AP® Biology
2007 Scoring Guidelines

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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	• Glycerol, two fatty acids, and polar head group w/phosphate • Amphipathic • Hydrophilic or polar (head) and hydrophobic or nonpolar (tails) • Forms a lipid bilayer	• Selectively permeable • Fluidity • Creates compartment/ separates cell from environment; barrier • Signals, inositol pathway (IP3) diacylglycerol (DAG)
Cholesterol	• Ring structure • Steroid • Amphipathic • Embedded in bilayer	• Moderates fluidity • Stabilizes membrane
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	<u>General Structure</u> • Polypeptides; amino acids • 2°, 3°, 4° structure description <u>Specific Structure</u> • Integral, transmembrane, embedded; forms a channel • Peripheral, on surface • Structure fit to substrate or ligand	• Transport • Enzyme, catalysis • Signal transduction • Attachment: extracellular matrix (ECM)-cytoskeleton • Recognition • Cell junction
Glycolipid/Glycoprotein	• Carbohydrate (chains) linked to lipid/protein	• Cell recognition • Attachment to external molecule or another cell

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2007 SCORING GUIDELINES

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 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 Ca^{2+} released from SR
- Ca^{2+} active transport into SR (reuptake of Ca^{2+})
- Repolarization or maintenance of membrane potential (Na^+/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 H^+ across membrane
- H^+ gradient established across membrane
- 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, IP_3, Ca^{2+})
- Antibodies activate immune function
- Descriptions of gap junctions, plasmodesmata (communicating junctions)

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2007 SCORING GUIDELINES

Question 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. **(3 points)**

- **Cephalization (1 point)**
  Defined: The concentration of the nervous system toward the anterior end of the organism
  OR
  Association: Cephalization tied to bilateral symmetry development

- **Origin (1 point)**
  Origin identification: (Platyhelminthes/flatworms)
  OR
  Evolutionary progression of development

- **Adaptive Significance/Advantage (1 point)**
  Efficient response to a stimulus (e.g., protection, predation, avoidance, movement toward or away)
  During movement sensory organs encounter the environment first

(b) **Describe** the development of the nervous system in the vertebrate embryo. **(4 points maximum)**

- **Tissue** of origin **(1 point)**
  - Ectoderm gives rise to the nervous system.
- **Processes** of development **(2 points)**
  - Neurulation described (neural tube formation) Note: The notochord does not become the nerve cord.
  - Other nerve development processes
    - Neural crest cells migrate to form the peripheral nervous system
    - Anterior portion of the neural tube/cord bulges to become the brain or brain regions
- **Endpoints** with structures described at the end of a process step of development **(1 point)**
  - The ectoderm folds into the neural crest/tube or dorsal nerve/spinal cord
  - Neural tube expands or develops into developmental brain region (e.g., fore-mid-hind brain, prosen-mesen-rhombencephalon)
  - Spinal column/vertebrae/cranium that protects the CNS
- **Signaling (1 point)**
  - Notochord (mesodermal in origin) signals or directs development of neural tube (ectodermal in origin)
  - *Hox* genes, morphogens (diffusible developmental signal)

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2007 SCORING GUIDELINES

Question 2 (continued)

(c) At the sound of shattering glass, people quickly turn their heads. **Discuss** how the human nervous system functions to produce this tynme of response to an external stimulus. **(5 points)**

- **Stimulus/Intermediating Structure of Receptor Action (1 point)**
  Stimulus (sound waves, pressure, heat, etc.) producing an appropriate receptor action (eardrum vibrating, cochlear hairs vibrating or bending, pressure receptors firing, heat receptors firing, etc.)
- **Input/Sensory/Afferent (1 point)**
  Signal direction toward the central nervous system
- **Integration (1 point)**
  Processing/Interpretation by CNS
  Interneurons/Association/Communicating/Internuncial
- **Output/Motor/Efferent Response (1 point)**
  Signal direction toward effectors (peripheral NS) **or** description of the response or autonomic nervous response (e.g., increase in blood pressure or heart rate, muscle contraction **but not just** turning of head)
- **Possible Elaboration (1 point)**
  Neural electrophysiology (e.g., action potential, neurotransmitters, synapse)
  Neuron structure and impulse pathway
  Sensory physiology

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2007 SCORING GUIDELINES

Question 3

Compared with other terrestrial biomes, deserts have extremely low productivity.

(a) **Discuss** how temperature, soil composition, and annual precipitation limit productivity in deserts. **(3 points maximum)**

Abiotic factor (description)	**How abiotic factor limits productivity (must be linked) (1 point per factor)**
Temperature	
Increase in transpiration/evaporation	Lowers photosynthetic rate
Desiccation	Lowers plant growth
Loss of water from tissues/guard cells	Lowers biomass production
Not optimal temperatures	PS/metabolic enzymes/proteins hindered
Soil composition	
Low organic content/nutrients	Lowers photosynthetic rate/plant growth
Low water retention	Lowers photosynthetic rate/plant growth
Sandy	Poor root anchorage limits plant growth
Compacted soil	Root limitations decrease photosynthesis
Annual precipitation	
Low rainfall	Little water available for photosynthesis
Seasonal rainfall	Lowers plant growth
	Period of high productivity/wildflowers

Clear definition/discussion of productivity: e.g., a measure of the amount of biomass produced by autotrophs/photosynthetic organism/plants…amount of light energy converted to chemical energy by autotrophs per unit time...reduced community productivity **(1 point)**

(b) **Describe** a four-organism food chain that might characterize a desert community, and **identify** the trophic level of each organism. **(2 points)**

- **Written description** of a minimum of 4 organisms (must include a producer/plant) **(1 point)**
- **Clear identification** of 4 distinct trophic levels of the organisms discussed **(1 point)**
  (producer → primary consumer → secondary consumer → tertiary consumer
  or top carnivore or decomposer or scavenger)

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Question 3 (continued)

(c) **Describe** the results depicted in the graph. **Explain** one anatomical difference and one physiological difference between species *A* and *B* that account for the CO_2 uptake patterns shown. **Discuss** the evolutionary significance of each difference. **(6 points maximum)**

Graph interpretation (3 points)

- Describe graph (plant *A* takes up CO_2 during day AND plant *B* takes up CO_2 at night) **(1 point)**
- Species *B* as CAM **(1 point)**
- Species *A* as C_3 or species *A* as C_4 **(1 point)**

Anatomical difference (1 point)

- Species *A* is C_4 with bundle sheath/wreath/Kranz anatomy
- Stomata location (pits/crypts, underside stems) linked to CO_2 uptake
- Stomata density linked to CO_2 uptake
- In species *B*/CAM vacuole/mesophyll of organic acids (malate)

Physiological difference (1 point)

- Species A stomata open during day
- CAM/species *B* stomata open at night/closed during day
- Species *A* uses C_3 pathway; CAM/ species *B* uses C_4 pathway
- C_3 uses Rubisco/ C_4 uses PEP Carboxylase
- Organic acids synthesis for CO_2 storage
- Carbon fixation during day vs. night

Evolutionary significance (2 points)

Discuss the evolutionary significance linked to each difference **(2 points, 1 point per difference)**
e.g., increased evolutionary success due to decrease in water loss in the desert environment
e.g., C_4 pathway circumvents the problem of photorespiration

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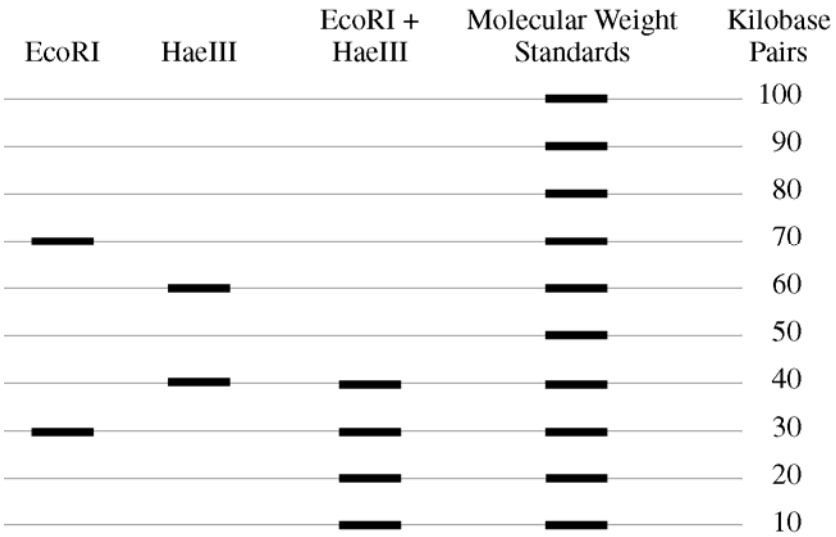
Question 4

A bacterial plasmid is 100 kb in length. The plasmid DNA was digested to completion with two restriction enzymes in three separate treatments: EcoRI, HaeIII, and EcoRI + HaeIII (double digest). The fragments were then separated with electrophoresis, as shown.

RESULTS OF GEL ELECTROPHORESIS



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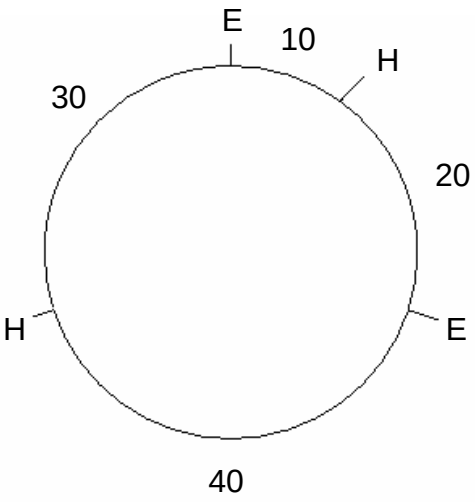
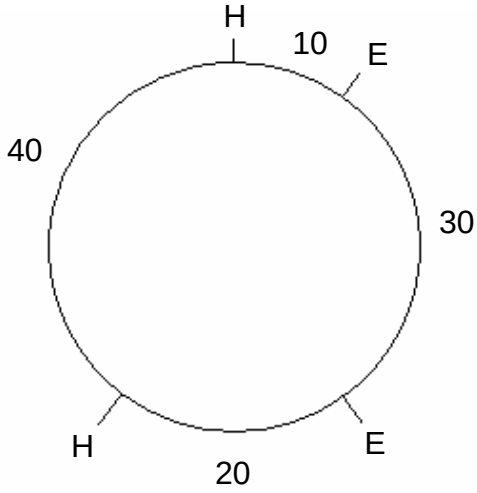
Question 4 (continued)

(a) Using the circle provided, **construct** a labeled diagram of the restriction map of the plasmid. **Explain** how you developed your map.

Construct a labeled map and **explain (3 points maximum)**





E = EcoRI Restriction Point
H = HaeIII Restriction Point

- Restriction sites correctly placed and kilobase sizes shown **(2 points)**

- Explanation **(1 point)**
  (NO POINTS for explanation with incorrect or missing map OR for interpreting gel only)
  - trial and error discussion
  - restriction site within larger fragment

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2007 SCORING GUIDELINES

Question 4 (continued)

(b) **Describe** how:

- Recombinant DNA technology could be used to insert a gene of interest into a bacterium
- Recombinant bacteria could be identified
- Expression of the gene of interest could be ensured

Describe how to: (6 points maximum)

(1) Insert gene of interest (4 points maximum)

- Cut gene of interest from source and/or cut plasmid with restriction enzyme
- Use SAME restriction enzyme on both
- Anneal/ligate/mix/combine gene of interest with vector (plasmid/virus/phage)
- "Sticky ends"/bp matches/complementarity
- Treatment for competent cells ($CaCl_2$/heat shock); incubate together
- Chemical modification can prevent restriction enzyme activity (e.g., methylation)
- Gene = cDNA (without introns) to fit into plasmid

(2) Identify recombinant bacteria (1 point)

- Phenotypic selection (antibiotic resistance/blue-white colony selection/"glo" gene, product produced [e.g., insulin])
- Radioactively/fluorescently labeled probe (tag/dye) / mRNA
- Electrophoresis of cut recombinant vs. original (gene/plasmid) **OR** with sequence comparison of recombinant vs. original (gene/plasmid) **(Not bacterial genome)**

(3) Ensure expression of gene of interest (1 point)

- Promoter [for prokaryote]
- cDNA/removal of introns for prokaryotic expression
- Operon (e.g., nutrient/arabinose induced)

(c) **Discuss** how a specific genetically modified organism might provide a benefit for humans and at the same time pose a threat to a population or ecosystem. **(3 points maximum)**

Discuss GM, benefit to humans, and threat to population/ecosystem

- Nonhuman organism with specific, heritable GM trait
- Plausible benefit to humans related to the GM trait
- Plausible or unknown threat to population/ecosystem related to GM trait/modified organism