

AP Biology Exam Review: Biochemistry

Helpful Videos and Animations:

1. Bozeman Biology: Biological Molecules
2. Bozeman Biology: Nucleic Acids
3. Bozeman Biology: Lipids
4. Bozeman Biology: Carbohydrates
5. Bozeman Biology: Proteins
6. Bozeman Biology: Polymers
7. Bozeman Biology: Gibbs Free Energy
8. Bozeman Biology: Life Requires Free Energy
9. Bozeman Biology: Coupled Reactions
10. Bozeman Biology: Enzymes

Relevant Objectives:

1. Be able to state the difference between a monomer and a polymer
2. Be able to name the four main classes of macromolecules and the monomers that compose them
3. Describe dehydration synthesis and hydrolysis reactions
4. Explain the properties of water and why they are essential to life
5. Describe the steps of protein folding
6. Explain the difference between polar and non polar molecules
7. Know and explain the steps of the scientific method
8. Know the components of a valid experiment
86. Explain the function of an enzyme and describe how an enzyme works
87. Explain factors influencing enzyme activity ([Substrate], [Enzyme], pH, temperature, [Ion], and describe how these factors influence activity
88. Be able to determine the rate of an enzyme catalyzed reaction from a graph or data table and compare and contrast rates
89. Explain how activators and inhibitors effect enzyme activity
90. Differentiate between different types of inhibitors - competitive, non-competitive, irreversible

Topic Outline

1. Bonds: Ionic, Covalent (Polar vs. Nonpolar), Hydrogen; know the relative strengths of each bond and where they are used in nature
2. Molecules and atoms from the environment are necessary to build new molecules
 - C,H,N,O,P, and S are the most common elements in living organisms
 - Carbon (know where it is found in the four macromolecules and how it cycles between the environment and living organisms via the Carbon Cycle)
 - Nitrogen (know where it is found in proteins and nucleic acids and how it cycles between the environment and living organisms via the Nitrogen Cycle)
 - Phosphorus (know where it is found in lipids and nucleic acids and how it cycles between the environment and living organisms via the Phosphorus Cycle)
 - Know where/how carbon, hydrogen, nitrogen, oxygen, phosphorus, and sulfur are used in the macromolecules
3. The Properties of Water (all come from water's polarity and its ability to form hydrogen bonds ; understand how the structure of the water molecule is related to its function)
 - Excellent solvent (know how water dissolves polar and ionic compounds → we have water-based cellular fluids)
 - Cohesion and adhesion → transpiration in plants
 - Less dense as a solid → prevents ponds and lakes from freezing solid
 - High Heat Capacity / Specific Heat → evaporative cooling (sweating) in animals ; moderates air temperatures near large bodies of water
4. pH: acid-base/ 0-14, # of H⁺ ions determines scale; logarithmic- pH 3 = 10⁻³ = 1/1000 (concentration of H⁺ ions)...blood- 7.4, stomach- 2, small intestine- 8; enzymes are specific to pH
5. Reactions of Life
 - Dehydration Synthesis (releases water; used to create polymers connected by covalent bonds; anabolic; endergonic)
 - Hydrolysis (uses water; used to break polymers into monomers by breaking covalent bonds; catabolic; exergonic)

6. Macromolecules

- Carbohydrates
 - CHO 1:2:1 ratio
 - Monomers = monosaccharides (know the basic structure and examples)
 - Dimers = disaccharides (know the basic structure, how they form, and examples)
 - Polymers = polysaccharides (know the basic structure, how they form, and the following examples – cellulose, starch, chitin, and glycogen)
- Lipids
 - C, H, O (not a 1:2:1 ratio) *P only in phospholipids
 - Basic structure (fatty acid chains and a polar region)
 - Degree of saturation of fatty acid chains (# of H's linked to carbons, which is inversely related to the number of hydrogen bonds) → unsaturated fatty acid chains with kinks (liquid at room temperature) vs. saturated straight fatty acid chains (solid at room temperature)
 - Phospholipids make up cell membranes (double layer) and are amphipathic- hydrophilic and hydrophobic
 - Functions = cell membrane (phospholipids), energy storage (fats, oils), steroid hormones like testosterone and estrogen (variations on a cholesterol 5-ring lipid), insulation, myelin sheath of neurons
- Proteins
 - C, H, O, N (may have other elements like S in R group)
 - Monomers = amino acids (know the basic structure ; the 20 different amino acids only differ in their R groups)
 - Parts of amino acid= carboxyl group (COOH) on one end, amino group on the other end (NH₂), central carbon and variable R group (can be hydrophobic or hydrophilic) which determines chemical properties.
 - Protein Folding- shape determines function; primary structure = amino acid chain; secondary = beta pleated sheet or alpha helix (hydrogen bonds between non-adjacent carboxyl and amino groups); tertiary = globular; folds in on itself (disulfide bridges, hydrogen bonds, hydrophobic interactions; ionic bonding between R groups); quaternary = more than one polypeptide.
 - Many functions: enzymes (ex: amylase), structure (ex: keratin), transport (ex: hemoglobin), signaling (ex: oxytocin hormone), protein carriers in cell membrane, antibodies
- Nucleic Acids
 - C,H,O,N, and P
 - Monomers = nucleotides (know the basic structure; made of nitrogenous bases, phosphate groups, and deoxyribose sugars)
 - Polymers = DNA and RNA
 - Nucleotide made up of sugar, phosphate and base
 - DNA is double stranded, has deoxyribose, A, G, C, T
 - RNA is single stranded, has ribose, A, G, C, U
 - mRNA- copies genetic message; rRNA- attaches mRNA and makes up ribosomes (most common);tRNA- carries amino acids; DNA- carries genetic code
 - Function: storage and transmission of genetic information

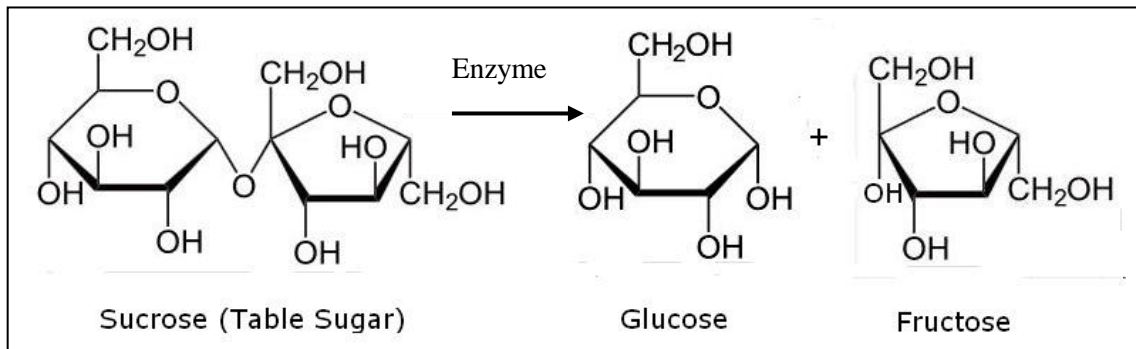
7. Enzymes

- Biological catalysts (made of protein) that speed up rate of chemical reactions by lowering activation energy required for reaction to occur
- Enzyme has active site (exposed R groups) where reaction occurs
- Enzymes can break down substance (catabolic reaction) or build up substances (anabolic)
- Enzyme/substrate complex is formed
- Substrate is what enzyme acts on
- Rate is determined by collisions between substrate and enzyme
- Ends in -ase, named after substrate often
- Enzyme is specific to substrate; the substrate must be complementary to the surface properties (shape and charge) of the active site (which is made up of R groups with specific chemistry, i.e. hydrophobic).
- Enzyme rate is affected by:

- pH (optimal for each enzyme),
- temperature (optimal for each enzyme but in general increased temp means increased collisions so rate goes up initially; too much heat can denature enzyme), enzyme concentration (more enzyme faster rate or vice versa)
- substrate concentration (more substrate = faster rate, until the point of enzyme saturation)
- Know the difference between an endergonic and exergonic reaction and be able to analyze their reaction curves ; be able to explain energy coupling and provide examples
- Inhibition-competitive inhibition (something competes for active site; can be overcome with more substrate)
- Non-competitive inhibition- attaches at allosteric site and changes shape of enzyme so it is not functional; can not be overcome with more substrate
- Coenzymes (organic; NAD and vitamin B etc.) and cofactors (inorganic; zinc, magnesium etc.) interact with enzymes to put them into the right structure to do work.

Practice Multiple Choice Questions:

1. Which of the following is *not* a property of carbon?
 - a. Carbon-to-carbon bonds are limited to single bonds.
 - b. Carbon has four valence electrons.
 - c. Carbon can form bonds to various other atoms.
 - d. Carbon-to-carbon bonds are strong.
2. Carbohydrate molecules:
 - a. serve as structural components of human cell walls.
 - b. form the regulatory compounds known as enzymes.
 - c. are a source of energy.
 - d. help protect vital organs from damage.



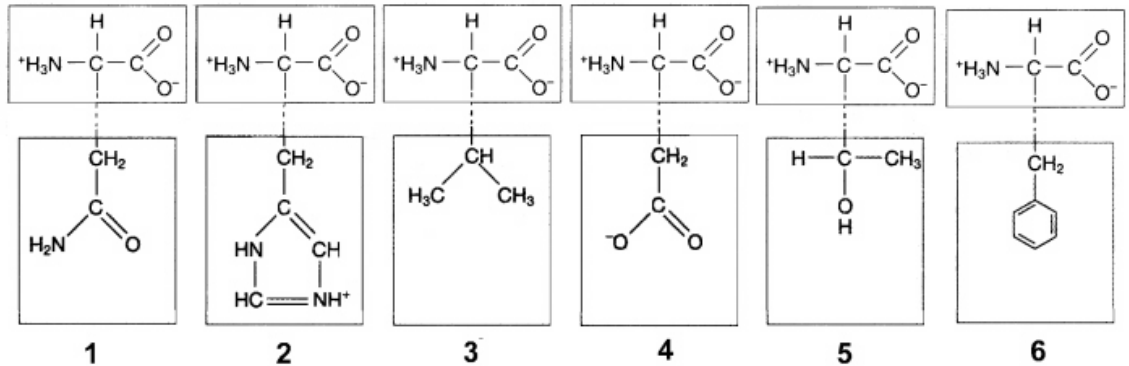
3. The process illustrated in the figure above is called:
 - a. condensation.
 - b. protein synthesis.
 - c. hydrolysis.
 - d. denaturation.
4. The products of the process in the figure above are:
 - a. monosaccharides.
 - b. molecules of glycerol.
 - c. representative of a glycoside linkage.
 - d. enzymes.
5. In which of the following reactions must the equivalent of a water molecule be added in order to break a bond?
 - a. fatty acids + glycerol \rightarrow fat
 - b. glucose + fructose \rightarrow sucrose
 - c. glycogen \rightarrow glucose
 - d. alanine + glycine \rightarrow dipeptide

6. Which of the following illustrates hydrolysis?
- the reaction of two monosaccharides to form a disaccharide
 - the reaction of two amino acids to form a dipeptide
 - the reaction of a hydrogen atom and a hydroxide ion to form water
 - the reaction of a fat to form glycerol and fatty acids

7. A molecule of a saturated triacylglycerol (aka triglyceride) contains:
- the maximum number of double bonds between carbons in the fatty acid chains.
 - the maximum number of triple bonds between carbons in the fatty acid chains.
 - the maximum number of hydrogen atoms in the fatty acid chains.
 - alternating single and double bonds between carbons in the fatty acid chains.

8. In the figure below, ionic attractions would form between the R groups of which amino acids?

- 1 and 3
- 2 and 4
- 3 and 5
- None of the above.



9. Which of the following is responsible for the alpha-helical structure of proteins?

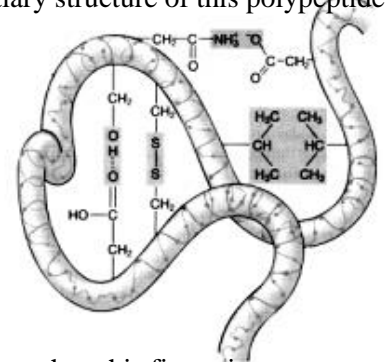
- hydrophobic interactions
- nonpolar covalent bonds
- ionic interactions
- hydrogen bonds

10. At which level of protein structure are peptide bonds most important?

- primary
- secondary
- quaternary
- globular

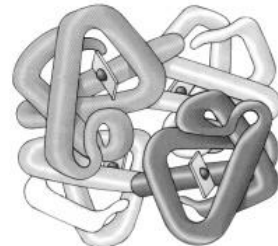
11. All of the following types of chemical bonds are responsible for maintaining the tertiary structure of this polypeptide *except*:

- ionic bonds.
- peptide bonds.
- hydrophobic interactions.
- disulfide bonds.



12. If the differently shaded portions of this molecule represent different polypeptide chains, then this figure is representative of:

- an amino acid.
- The primary structure of a protein
- The secondary structure of a protein
- The quaternary structure of a protein



13. Analysis of a certain complex compound shows that it contains phosphate groups, ribose groups, and pyrimidines. Based on this information, which of the following is the best description of this compound?

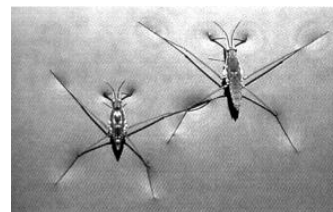
- a. It is most likely ribonucleic acid.
- b. It is DNA.
- c. It is an inorganic compound.
- d. It contains thymine.

14. Which monomer is incorrectly matched with the corresponding polymer?

- a. Amino acids are used to build proteins.
- b. Monosaccharides are used to build polysaccharides.
- c. Fatty acids are used to build nucleic acids.
- d. Glucose molecules are used to build starches.

15. Which characteristic of water molecules directly contributes to the remarkable "water walking" success of the aquatic insects pictured in the accompanying figure?

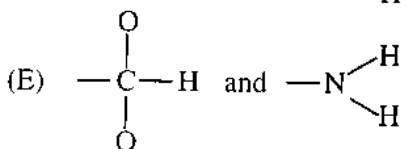
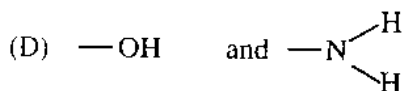
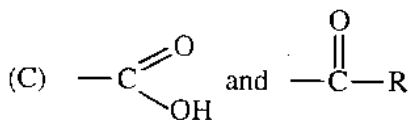
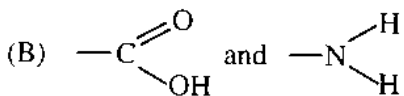
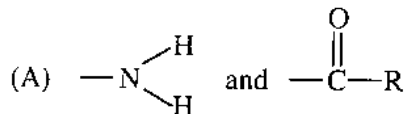
- a. hydrogen bonds
- b. capillary action
- c. nonpolar covalent bonds
- d. ionic bonds



16. A stalk of celery is placed in a solution of blue colored dye. After one hour, the leaves have blue fluid in their veins. Which property of water is being demonstrated?

- a. adhesion and cohesion
- b. evaporation and cooling
- c. lower density as a solid than as a liquid
- d. high specific heat

17. Which of the following pairs of functional groups characterizes the structure of an amino acid?



18. A feature of organic compounds NOT found in inorganic compounds is the presence of

- a. ionizing chemical groups
- b. electrons
- c. carbon atoms covalently bonded to each other
- d. oxygen

19. The carbon that makes up organic molecules in plants is derived directly from

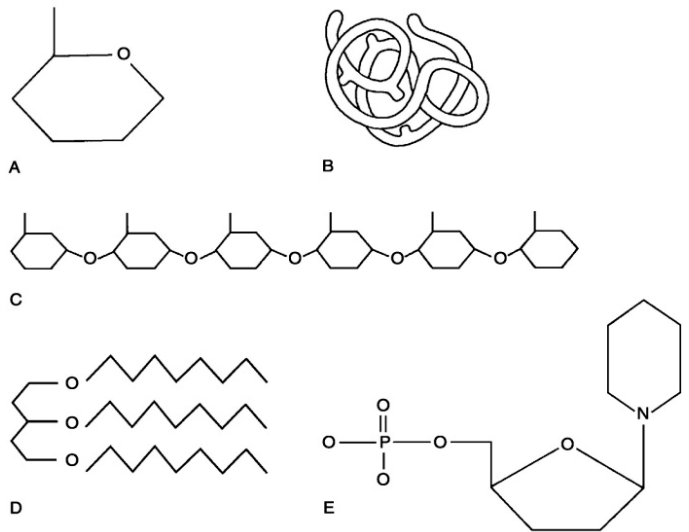
- combustion of fuels
- carbon fixed in photosynthesis
- carbon dioxide produced in respiration
- carbon in the lithosphere

20. Which of the following is responsible for the cohesive property of water?

- Hydrogen bonds between the oxygen atoms of two adjacent water molecules
- Covalent bonds between the hydrogen atoms of two adjacent water molecules
- Hydrogen bonds between the oxygen atom of one water molecule and a hydrogen atom of another water molecule
- Covalent bonds between the oxygen atom of one water molecule and a hydrogen atom of another water molecule

Write the letter or letters that correspond to the picture that matches with each description

- Lipid.
- Functional protein.
- Nucleotide.
- Polysaccharide.
- Monosaccharide.
- Polymer
- Tertiary (protein) structure



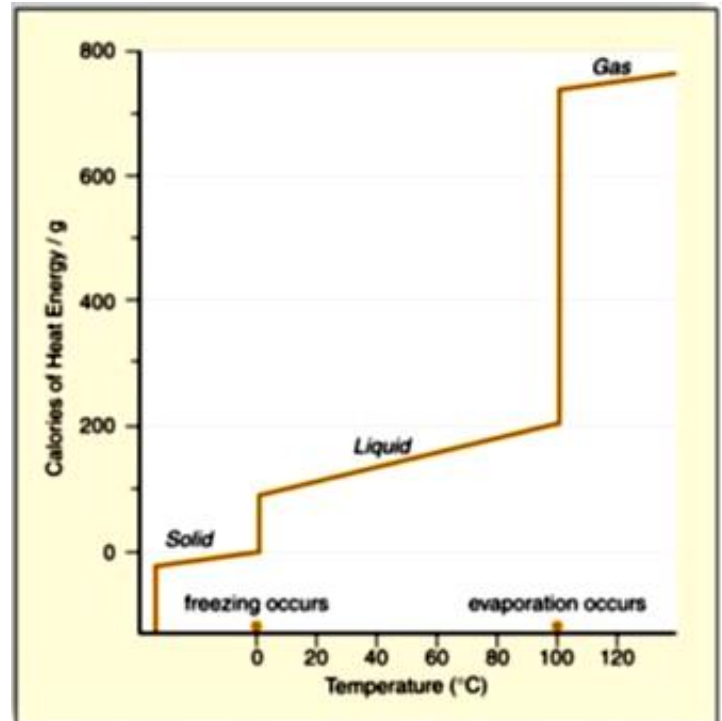
28. The figure below shows the calories of heat energy required to convert a gram of water from solid to liquid state, and then again from liquid to a gaseous state. Especially distinctive is the large increase in energy required to move water from liquid to gas form.

This graph predicts which of the following properties of water that would affect plant survival?

- Plant leaves doing transpiration are cooled down on hot days.
- Inside a plant stem, cohesion attracts one water molecule to the water molecule above it, allowing a “chain” of water molecules to move up the stem.
- At a plant’s roots, adhesion attracts water molecules to “stick” to root hairs, aiding absorption.
- Sugar will dissolve in water, leading to a plant fluid called phloem, which typically flows from the leaves, down towards the roots.

29. Air that is dry changes temperature quickly, while air that is moist retains its temperature. What property allows for this regulation of temperature?

- The heat of fusion in of the nitrogen in the air, due to the free electrons.
- The high electric potential of the air, which results from the static charges of the molecules in dry conditions.
- The green house effect, due to the increase in carbon dioxide in the atmosphere.
- The high specific heat of water, which results from the polarity and hydrogen bonding.



a. Calories lost when 1 g of liquid water freezes and calories required when 1 g of liquid water evaporates.

30. Which of the following is an example of a hydrogen bond?
- The peptide bond between amino acids in a protein
 - The bond between an oxygen atom and a hydrogen in the carboxyl group of a fatty acid.
 - The attraction between a hydrogen of one water molecule and the oxygen of another water molecule.
 - The bond between carbon and hydrogen in methane

Questions 31-34 Choose an item from the list below that is best associated with the following statements.

- Cholesterol
- Triglyceride
- Phospholipid
- Protein

- The major component of the fluid bilayer of a plasma membrane
- Carrier molecule in the plasma membrane
- Steroid affecting the fluidity of the plasma membrane
- ATP synthase (synthetase) in the inner mitochondrial and chloroplast membrane

35. Which of the following best characterizes the reaction represented below



- hydrolysis
- catabolism
- oxidation-reduction
- exergonic reaction
- endergonic reaction

36. Which of the following can be used to determine the rate of enzyme-catalyzed reactions

- rate of disappearance of the enzyme
- rate of disappearance of the substrate
- rate of disappearance of the product
- change in volume of the solution
- increase in activation energy

Practice Long Response Questions: Make an outline of the information you would include in each of these essays.

1. Water is important for all living organisms. The functions of water are directly related to its physical properties.

- Describe how the properties of water contribute to TWO of the following
 - transpiration
 - thermoregulation in endotherms
 - plasma membrane structure
- Water serves as a reactant and a product in the carbon cycle. Discuss the role of water in the carbon cycle.
- Discuss the impact of one human activity on the water cycle.

2. The physical form of cells and organisms is often influenced by special structural polymers. For the polymers below, describe the structure and role of each in a cell or organism.

Polymers: messenger RNA & transfer RNA

3. Proteins — large complex molecules — are building blocks of all living organisms. Discuss the following in relation to proteins.

- the chemical composition and levels of structure of proteins
- the roles of DNA and RNA in protein synthesis
- the roles of proteins in membrane structure and transport of molecules across the membrane

