AP Biology – Fall Semester Review

Introduction: Themes in the Study of Life
Exploring Life on its Many Levels
- Diagram the hierarchy of structural levels in biology.
- Explain how the properties of life emerge from complex organization.
- Describe the seven properties of life.
- Describe the dilemma of reductionism.
- Explain what is meant by "form fits function."
- Explain how regulatory mechanisms control reactions in organisms.

Science as a Process
- Outline the scientific method.
- Distinguish between a scientific hypothesis and a scientific theory.

Chemical Elements and Compounds
- Distinguish between an element and a compound.

Exploring Life on its Many Levels
- Identify the four elements that make up 96% of living matter.

Atoms and Molecules
- Describe the structure of an atom.
- Define and distinguish among atomic number, mass number, atomic weight, and valence.
- Explain why radioactive isotopes are important to biologists.
- Explain how its electron configuration influences the chemical behavior of an atom.
- Distinguish among nonpolar covalent, polar covalent, and ionic bonds.
- Explain why weak bonds are important to living organisms.
- Describe and compare hydrogen bonds and van der Waals interactions.
- Explain how a molecule's shape influences its biological function.
- Describe how the relative concentrations of reactants and products affect a chemical reaction.

Effects of Water's Polarity
- Describe how water contributes to the fitness of the environment to support life.
- Describe the structure and geometry of a water molecule, and explain what properties emerge as a result of this structure.
- Explain the relationship between the polar nature of water and its ability to form hydrogen bonds.
- List four characteristics of water that are emergent properties resulting from hydrogen bonding.
- Describe the biological significance of the cohesiveness of water.
- Explain how water's high specific heat, high heat of vaporization, and expansion upon freezing affect both aquatic and terrestrial ecosystems.
- Distinguish among a solute, a solvent, and a solution.
- Explain how the polarity of the water molecule makes it a versatile solvent.
- Distinguish between hydrophilic and hydrophobic substances.
- Distinguish between a mole and the molecular weight of a substance.

Dissociation of Water Molecules
- Explain how acids and bases directly or indirectly affect the hydrogen ion concentration of a solution.
- Describe the causes of acid precipitation and explain how it harms the environment.

The Importance of Carbon
- Explain how carbon's electron configuration determines the kinds and numbers of bonds that carbon will form.
- Describe how carbon skeletons may vary, and explain how this variation contributes to the diversity and complexity of organic molecules.
- Distinguish among the three types of isomers: structural, geometric, and enantiomer.

Functional Groups
- Name the major functional groups and describe the chemical properties of the organic molecules in which they occur. Polymer Principles
- Explain how monomers are used to build polymers.
- List the four major classes of macromolecules.
- Compare condensation and hydrolysis.
- Explain how organic polymers contribute to biological diversity.
Carbohydrates: Fuel and Building Material
- Describe the distinguishing characteristics of carbohydrates and explain how they are classified.
- Distinguish between monosaccharides and disaccharides.
- Identify a glycosidic linkage and describe how it is formed.
- Describe the structure and functions of polysaccharides.
- Distinguish between the glycosidic linkages found in starch and cellulose and explain why the difference is biologically important.

Lipids: Diverse Hydrophobic Molecules
- Explain what distinguishes lipids from other major classes of macromolecules.
- Describe the unique properties, building-block molecules, and biological importance of the three important groups of lipids: fats, phospholipids, and steroids.
- Identify an ester linkage and describe how it is formed.
- Distinguish between a saturated and an unsaturated fat and list some unique emergent properties that are a consequence of these structural differences.

Proteins: Many Structures, Many Functions
- Describe the characteristics that distinguish proteins from the other major classes of macromolecules and explain the biologically important functions of this group.

Science as a Process
- List and describe the four major components of an amino acid. Explain how amino acids may be grouped according to the physical and chemical properties of the side chains.
- Identify a peptide bond and explain how it is formed.
- Distinguish between a polypeptide and a protein.
- Explain what determines protein conformation and why it is important.
- Define primary structure and describe how it may be deduced in the laboratory.
- Describe the two types of secondary protein structure. Explain the role of hydrogen bonds in maintaining the structure.
- Explain how weak interactions and disulfide bridges contribute to tertiary protein structure.
- Using collagen and hemoglobin as examples, describe quaternary protein structure.
- Define denaturation and explain how proteins may be denatured.

Nucleic Acids: Informational Polymers
- Describe the characteristics that distinguish nucleic acids from the other major groups of macromolecules.
- Summarize the functions of nucleic acids.
- List the major components of a nucleotide, and describe how these monomers are linked to form a nucleic acid.
- Distinguish between a pyrimidine and a purine.
- Briefly describe the three-dimensional structure of DNA.
- Explain how the structure of DNA and proteins can be used to document the hereditary background of an organism.

Metabolism, Energy, and Life
- Explain the role of catabolic and anabolic pathways in the energy exchanges of cellular metabolism.
- Distinguish between kinetic and potential energy.
- Distinguish between open and closed systems.
- Explain, in your own words, the first and second laws of thermodynamics.
- Distinguish between exergonic and endergonic reactions.
- Describe the three main kinds of cellular work.

Evolution, Unity, and Diversity
- List the three components of ATP and identify the major class of macromolecules to which ATP belongs.
- Explain how ATP performs cellular work.

Enzymes
- Describe the function of enzymes in biological systems.
- Explain the relationship between enzyme structure and enzyme specificity.
- Explain the induced-fit model of enzyme function and describe the catalytic cycle of an enzyme.
- Describe several mechanisms by which enzymes lower activation energy.
- Explain how substrate concentration affects the rate of an enzyme-controlled reaction.
- Explain how enzyme activity can be regulated or controlled by environmental factors, co-factors, and enzyme inhibitors.
AP Biology – Fall Semester Review

How We Study Cells
• Distinguish between magnification and resolving power.
• Describe the principles, advantages, and limitations of the light microscope, transmission electron microscope, and scanning electron microscope.
• Describe the major steps of cell fractionation and explain why it is a useful technique.

A Panoramic View of the Cell
• Distinguish between prokaryotic and eukaryotic cells.
• Explain why there are both upper and lower limits to cell size.
• Explain why compartmentalization is important in eukaryotic cells.

The Nucleus and Ribosomes
• Describe the structure and function of the nucleus and briefly explain how the nucleus controls protein synthesis in the cytoplasm.
• Describe the structure and function of a eukaryotic ribosome.

The Endomembrane System
• List the components of the endomembrane system, describe their structures and functions, and summarize the relationships among them.
• Explain how impaired lysosomal function can cause the symptoms of storage diseases.
• Describe the different structures and functions of vacuoles.
• Describe the structure of a mitochondrion and explain the importance of compartmentalization in mitochondrial function.

Evolution, Unity, and Diversity
• Distinguish among amyloplasts, chromoplasts, and chloroplasts.
• Identify the three functional compartments of a chloroplast. Explain the importance of compartmentalization in chloroplast function.

Other Membranous Organelles
• Explain the roles of mitochondria and chloroplasts.
• Explain the role of peroxisomes in eukaryotic cells.

The Cytoskeleton
• Describe the functions of the cytoskeleton.
• Describe the structure, monomers, and functions of microtubules, microfilaments, and intermediate filaments.
• Explain how the ultrastructure of cilia and flagella relate to their functions.

Cell Surfaces and Junctions
• Describe the structure and list four functions of the extracellular matrix in animal cells.
• Describe the structures of intercellular junctions found in plant and animal cells and relate those structures to their functions.

Membrane Structure
• Describe the properties of phospholipids and their arrangement in cellular membranes.
• Explain what freeze-fracture techniques reveal about the involvement of proteins in membranes.
• Describe the fluid properties of the cell membrane and explain how membrane fluidity is influenced by membrane composition.
• Describe how proteins and carbohydrates are spatially arranged in cell membranes and how they contribute to membrane function.

Traffic across Membranes
• Describe factors that affect the selective permeability of membranes.
• Describe the locations and functions of transport proteins.
• Define diffusion. Explain what causes diffusion and why it is a spontaneous process.
• Explain what regulates the rate of passive transport.
• Explain why a concentration gradient across a membrane represents potential energy.
• Distinguish between hypertonic, hypotonic, and isotonic solutions.
• Define osmosis and predict the direction of water movement based on differences in solute concentrations.
Evolution, Unity, and Diversity

- Explain how transport proteins are similar to enzymes.
- Explain how transport proteins facilitate diffusion.
- Explain how active transport differs from diffusion.
- Explain what mechanism can generate a membrane potential or electrochemical gradient.
- Describe the process of co-transport.
- Explain how large molecules are transported across the cell membrane.
- Compare pinocytosis and receptor-mediated endocytosis.

Principles of Energy Harvest

- Distinguish between fermentation and cellular respiration.
- Describe the summary equation for cellular respiration. Also note the specific chemical equation for the degradation of glucose.
- Explain how ATP is recycled in cells.
- Define oxidation and reduction.
- Explain how redox reactions are involved in energy exchanges.
- Explain why organic molecules that have an abundance of hydrogen are excellent cellular fuels.
- Describe the role of NAD+ and the electron transport chain during respiration.

The Process of Cellular Respiration

- Describe the cellular regions where glycolysis, the Krebs cycle, and the electron transport chain occur.
- Explain why ATP is required for the preparatory steps of glycolysis.
- Identify where sugar oxidation, substrate-level phosphorylation, and the reduction of NAD+ occur in glycolysis.
- Describe where pyruvate is oxidized to acetyl CoA, what molecules are produced, and how this process links glycolysis to the Krebs cycle.
- Describe the form and fate of the carbons in the Krebs cycle.
- Explain how the exergonic "slide" of electrons down the electron transport chain is coupled to the endergonic production of ATP by chemiosmosis.
- Describe the process of chemiosmosis.
- Explain how membrane structure is related to membrane function in chemiosmosis.
- Summarize the net ATP yield from the oxidation of a glucose molecule by constructing an ATP ledger that includes coenzyme production during the different stages of glycolysis and cellular respiration.

Related Metabolic Processes

- Explain why fermentation is necessary.
- Compare the fate of pyruvate in alcohol fermentation and lactic acid fermentation.
- Compare the processes of fermentation and cellular respiration.
- Describe evidence that the first prokaryotes produced ATP by glycolysis.
- Describe how food molecules other than glucose can be oxidized to make ATP.
- Explain how glycolysis and the Krebs cycle can contribute to anabolic pathways.

Photosynthesis in Nature

- Distinguish between autotrophic and heterotrophic nutrition.
- Distinguish between photoautotrophs and chemoautotrophs.
- Describe where most chloroplasts are located in a leaf.
- Explain how chloroplast structure relates to its function.
- Write a summary equation for photosynthesis.

The Pathways of Photosynthesis

- Explain the role of redox reactions in photosynthesis.
- Describe in general the two main stages of photosynthesis.
- Explain why the absorption spectrum for chlorophyll differs from the action spectrum for photosynthesis.
- Explain what happens when chlorophyll or accessory pigments absorb photons.
AP Biology – Fall Semester Review

Science as a Process
- Trace electron flow through photosystems II and I.
- Compare cyclic and noncyclic electron flow and explain the relationship between these components of the light reactions.
- Describe important differences in chemiosmosis between oxidative phosphorylation in mitochondria and photophosphorylation in chloroplasts.
- Describe the role of ATP and NADPH in the Calvin cycle.
- Describe the major consequences of photorespiration.
- Describe two important photosynthetic adaptations that minimize photorespiration.
- Describe the fate of photosynthetic products.

An Overview of Cell Signaling
- Describe the basic signal-transduction pathway of yeast. Explain why we believe these pathways in yeast, mammals, and plants evolved before the first multicellular organisms appeared on Earth.
- Categorize chemical signals in terms of the proximity of the communicating cells.
- Describe the three main stages of cell signaling.

Signal Reception and the Initiation of Transduction
- Describe the nature of a ligand-receptor interaction and state how such interactions initiate a signal-transduction system.
- Compare and contrast G-protein-linked receptors, tyrosine-kinase receptors, and ligand-gated ion channels.

Signal-Transduction Pathways
- Describe several advantages of using a multistep pathway in the transduction stage of cell signaling.
- Explain what is usually passed along in a signal-transduction pathway.
- Describe how phosphorylation propagates signal information.
- Describe how cyclic AMP is formed and how it propagates signal information.

Cellular Responses to Signals
- Describe how signal information is transduced into cellular responses in the cytoplasm and in the nucleus.
- Describe how signal amplification is accomplished in target cells.

Evolution, Unity, and Diversity
- Describe how target cells discriminate among signals and how the same signal can elicit multiple cellular responses.
- Explain how scaffolding proteins help to increase the efficiency of signal transduction.

The Key Roles of Cell Division
- Explain how cell division functions in reproduction, growth, and repair.
- Describe the structural organization of the genome.
- Describe the major events of cell division that enable the genome of one cell to be passed on to two daughter cells.
- Describe how the chromosome number changes throughout the human life cycle.

The Mitotic Cell Cycle
- List the phases of the cell cycle and describe the sequence of events that occurs during each phase.
- List the phases of mitosis and describe the events characteristic of each phase.
- Compare cytokinesis in animals and plants.
- Describe the process of binary fission in bacteria and how this process may have evolved in eukaryotic mitosis.

Evolution, Unity, and Diversity
- Describe the roles of checkpoints, cyclin, Cdk, and MPF in the cell cycle control system.
- Describe the internal and external factors that influence the cell cycle control system.

Science as a Process
- Explain how the abnormal cell division of cancerous cells differs from normal cell division.

An Introduction to Heredity
- Explain why organisms reproduce only their own kind and why offspring more closely resemble their parents than unrelated individuals of the same species.
- Explain what makes heredity possible.
- Distinguish between asexual and sexual reproduction.
AP Biology – Fall Semester Review

The Role of Meiosis in Sexual Life Cycles
- Distinguish among the life cycle patterns of animals, fungi, and plants.
- List the phases of meiosis I and meiosis II and describe the events characteristic of each phase. Recognize the phases of meiosis from diagrams or micrographs.
- Describe the process of synapsis during prophase I and explain how genetic recombination occurs.
- Describe the key differences between mitosis and meiosis. Explain how the end result of meiosis differs from that of mitosis.

Origins of Genetic Variation
- Explain how independent assortment, crossing over, and random fertilization contribute to genetic variation in sexually reproducing organisms.
- Explain why inheritable variation was crucial to Darwin's theory of evolution.
- Gregor Mendel's Discoveries
- Explain how observations by Mendel and others and Mendel's hypothesis of inheritance differed from the blending theory of inheritance.
- List several features of Mendel's methods that contributed to his success.
- Define true breeding, hybridization, monohybrid cross, P generation, F1 generation, and F2 generation.
- List and explain the four components of Mendel's hypothesis that led him to deduce the law of segregation.
- Explain how Mendel's law of segregation got its name.
- Use a Punnett square to predict the results of a monohybrid cross and state the phenotypic and genotypic ratios of the F2 generation.
- Distinguish between the following pairs of terms: dominant and recessive; heterozygous and homozygous; genotype and phenotype.
- Explain how a testcross can be used to determine if a dominant phenotype is homozygous or heterozygous.
- Use a Punnett square to predict the results of a dihybrid cross and state the phenotypic and genotypic ratios of the F2 generation.
- Define Mendel's law of independent assortment.
- Explain why Mendel was wise to use large sample sizes in his studies. Extending Mendelian Genetics
- Give an example of incomplete dominance and explain why it is not evidence for the blending theory of inheritance.
- Explain how the phenotypic expression of the heterozygote is affected by complete dominance, incomplete dominance, and co-dominance.
- Explain why Tay-Sachs is considered recessive at the organismic level but co-dominant at the molecular level.
- Explain why genetic dominance does not mean that the dominant allele subdues a recessive allele. Illustrate your explanation with the use of the round versus wrinkled pea seed shape.
- Explain why dominant alleles do not necessarily mean that the allele is more common in a population. Illustrate your explanation with the character polydactylly.
- Describe the inheritance of the ABO blood system and explain why the IA and IB alleles are said to be co-dominant.
- Define and give examples of pleiotropy and epistasis.
- Describe a simple model for polygenic inheritance and explain why most polygenic characters are described in quantitative terms.
- Describe how environmental conditions can influence the phenotypic expression of a character. Explain what is meant by "a norm of reaction."
- Distinguish between the specific and broad interpretations of the terms "phenotype" and "genotype."

Mendelian Inheritance in Humans
- Explain why studies of human inheritance are not as easily conducted as Mendel's work with his peas.
- Explain how a lethal recessive gene can be maintained in a population.
- Describe the inheritance and expression of cystic fibrosis, Tay-Sachs disease, and sickle-cell disease.
- Explain why consanguinity increases the probability of homozygosity in offspring.
- Explain why lethal dominant genes are much rarer than lethal recessive genes.
- Give an example of a late-acting lethal dominant in humans and explain how it can escape elimination.
- Define and give examples of multifactorial disorders in humans. Explain what can currently be done to reduce the frequency of these diseases.
- Explain how carrier recognition, fetal testing, and newborn screening can be used in genetic screening and counseling.
Relating Mendelism to Chromosomes
- Explain how the observations of cytologists and geneticists provided the basis for the chromosome theory of inheritance.
- Describe the contributions that Walter Sutton, Theodor Boveri, and Thomas Hunt Morgan made to current understanding of chromosomal inheritance.
- Explain why *Drosophila melanogaster* is a good experimental organism.
- Define and compare linked genes and sex-linked genes. Explain why the inheritance of linked genes is different from independent assortment.
- Distinguish between parental and recombinant phenotypes.
- Explain why linked genes do not assort independently.
- Explain how crossing over can unlink genes.
- Explain how Sturtevant created linkage maps.
- Define a map unit.
- Explain why Mendel did not find linkage between seed color and flower color.
- Explain how genetic maps are constructed for genes located far apart on a chromosome.
- Explain the impact of multiple crossovers between loci.
- Explain what additional information cytological maps provide over linkage maps.

Sex Chromosomes
- Explain how sex is genetically determined in humans and the significance of the SRY gene.
- Explain why sex-linked diseases are more common in human males.
- Describe the inheritance patterns and symptoms of color blindness, Duchenne muscular dystrophy, and hemophilia.

Errors and Exceptions in Chromosomal Inheritance
- Distinguish among nondisjunction, aneuploidy, trisomy, triploidy, and polyploidy. Explain how these major chromosomal changes occur and describe the consequences.
- Distinguish among deletions, duplications, inversions, and translocations.
- Describe the type of chromosomal alterations implicated in the following human disorders: Down syndrome, Klinefelter's syndrome, extra Y, triple-X syndrome, Turner's syndrome, cri du chat syndrome, and chronic myelogenous leukemia.
- Give some exceptions to the chromosome theory of inheritance. Explain why extranuclear genes are not inherited in a Mendelian fashion and how they can contribute to disease.

DNA as the Genetic Material
- Explain why researchers originally thought protein was the genetic material.
- Summarize the experiments performed by the following scientists that provided evidence that DNA is the genetic material:
  - Frederick Griffith
  - Oswald Avery, Maclyn McCarty, and Colin MacLeod
  - Alfred Hershey and Martha Chase
  - Erwin Chargaff
- Explain how Watson and Crick deduced the structure of DNA and describe the evidence they used. Explain the significance of the research of Rosalind Franklin.
- Describe the structure of DNA. Explain the "base-pairing rule" and describe its significance.

DNA Replication and Repair
- Describe the semiconservative model of replication.
- Describe the process of DNA replication. Note the structure of the many origins of replication and replication forks and explain the role of DNA polymerase.
- Explain what energy source drives the polymerization of DNA.
- Define "antiparallel" and explain why continuous synthesis of both DNA strands is not possible.
- Explain how the lagging strand is synthesized even though DNA polymerase can add nucleotides only to the 3' end.
- Explain the roles of DNA ligase, primer, primase, helicase, and the single-strand binding protein.
- Explain why an analogy can be made comparing DNA replication to a locomotive made of DNA polymerase moving along a railroad track of DNA.
Evolution, Unity, and Diversity

- Explain the roles of DNA polymerase, mismatch repair enzymes, and nuclease in DNA proofreading and repair.
- Describe the structure and functions of telomeres. Explain the significance of telomerase to healthy and cancerous cells.

The Connection Between Genes and Protein

- Explain how RNA differs from DNA
- Briefly explain how information flows from gene to protein
- Distinguish between transcription and translation
- Explain the evolutionary significance of a nearly universal genetic code

The Synthesis and Processing of RNA

- Explain how RNA polymerase recognizes where transcription should begin. Describe the promoter, the terminator, and the transcription unit.
- Explain the general process of transcription in eukaryotic cells.

The Synthesis of Protein

- Describe the structure and function of tRNA
- Describe the structure and functions of ribosomes
- Describe the process of translation

The Structure of Eukaryotic Chromatin

- Describe the current model for progressive DNA packaging
- Explain how histones influence folding in eukaryotic chromosomes

DNA Cloning

- Explain how the creation of sticky ends by restriction enzymes is useful in producing a recombinant DNA molecule
- Describe the Polymerase Chain Reaction (PCR)