Gene Expression and Gene Regulation**

* The different types and roles of RNA: mRNA, tRNA, rRNA
* Transcription is the process that converts DNA code into an mRNA message using the enzyme RNA polymerase.
* Eukaryotic mRNA is processed: 5’ cap, 3’ tail, and introns spliced out.
* Role of alternative splicing.
* Translation is the process of converting an mRNA message into protein using ribosomes. mRNA attaches to a ribosome. tRNAs deliver the appropriate amino acids. The ribosome reads the mRNA and builds the protein.
* A codon table can be used to convert mRNA codons into amino acids.
* DNA mutations can be positive, negative, or neutral to the cell and organism.
* Types of DNA point mutations: silent, missense, nonsense, and frame shift.
* Chromosomal mutations involve entire chromosomes or sections of a chromosome: deletion, inversion, duplication, and translocation.
* Different types of genetic engineering: restriction enzymes to cut DNA, gel electrophoresis to separate pieces of DNA, PCR to copy large amounts of DNA, and gene sequencing to determine the code.
* The use of plasmids, viruses, and direct DNA insertion to add genes to an organism’s genome.
* Prokaryotic gene regulation using the lac operon as an example.
* DNA sequences that act as promoters, enhancers, and silencers.
* Transcription factor proteins that bind to DNA sequences to enhance or repress gene expression.
* Eukaryotic organisms rely on transcription factors to orchestrate the activation of genes on multiple chromosomes.