

AP BIOLOGY QUIZ – QUESTIONS & ANSWERS - UNIT 1

(You will be allowed to use **any handwritten (handprinted) notes** from these "Questions & Answers" as a cheat-sheet for the quiz.)

- 1) Explain the importance of water's polarity to its role as a universal solvent.
- 2) How does the structure of carbon contribute to the complexity of organic molecules?
- 3) Describe the role of dehydration synthesis and hydrolysis in the formation and breakdown of macromolecules.
- 4) Compare and contrast the structures and functions of carbohydrates and lipids.
- 5) Why is gene expression important in the Chemistry of Life?
- 6) Describe the role of enzymes in biological reactions, including the concepts of activation energy and enzyme-substrate specificity.
- 7) What is the role of nucleic acids in storing and transmitting genetic information?
- 8) Compare the structure and function of saturated and unsaturated fatty acids.
- 9) Explain the significance of hydrogen bonds in the properties of water and biological molecules.
- 10) How do pH and temperature affect enzyme activity, and why is enzyme regulation important in biological systems?

1) Explain the importance of water's polarity to its role as a universal solvent.

Water is a polar molecule, meaning it has a slight positive charge on one end (hydrogen) and a slight negative charge on the other (oxygen). This polarity allows water to interact with various solutes. When ionic compounds are introduced into water, the positive end of water (the hydrogen atoms) surrounds the negative ions, while the negative end (the oxygen atom) surrounds the positive ions. This interaction allows water to dissolve many substances, making it an excellent solvent.

The ability of water to dissolve various molecules is crucial in biological systems because it allows for the easy transport of nutrients, gases, and waste products. In cells, this property helps in forming aqueous solutions where chemical reactions, such as metabolic processes, occur. Without water's solvent properties, many essential biochemical reactions would be impossible.

2) How does the structure of carbon contribute to the complexity of organic molecules?

Carbon's ability to form four covalent bonds allows it to create a wide variety of complex molecules. Carbon atoms can bond with each other in chains, rings, or branched structures, which can include other atoms like hydrogen, oxygen, nitrogen, and sulfur. This versatility enables the formation of the diverse macromolecules essential to life, such as carbohydrates, proteins, lipids, and nucleic acids.

The complexity of carbon-based molecules is a key feature of living organisms. Carbon's bonding properties lead to an incredible diversity in molecular shapes and sizes, which, in turn, leads to the complexity of biological processes. For example, proteins' three-dimensional shapes are dependent on the intricate carbon-containing structures of amino acids, which are essential for enzyme function and cellular communication.

3) Describe the role of dehydration synthesis and hydrolysis in the formation and breakdown of macromolecules.

Dehydration synthesis is the process by which monomers are joined together to form polymers through the removal of a water molecule. During this process, a hydrogen atom from one monomer combines with a hydroxyl group from another monomer, resulting in the release of water and the formation of a covalent bond. This reaction is essential for building complex molecules such as proteins, carbohydrates, and nucleic acids.

Hydrolysis is the reverse of dehydration synthesis and involves the addition of water to break down polymers into monomers. In biological systems, hydrolysis is critical for digestion, where large molecules like proteins and polysaccharides are broken down into smaller, usable units like amino acids and simple sugars. Both dehydration synthesis and hydrolysis are fundamental processes in metabolism, helping to manage the synthesis and degradation of important macromolecules.

4) Compare and contrast the structures and functions of carbohydrates and lipids.

Carbohydrates are composed of carbon, hydrogen, and oxygen, typically in a 1:2:1 ratio. Their primary function is to provide energy; they can be quickly broken down into glucose, which is used in cellular respiration. Carbohydrates can exist as simple sugars (monosaccharides) or more complex forms like starches and cellulose (polysaccharides). In addition to energy, carbohydrates play a structural role in cell walls (cellulose in plants) and in cell recognition processes.

Lipids, on the other hand, are largely nonpolar molecules composed mainly of carbon and hydrogen, making them hydrophobic. They function as long-term energy storage molecules, structural components of cell membranes (phospholipids), and signaling molecules (steroids). While both carbohydrates and lipids provide energy, lipids are more energy-dense and are used for longer-term storage, whereas carbohydrates are more immediate energy sources.

5) Why is gene expression important in the Chemistry of Life?

Gene expression involves the process by which information from a gene is used to synthesize a functional gene product, typically proteins, though in some cases RNA molecules can be the final product.

The process of gene expression involves:

1. **Transcription:** The process where the DNA sequence of a gene is copied into messenger RNA (mRNA). Key enzymes involved here include RNA polymerase.
2. **Translation:** The mRNA is then translated into a protein. This happens at the ribosome, where transfer RNA (tRNA) brings the appropriate amino acids to build the protein.
3. **Regulation of Gene Expression:** Not all genes are active all the time. Various mechanisms (such as transcription factors, repressors, and enhancers) control when and how genes are expressed, allowing the cell to respond to its environment or developmental cues.
4. **Mutations:** Changes in the DNA sequence can affect gene expression, which might lead to nonfunctional proteins or different traits.

6) Describe the role of enzymes in biological reactions, including the concepts of activation energy and enzyme-substrate specificity.

Enzymes are biological catalysts that speed up chemical reactions by lowering the activation energy required for the reaction to occur. Without enzymes, most biochemical reactions would happen too slowly to sustain life. Enzymes work by stabilizing the transition state of a reaction, allowing reactants (substrates) to be converted into products more efficiently.

Enzymes are highly specific to their substrates due to their active site's unique shape. The active site binds to the substrate, forming an enzyme-substrate complex. This specificity is often described by the "lock and key" model or the "induced fit" model, where the enzyme slightly changes shape to accommodate the substrate. This precise interaction ensures that enzymes catalyze only specific reactions, which is essential for maintaining the regulation of metabolic pathways.

7) What is the role of nucleic acids in storing and transmitting genetic information?

Nucleic acids, DNA and RNA, are polymers composed of nucleotide monomers. DNA stores genetic information in the form of sequences of nucleotides, each consisting of a sugar, phosphate group, and nitrogenous base (adenine, thymine, cytosine, and guanine). The order of these bases encodes the instructions for building proteins, which determine an organism's traits.

RNA plays a key role in transmitting genetic information from DNA to the ribosomes, where proteins are synthesized. Messenger RNA (mRNA) carries the genetic code from DNA to the ribosome, while transfer RNA (tRNA) and ribosomal RNA (rRNA) assist in the translation process. Without nucleic acids, the continuity of genetic information and the production of functional proteins would be impossible.

8) Compare the structure and function of saturated and unsaturated fatty acids.

Saturated fatty acids have no double bonds between carbon atoms, meaning each carbon is fully saturated with hydrogen atoms. This results in straight chains that can pack closely together, making saturated fats solid at room temperature. Saturated fats are typically found in animal products and are associated with an increased risk of cardiovascular disease.

Unsaturated fatty acids contain one or more double bonds, which introduce kinks in the carbon chain, preventing close packing. This causes unsaturated fats to be liquid at room temperature. Unsaturated fats, found in plant oils and fish, are considered healthier than saturated fats because they can reduce cholesterol levels and lower the risk of heart disease.

9) Explain the significance of hydrogen bonds in the properties of water and biological molecules.

Hydrogen bonds are weak interactions that occur when a hydrogen atom, covalently bonded to an electronegative atom like oxygen or nitrogen, is attracted to another electronegative atom. In water, hydrogen bonds are responsible for many of its unique properties, such as high specific heat, cohesion, adhesion, and surface tension. These properties are crucial for maintaining stable environments for life.

In biological molecules, hydrogen bonds play a critical role in maintaining structure. For example, they help stabilize the alpha-helices and beta-sheets in proteins, as well as the double-helix structure of DNA. These interactions are essential for the proper folding of proteins and the accurate replication of genetic information.

10) How do pH and temperature affect enzyme activity, and why is enzyme regulation important in biological systems?

Enzymes are sensitive to changes in pH and temperature, as both factors can affect their three-dimensional structure. Each enzyme has an optimal pH and temperature range within which it functions most efficiently. Deviations from these optimal conditions can lead to denaturation, where the enzyme's structure unravels, causing a loss of function.

Enzyme regulation is crucial in biological systems to maintain homeostasis and ensure that metabolic pathways proceed at the proper rate. Cells regulate enzyme activity through various mechanisms, such as allosteric regulation, feedback inhibition, and competitive inhibition. Proper regulation allows cells to respond to changes in the environment, prevent the over-accumulation of products, and coordinate complex metabolic processes.