

## 2007 AP<sup>®</sup> BIOLOGY FREE-RESPONSE QUESTIONS

### BIOLOGY

### SECTION II

Time—1 hour and 30 minutes

**Directions:** Answer all questions.

Answers must be in essay form. Outline form is not acceptable. Labeled diagrams may be used to supplement discussion, but in no case will a diagram alone suffice. It is important that you read each question completely before you begin to write. Write all your answers on the pages following the questions in this booklet.

1. Membranes are essential components of all cells.
  - (a) **Identify** THREE macromolecules that are components of the plasma membrane in a eukaryotic cell and **discuss** the structure and function of each.
  - (b) **Explain** how membranes participate in THREE of the following biological processes:
    - Muscle contraction
    - Fertilization of an egg
    - Chemiosmotic production of ATP
    - Intercellular signaling
2. Cephalization and the development of a brain were important steps in animal evolution.
  - (a) **Discuss** the evolutionary origin and adaptive significance of cephalization in animal phyla.
  - (b) **Describe** the development of the nervous system in the vertebrate embryo.
  - (c) At the sound of shattering glass, people quickly turn their heads. **Discuss** how the human nervous system functions to produce this type of response to an external stimulus.

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## 2007 SCORING GUIDELINES

### Question 1

Membranes are essential components of all cells.

- (a) **Identify** THREE macromolecules that are components of the plasma membrane in a eukaryotic cell and **discuss** the structure and function of each. **(6 points maximum; 1 point for each macromolecule + structure, 1 point for each macromolecule + function)**

NOTE: Only first three molecules mentioned will be scored.

Macromolecule	Structure	Function (must match selected macromolecule)
Phospholipids OR Lipid with phosphate	<ul style="list-style-type: none"> <li>Glycerol, two fatty acids, and polar head group w/phosphate</li> <li>Amphipathic</li> <li>Hydrophilic or polar (head) and hydrophobic or nonpolar (tails)</li> <li>Forms a lipid bilayer</li> </ul>	<ul style="list-style-type: none"> <li>Selectively permeable</li> <li>Fluidity</li> <li>Creates compartment/ separates cell from environment; barrier</li> <li>Signals, inositol pathway (IP3) diacylglycerol (DAG)</li> </ul>
Cholesterol	<ul style="list-style-type: none"> <li>Ring structure</li> <li>Steroid</li> <li>Amphipathic</li> <li>Embedded in bilayer</li> </ul>	<ul style="list-style-type: none"> <li>Moderates fluidity</li> <li>Stabilizes membrane</li> </ul>
Proteins OR  <u>The following specific types must indicate that they are proteins</u> Integral Peripheral Pump Receptor Transport Recognition Tight junction Desmosomes Gap junctions Integrins Enzyme Channel	<p style="text-align: center;"><u>General Structure</u></p> <ul style="list-style-type: none"> <li>Polypeptides; amino acids</li> <li>2°, 3°, 4° structure description</li> </ul> <p style="text-align: center;"><u>Specific Structure</u></p> <ul style="list-style-type: none"> <li>Integral, transmembrane, embedded; forms a channel</li> <li>Peripheral, on surface</li> <li>Structure fit to substrate or ligand</li> </ul>	<ul style="list-style-type: none"> <li>Transport</li> <li>Enzyme, catalysis</li> <li>Signal transduction</li> <li>Attachment: extracellular matrix (ECM)-cytoskeleton</li> <li>Recognition</li> <li>Cell junction</li> </ul>
Glycolipid/Glycoprotein	<ul style="list-style-type: none"> <li>Carbohydrate (chains) linked to lipid/protein</li> </ul>	<ul style="list-style-type: none"> <li>Cell recognition</li> <li>Attachment to external molecule or another cell</li> </ul>

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**Question 1 (continued)**

- (b) **Explain** how membranes participate in THREE of the following biological processes:  
**(6 points maximum; 2 points maximum per section)**

**Muscle contraction**

- Motor neuron or axon terminal releases neurotransmitter or acetylcholine (ACh)
- ACh binds to receptors
- Depolarization or  $\text{Na}^+$  moves in through membrane channels or membrane depolarizes
- Action potential propagates along cell membrane (sarcolemma) or T tubules
- Depolarization changes permeability of sarcoplasmic reticulum (SR) or  $\text{Ca}^{2+}$  released from SR
- $\text{Ca}^{2+}$  active transport into SR (reuptake of  $\text{Ca}^{2+}$ )
- Repolarization or maintenance of membrane potential ( $\text{Na}^+/\text{K}^+$  pump)
- Smooth or cardiac muscle gap junctions directly transfer membrane potential between cells

**Fertilization of an egg**

- Part of the acrosomal reaction or sperm acrosome releases hydrolytic enzymes (by exocytosis)
- Sperm binds to receptors on egg
- Fusion of sperm and egg plasma membranes
- Change in membrane electrical charge or fast block (depolarization) to prevent further fertilization (polyspermy)
- Cortical reaction or slow block by exocytosis (prevents polyspermy) or “hardening” of membrane
- Separation of fertilization membrane (envelope)
- Fusion of egg and sperm nuclear membranes or nuclei

**Chemiosmotic production of ATP**

- Electron transport chain (ETC) in membrane pumps  $\text{H}^+$  across membrane
- $\text{H}^+$  gradient established across membrane
- $\text{H}^+$  move through ATP synthase embedded in membrane to produce ATP
- Membrane infolding increases surface area

**Intercellular signaling**

- Release of chemical signals by exocytosis
- Receptors in membrane bind ligands or chemical signals or chemical signals pass through the membrane (examples: neurotransmitters, hormones, pheromones)
- Ligand-gated ion channels opening/closing
- Cascade of cellular events, including enzymatic reactions and second messengers (examples: G-proteins, cAMP,  $\text{IP}_3$ ,  $\text{Ca}^{2+}$ )
- Antibodies activate immune function
- Descriptions of gap junctions, plasmodesmata (communicating junctions)