AP® Biology
2008 Scoring Guidelines

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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.

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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.

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Question 2

2. Consumers in aquatic ecosystems depend on producers for nutrition.

(a) **Explain** the difference between gross and net primary productivity. **(2 points)**

- Definition of gross primary productivity **(1 point)**
  - Total energy converted/transformed by photosynthesis
  - Total organic molecules produced or carbon fixed
- Definition of net primary productivity **(1 point)**
  - The biomass or total energy converted minus the amount used by the producers for cell respiration
  - The amount of energy or organic molecules left for the next trophic level
  - The energy that is available to organisms that eat primary producers
  - Gross primary productivity minus respiration

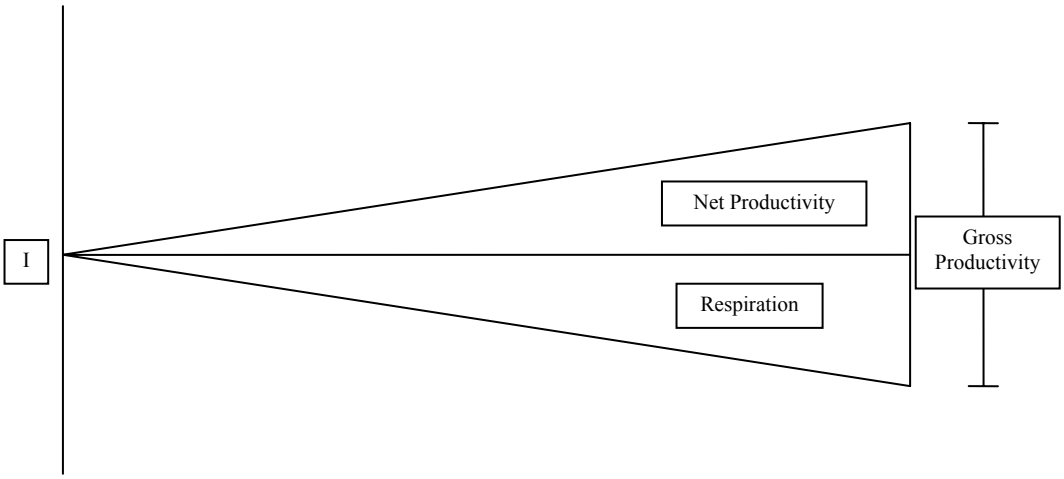
(b) **Describe** a method to determine net and gross primary productivity in a freshwater pond over a 24-hour period. **(1 point for each bullet; 4 points maximum)**

Measurement described
- Dissolved oxygen production or increase in biomass, or carbon dioxide uptake

Instrument/technique used to collect the data
- Winkler or C^{14} or oxygen probe

Methodology/design described
- Initial/baseline comparison
- Light and dark bottle comparison

Data analysis
- Light minus initial = net productivity
- Initial minus dark = respiration
- Light minus dark = gross productivity



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Question 2 (continued)

(c) **Explain** the data presented by the graph, including a description of the relative rates of metabolic processes occurring at different depths of the pond. **(1 point for each bullet; 4 points maximum)**

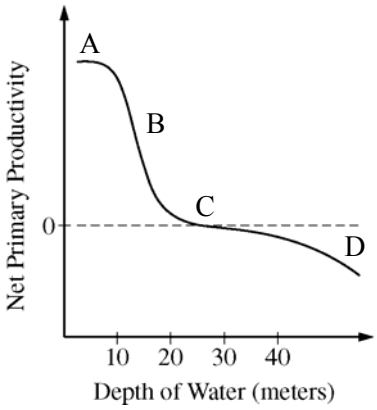
Explanation of data:

- As depth is increased, the net primary productivity decreases because light decreases/lower rates of photosynthesis.

Description of relative rates of metabolic process occurring at specific depths according to the graph (letters added to graph to simplify rubric):

- A: The upper area of the graph is equally productive because light availability is not a limiting factor at the surface/ photosynthesis is not limited.
- B: The rapidly decreasing productivity region is a result of decreasing light available for photosynthesis/photosynthesis is decreasing rapidly.
- C: At 0 (the compensation point) the photosynthetic product is equal to the cell respiration requirements due to light availability/photosynthesis equals cell respiration.
- D: Below 0 the photosynthetic product does not meet the cell respiration requirements due to insufficient light. Photosynthesis less than respiration.

NET PRIMARY PRODUCTIVITY IN A FRESHWATER POND ECOSYSTEM DURING SPRING



(d) **Describe** how the relationship between net primary productivity and depth would be expected to differ if new data were collected in mid-summer from the same pond. **Explain** your prediction. **(1 point for each bullet; 2 points maximum)**

- Description of a plausible prediction of a change in graph or a change in the relationship between productivity and depth from spring graph to mid-summer graph.
- Explanation of a plausible prediction of a shift in the graph must be tied to a valid or plausible reason.

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Question 3

3. Regulation is an important aspect of all biological processes.

For FOUR of the following processes, **describe** the specific role of the regulator and **discuss** how the process will be altered if the regulation is disrupted.

SCORING RUBRIC FOR EACH PROCESS **(1 point per bullet; 3 points maximum per process)**

Role of regulator **(2 points)**
- Cause and effect
- Effecting mechanism

How process is disrupted **(2 points)**
- Increase in regulator
- Decrease in regulator

Cell Cycle/Cyclin

Role of regulator
- Allows cell cycle to proceed OR get past checkpoint from one phase to next: G_1, S, G_2
- Works/combines with Cdk, S-phase, MPF, APC; OR how concentration fluctuates

How process is disrupted
- Decrease in cyclin: no mitosis/not past checkpoints/G_1, cell in G_0; examples: nerve and muscle cells
- Increase in cyclin: cancer/uncontrolled growth/cell division

Metabolic Rate/Thyroxine

Role of regulator
- Stimulates/increases metabolic rate
- Discuss negative feedback, TSH OR hypothalamus-releasing hormone—anterior pituitary—TSH OR metamorphosis in frog OR conversion $T_4 \rightarrow T_3$ discussion

How process is disrupted
- Decrease in thyroxine: weight gain, lethargy, no negative feedback (altered), hypothyroidism, osteoporosis OR decrease in iodine: decrease in thyroxine—goiter
- Increase in thyroxine: weight loss, increase in heart rate, increase in blood pressure, hyperthyroidism, Grave's disease

Ovarian Cycle/FSH

Role of regulator
- Stimulates maturation/development of follicle/egg OR stimulates estrogen production OR leads to (not causes or triggers) ovulation
- Continuation of meiosis OR completion of meiosis 1 OR discuss negative feedback, FSH/estrogen

How process is disrupted
- Decrease in FSH: sterile, no possibility of fertilization/pregnancy—no ovulation
- Increase in FSH: multiple eggs develop, multiple births

Question 3 (continued)

Prey Population Dynamics/Predators

Role of regulator

- Predator decreases (consumes, eats, etc.) prey population in size/number
- Negative feedback discussion: graph/lag elaboration, cyclic fluctuation or equilibrium leads to stabilizing size or carrying capacity

How process is disrupted

- Decrease in predators: prey population increases, exceeds carrying capacity, increased competition for resources—decrease in prey
- Increase in predators: prey population decreases, boom/bust as result of more prey being captured/eaten causing decrease in prey population; may cause predator decrease due to lack of food

Ecological Succession/Fire

Role of regulator

- Triggers/sets stage for succession; OR maintains a stable community
- Returns/releases nutrients into soil; OR triggers germination in some plant species; OR changes community makeup, allows for pioneer species, eliminates some species

How process is disrupted

- Decrease in fire: leads to invasive species opportunity, lack of nutrient recycling, leads to detritus build-up (may lead to catastrophic fire)
- Increase in fire: never achieves stable/climax community, succession is suspended, increase/decrease in biodiversity (with explanation)

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Question 4

4. Flowering plants have evolved various strategies for fertilization.

(a) **Describe** the process of fertilization in flowering plants. **(3 points maximum)**

Double fertilization **(2 points maximum)**

- Sperm + egg → zygote (2n)/fertilized egg
- Sperm (n) + 2 polar nuclei (n+n) → endosperm food source (3n)

Pollen tube formation **(1 point maximum)**

- Pollen grain adheres to stigma, absorbs water and germinates; growth of pollen tube (tube nucleus)
- Generative nucleus divides into two sperm nuclei (or pollen grain has two sperm nuclei)
- Development of embryo sac (female gametophyte)

(b) **Discuss** TWO mechanisms of pollen transfer and the adaptations that facilitate each mechanism. **(4 points maximum)**

Mechanism **(1 point for each mechanism discussed <u>with action verb</u>; 2 points maximum)**	**Adaptations** **(1 point for each adaptation appropriate to the mechanism(s) discussed; 2 points maximum)**
Wind (e.g., blows, carries)	Pollen shape (pits) Lightweight pollen Feather-like, sticky stigma High pollen:ovule ratio Male flowers elevated/exposed anther Stem/stamen modification for pollen release
Animal vectors (e.g., transfer, carry)	Barbs, spikes on pollen (attaches) Nectar/fragrance/color/UV patterns Coevolution of animals (specific example) Shape of flower/position of pollen
Water (e.g., transfers, carries)	Lightweight pollen floats on water
Gravity (self-pollination) (e.g., falls, drops)	Anther/stigma mature at same time Anthers above stigma

Some species of flowering plants have evolved mechanisms to prevent self-fertilization.

(c) **Discuss** an evolutionary advantage of preventing self-fertilization. **(2 points maximum)**

- Maintains/increases genetic variability of the population (<u>not at individual level</u>)
- Variability in action—explain or give an example
  (e.g., more material for natural selection, avoids effects of inbreeding, allows population to cope with changing environment)
- Hybrid vigor

Question 4 (continued)

(d) **Describe** TWO mechanisms that prevent self-fertilization. **(3 points maximum)**
1 point for a description of each mechanism as suggested by the bullets below (2 points maximum); 1 point for an appropriate specific example or detailed description

Self-incompatibility

- Pollen fails to germinate (stigma epidermal cells prevent germination of pollen through signal transduction pathway).
- Pollen tube does not complete development (due to destruction by RNAses).
- Sperm fails to unite with egg.
- S-genes must be different (allele incompatibility).
    - If pollen grain and stigma have matching alleles at the S-locus then the male gametophyte fails to begin process of fertilization.

Structural adaptations

- Stigmas are higher than anthers or vice-versa (pin and thrum) (heterostylous).
- Separate male/female flowers (monoecious)/separate sexes/stamens OR carpels (dioecious).
- Temporal separation of maturation of male/female parts (dichogamy/protogyny/protandry).
- Nectar production at different times.
- Mechanical isolation: difference in size of pollen grains and stigma papillae.