AP BIO Unit 1 Released FRQs

2009 B #3

3. Water is essential to all living things.
   (a) **Discuss** THREE properties of water.
   (b) **Explain** each of the following in terms of the properties of water. You are not limited to the three properties discussed in part (a):
   - the role of water as a medium for the metabolic processes of cells
   - the ability of water to moderate temperature within living organisms and in organisms' environments
   - the movement of water from the roots to the leaves of plants

2009 B #3 Answer Key

Question 3

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(a) **Discuss** THREE properties of water.

(b) **Explain** each of the following in terms of the properties of water. You are not limited to the three properties discussed in part (a):

- the role of water as a medium for the metabolic processes of cells
- the ability of water to moderate temperature within living organisms and in organisms' environments
- the movement of water from the roots to the leaves of plants

(a) Discuss THREE properties of water (**6 points maximum)**:

Name of property **and** correct description **(2 points)**. Points **MUST** provide both property and description.

Property	**and Description (2 points jointly)**
Polarity of water	Polar covalent bonds created by unequal sharing of electrons between O and H **within** the molecule
Specific heat/high heat capacity	Heat absorption without temperature change
High heat of vaporization	Water molecules absorb energy as it changes state/breaking of bonds by absorbing energy
Adhesion	Attraction to other molecules that are polar or have charge
Cohesion	Attraction to other water molecules due to polar nature of water/ surface tension
Three states of matter	Ice–liquid–gas (vapor) Kinetic energy differences Expands at 4°C to become less dense
Repels hydrophobic material	Moves aside nonpolar substances

(b) Explain each of the following in terms of water properties **(6 points maximum; 2 points for each part)**. To earn 10 points, students must get at least 1 application point for each area.

Water's role as a medium for the metabolic processes of cells **(2 points maximum)**:

- Diffusion—allows for movement of materials through an aqueous solution down the concentration gradient
- Osmosis—movement of water across membranes due to water potential differences (down the gradient)
- Solvent—dissociation/ionization of materials
- Buffer—explanation of role water plays in formation of bicarbonate ion

Question 3 (continued)

Water's ability to moderate temperature within living organisms/environments **(2 points maximum)**:

- Specific heat—moderates climates, maintains stable temperature in cells, constant internal environment
- High heat of vaporization—perspiration cooling, evaporative cooling
- Ice forming and acting as insulator for lakes, keeping water in liquid state

Water from the roots to the leaves of plants **(2 points maximum)**:

- Transpiration—moving water away from leaves due to water potential differences/evaporation through stomata
- Capillary action of water due to adhesion and cohesion
- Root pressure—driven by osmosis/movement of water into roots
- Negative pressure potential—caused by surface tension of water as it is pulled up xylem

2009 B #4

4. Many organisms require a continuing source of oxygen for respiration. **Discuss** important structural and physiological adaptations for oxygen uptake in THREE of the following:
   - a paramecium
   - a tree
   - a fish
   - a mammal

2009 B #4 Answer Key

Question 4

Many organisms require a continuing source of oxygen for respiration. **Discuss** important structural and physiological adaptations for oxygen uptake in THREE of the following:

- a paramecium
- a tree
- a fish
- a mammal

Each structural and physiological adaptation earns 1 point. Student must mention at least one structural and one physiological area to earn 10 points. **Only the first three** organisms mentioned earn points.

- **Paramecium (4 points maximum)**:

Structural (1 point each)	Physiological (1 point each)
Membrane surface area/volume small	Utilizes diffusion
Wet habitat	Cytoplasmic streaming
Membrane permeable to oxygen	Ventilation of surface with cilia

- **Tree (4 points maximum)**:

Structural (1 point each)	Physiological (1 point each)
Stomata/guard cells	Stomatal **regulation**
Large wet internal surface area in mesophyll	Surface for gas exchange
Lenticels	Cohesion, transport
Pneumatophores	Pressure flow/source to sink
Root hairs	
Epidermis permeable to oxygen	
	Photosynthesis production of oxygen

- **Fish (4 points maximum)**:

Structural (1 point each)	Physiological (1 point each)
Gills	Countercurrent exchange
Operculum	Operculum movement/gill slit movement
	Ram ventilation (swimming)
Vascularization/gill capillaries	Increase surface area/diffusion
	Blood flow—heart pumping
Hemoglobin	Iron molecules holding oxygen
Lungfish lungs	

Question 4 (continued)

- **Mammal (4 points maximum)**:

Structural (1 point each)	Physiological (1 point each)
Lungs	Homeostatic adjustments via medulla
Vascularization of alveoli	Capillaries increase surface area/diffusion
Hemoglobin/RBC	Iron molecules holding oxygen
Diaphragm/ventilation (breathing) mechanisms	Ventilation physiology
Four-chambered heart	Separate pulmonary and systemic blood
	Blood flow—heart pumping

2008 #1

1. The physical structure of a protein often reflects and affects its function.

   (a) **Describe** THREE types of chemical bonds/interactions found in proteins. For each type, **describe** its role in determining protein structure.

   (b) **Discuss** how the structure of a protein affects the function of TWO of the following.

   - Muscle contraction
   - Regulation of enzyme activity
   - Cell signaling

   (c) Abnormal hemoglobin is the identifying characteristic of sickle cell anemia. **Explain** the genetic basis of the abnormal hemoglobin. **Explain** why the sickle cell allele is selected for in certain areas of the world.

2008 #1 Answer Key

Question 1

1. The physical structure of a protein often reflects and affects its function.

(a) **Describe** THREE types of chemical bonds/interactions found in proteins. For each type, **describe** its role in determining protein structure. **(6 points; 1 point for bond/interaction description, 1 point for description of role)**

Bond/interaction	Description	Role associated to bond/interaction
Covalent/ peptide	sharing electrons **OR** linking amino acids together	amino acid sequence **OR** primary structure (no credit for chain or polypeptide alone)
Disulfide/ covalent	disulfide, S–S bond (bridges); sulfur-containing R group bonding	tertiary or quaternary structure
Hydrogen	H–O or H–N interactions	α helix, β sheet; secondary, tertiary, or quaternary structure
van der Waals	unequal electron clouds in R group; dipole moments	tertiary or quaternary structure
Hydrophobic	nonpolar R groups	tertiary or quaternary structure
Ionic	charged R groups	tertiary or quaternary structure

(b) **Discuss** how the structure of a protein affects the function of TWO of the following. **(3 points maximum)**

Muscle contraction **(1 point for each bullet; 2 points maximum)**

- Actin (thin filaments) and myosin; cross-bridges OR filamentous proteins slide past each other.
- Troponin/tropomyosin interaction blocks binding of myosin to actin.
- Ca^{2+} changes troponin shape/binding of troponin-tropomyosin to actin altered.
- ATP/ADP changes myosin structure.

Regulation of enzyme activity **(2 points maximum)**

- Shape change caused by **(1 point for each bullet)**
  - Binding of allosteric or noncompetitive inhibitor.
  - Binding of allosteric activator.
  - Feedback control.
  - pH or temperature changes.
  - Cleavage of pre-enzyme (e.g., zymogen).
  - Cooperativity; coenzymes; cofactors.
  - Covalent modification (e.g., phosphorylation).
- Competitive inhibitors binding in the active site prevent substrate binding.

NOTE: The active site regulating enzyme activity is not enough to earn a point.

Question 1 (continued)

Cell signaling **(2 points maximum)**

- Receptor-ligand binding **(1 point for each bullet)**
  - Event: Ligand binds specifically to receptor.
  - Result: Receptor structure altered by binding, transducing signal through membrane.

  Examples may include hormones, neurotransmitters.
- Enzyme-linked receptors: binding of ligand causes enzyme to catalyze reaction.
- Gap junctions: shape of junctions allows for passage of regulatory ions or molecules.
- Ligand-gated channel: binding of ligand opens channel.
- Immune signaling: leads to activation of cells.

(c) Abnormal hemoglobin is the identifying characteristic of sickle cell anemia. **Explain** the genetic basis of the abnormal hemoglobin. **Explain** why the sickle cell allele is selected for in certain areas of the world. **(3 points maximum)**

Genetic basis **(2 points maximum)**

- Point mutation in DNA; base substitution leading to a different amino acid in the hemoglobin.
- Changing glutamate (glutamic acid) to valine (in β-globin).

Selection **(2 points maximum)**

- Sickle cell condition protects against or resists malaria.
- Changed hemoglobin leads to oxygen-deprivation minimizing malarial infection.
- Heterozygotes maintain a reproductive advantage/success.

NOTE: Stating that sickle cell confers immunity to malaria does not earn a point.

2008 B #2

2. Many biological structures are composed of smaller units assembled into more complex structures having functions based on their structural organization.

   For THREE of the following complex structures, describe the smaller units, their assembly into the larger structures, and one major function of these larger, organized structures.

   (a) A eukaryotic chromosome

   (b) A mature angiosperm root

   (c) A colony of bees

   (d) An inner membrane of a mitochondrion

   (e) An enzyme

2008 B #2 Answer Key

Question 2

2. Many biological structures are composed of smaller units assembled into more complex structures having functions based on their structural organization.

   For THREE of the following complex structures, describe the smaller units, their assembly into the larger structures, and one major function of these larger, organized structures.

   For each:

Unit Structure (with description) **1 point**	**Organization/Assembly** **2 points maximum* (*1 may be general, second specific to larger structure)**	**Function/Benefit** **1 point maximum**

   Structures → Emergent properties **(4 points maximum each, only grade first 3)**

   (a) A eukaryotic chromosome

   Unit Structure—Organization/Assembly (must demonstrate organization to a chromosome):
   - Describe nucleotides (or later structure in the sequence)
     → DNA → nucleosomes* → chromosome
     *around histones (non-DNA)
   - Describe levels of folding
     → heterochromatin → condensed chromosome
   - Describe DNA (or later structure in the sequence)
     → functional sequences (introns/exons/spacers) → genes → regulatory elements → chromosome

   Function/Benefit:
   - Package DNA
   - Make for efficient cell division
   - Juxtaposition of coding elements
   - Gene regulation
   - Storage/protection of genetic information

   (b) A mature angiosperm root

   Unit Structure—Organization/Assembly (must demonstrate organization to a functional root):
   - Describe organelles (or later structure in the sequence)
     → cells → tissues→ layer → root

   Function/Benefit:
   - Storage
   - Transport H_2O (absorption only via root hairs)
   - Symbiotic relationships
   - Secondary growth

2006 B #2

2. The relationship of structure to function is one of the major themes in biology. For **three** of the following structure/function pairs, describe the structure and then explain how the function is related to the structure.
   (a) Enzyme structure/catalysis
   (b) mRNA structure/protein synthesis
   (c) Cell membrane structure/signal transduction
   (d) Membrane protein structure/active transport or facilitated diffusion

2006 B #2 Answer Key

Question 2

The relationship of structure to function is one of the major themes in biology. For **three** of the following structure/function pairs, describe the structure and then explain how the function is related to the structure.

(a) Enzyme structure/catalysis **(4 points maximum)**

Description (2 points)

- 3-D shape that results from folding of polypeptide chains
- Folding produces a pocket in which substrate may bind
- Levels of protein structure (primary, secondary, tertiary)

Explanation (2 points)

- Complementary 3-D shape of enzyme and substrate are required for proper interaction and catalysis in active site—reduction of activation energy; induced fit
- Allosteric modulation, effect of pH, temperature (or other environmental factors) on enzyme shape
- Elaboration points: competitive/non-competitive inhibition—effect on enzyme action; amino acid side groups in active site interact with substrate to stress bonds in substrate and reduce activation energy of reaction

(b) mRNA structure/protein synthesis **(4 points maximum)**

Description (2 points)

- Linear sequence of RNA nucleotides
- Details: 5' cap; poly-A tail; introns
- Description of origin and/or fate of mRNA (transcription, processing and translation)
- Fine details of RNA nucleotide structure

Explanation (2 points)

- The linear sequence of RNA nucleotides, read as codons (three at a time; contiguous; nonoverlapping)
- specify the sequence of amino acids incorporated in a new protein being constructed at a ribosome
- start codon and/or stop codon roles

(c) Cell membrane structure/signal transduction **(4 points maximum)**

Description (2 points)

- A phospholipid bilayer that incorporates malleable (and, often, mobile) integral or membrane associated proteins
- Membrane-embedded receptor molecules with transmembrane domains

Explanation (2 points)

- Receptor proteins undergo shape changes when proper stimulus is present—signal is communicated through membrane by allosteric shape change
- The altered proteins may then influence other cellular events or states: activation of G-proteins and/or tyrosine-kinase receptor protein auto- and heterophosphorylations leading to cellular response

Question 2 (continued)

(d) Membrane protein structure/active transport or facilitated diffusion **(4 points maximum)**

Description (2 points)

- Phospholipid bilayer (credited unless already described in c)
- Integral protein in membrane
- Protein's 3-D shape allows it to act as a channel, bind solutes, and/or bind ATP, as necessary

Explanation (2 points)

- Some solutes, like ions and larger hydrophobic molecules cannot cross phospholipid membranes unassisted.
- Integral proteins allow such substances to pass: hydrophilic channel; binding of solute leads to shape change in protein.
- Hydrolysis of ATP causes shape change in protein leading to shuttle of material from one side of membrane to the other.