AP® Biology
2010 Scoring Guidelines
Form B

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Question 1

Biological molecules can be separated by using chromatographic techniques. The diagram shows the separation of several spinach leaf pigments by paper chromatography. Using the diagram,

(a) **Explain** how paper chromatography can be used to separate pigments based on their chemical and physical properties. **(4 points maximum)**

Separation property 2 points maximum	**Relationship to movement 2 points maximum**
Solubility in solvent used.	Greater solubility → further movement.
Molecular size/weight.	Smaller size → further movement.
Polarity/hydrophobicity/H-bonding.	Chemical similarity between solvent/pigment (solvent: pigment) → further movement.
Adhesion (affinity for paper).	Less adhesion → further movement.

- Description of chromatography protocol.

(b) **Discuss** the role of pigments both in capturing light energy and in converting it to the chemical energy of ATP and NADPH. **(3 points maximum for capturing; 3 points maximum for converting; 5 points maximum)**

Capturing

- Electromagnetic spectrum is described.
- Specific pigments absorb specific wavelength.
- Absorption/reflection (e.g., chlorophyll absorbs red/blue; reflects or transmits green).
- Pigments are embedded in thylakoid membranes.
- Antennae and/or accessory pigments.
- Electron energy level is boosted by absorption of photons (light).

Converting

- Photosynthesis is the process.
- Brief description of pathway through photosystems II and I.
- Electron transport or chemiosmosis, or both, transform light energy to chemical energy (produce NADPH/H^+/ATP).
- Brief description of electron transport or chemiosmosis, or both.
- Cyclic pathway.
- Splitting of water/photolysis.
    - H^+, e^-, O_2

(c) Use the ruler shown above to **determine** the R_f value of xanthophyll. **Show** your calculations. **(2 points maximum**)

- Formula or description $d_{pigment}/d_{solvent}$
- Calculation 3.5/7.5 ≈ 0.5

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Question 2

Certain human genetic conditions, such as sickle cell anemia, result from single base-pair mutations in DNA.

(a) **Explain** how a single base-pair mutation in DNA can alter the structure and, in some cases, the function of a protein. **(4 points maximum)**

DNA (3 points maximum)

- Define mutation; change in bases: A, C, G or T.
- Describe type of mutation: duplication, frameshift, nonsense, deletion, substitution (point mutation).
- Describe central dogma: DNA → RNA → protein.
- Describe process of central dogma: transcription → translation.
- Translation of codons: 3 nucleotides → 1 amino acid.
- Redundancy in genetic code: 64 combinations: 20 amino acids (or can result in "stop" codon).

Protein (3 points maximum)

- Describe altered protein structure: primary, secondary, tertiary, quaternary.
- Describe protein function change: active site conformation, oxygen binding.
- Describe structural change: hydrophobic/hydrophilic interactions, disulfide bonds, R-group interactions, hydrogen bonds.

(b) **Explain**, using a specific example, the potential consequences of the production of a mutant protein to the structure and function of the cells of an organism. **(4 points maximum)**

- Type of change: dominant, recessive.
- Changed protein → changed trait/character/function (gain or loss of function).
- Description of example (any trait).
- Description of protein structure or example after change.
- Description of function after change.
- Elaboration with sickle: mutation/effect in organism, Glu → Val, etc.
- Heterozygotic advantage (resistance to malaria).

(c) **Describe** how the frequency of an allele coding for a mutant protein may increase in a population over time. **(4 points maximum)**

- Hardy-Weinberg equation, with description ($p^2 + 2pq + q^2 = 1$; $p + q = 1$).
- Natural selection/adaptation, with description or example.
- Additional point for elaboration of natural selection.
    - More born than will survive, variations in individuals, variations in gene pool, sexual selection, adaptations to environment → differential reproductive success.
- Small population, with description or example (genetic drift).
- Sexual selection or inbreeding, with description or example.
- Immigration/emigration/migration, with description or example.
- Effects of germ line vs. somatic change.

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Question 3

Bacteria play central biological roles.

(a) Bacteria may act as
- producers
- parasites
- mutualistic symbionts
- decomposers

Select THREE of the ecological roles above. For each one you choose, **describe** how bacteria carry out the role and **discuss** its ecological importance. **(3 points maximum for each ecological niche; 9 points maximum)**

	1 point each	**1 point each**	**1 point each**
	Defines ecological role (this may be included in example).	Case, example or specific description.	Details, mechanism, elaboration.
Producer	• Primary source of energy for food chain/ecosystem. • Fixes carbon/primary source of organic molecules/produces oxygen.	• Cyanobacteria. • Chemoautotrophs (deep-sea vents). • Photoautotrophs (purple bacteria and green bacteria).	• Role of photosynthesis, light as energy source. OR • Conversion of energy from organic or inorganic sources.
Parasite	• +/- interactions. • Limiting factor in host population size. • Selective agent on host species.	• *Streptococcus*, *Pneumococcus*, etc. (identifies organism). OR • Pathogen causing disease, e.g., cholera, tuberculosis (identifies disease).	• How disease is induced and/or maintained. • Population control (balance in ecosystems).
Mutualistic symbiont	• +/+ interaction. • Expands niche. • Enhances competitive fitness (may confer resistance).	• *Rhizobium* in legumes. • *E. coli* in human digestive Tract. • *Staphylococcus epidermis* on skin. • Cellulose digesters in ruminants. • Etc.	• Implications of specific symbiosis (e.g., availability of nitrogen). • Maintains normal flora and its benefits. • Early exposure induces antibody formation.
Decomposer	• Recycles nutrients. • May also be a mutualistic symbiont. • Removes waste and harmful products (pesticides, oil spills).	• Nitrifying bacteria, denitrifying bacteria. • Nitrogen cycle. • Others (yield phosphate, sulfate).	• Dead organisms and waste as a source of nutrients. • Steps in nitrogen cycle (details, not duplication).

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Question 3 (continued)

(b) **Explain** how bacteria can be altered to make genetically engineered products. **(3 points maximum)**

1 point each for explaining concept fully and/or for describing the lab method.

- Isolating donor DNA/gene; using restriction enzyme; making cDNA, etc.
- Preparing recombinant vector: cutting vector using restriction enzyme; splicing sticky ends (with ligase).
- Delivering vector: transformation with recombinant plasmid, heat shock, virus/retrovirus, etc.
- Testing product or selecting for strain.
- Proliferation of reproducing cells protein purification.
- Examples of products of modified bacteria are insulin, growth hormone, gene amplification, waste decomposition enzymes, etc.

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Question 4

On a trip to a dense forest, a biologist noticed that millipedes (small invertebrates) were plentiful under logs but were rarely seen in any other location.

(a) **Propose** THREE environmental variables (two abiotic and one biotic) that could explain why millipedes are found more frequently under logs. (**1 point each; 3 points maximum)**

The following list is not exhaustive.

Abiotic factors 2 points maximum	**Biotic factors 1 point maximum**
Light	Reproduction
Temperature	Predation
Water	Food supply
Soil Texture Nutrients pH	Competition
Wind	
Periodic disturbances — fire/storms/volcanoes	

Note: Nutrient can be abiotic or biotic depending on how it is used. Climate/weather/shelter are too general!

(b) For ONE of the abiotic environmental variables you chose above, **design** a controlled experiment to test a hypothesis that this factor affects the distribution of millipedes on the forest floor. **Describe** data that would support your hypothesis. **(1 point each; 6 points maximum)**

Must relate to one of the two abiotic factors accepted in part (a) AND measure/relate to millipede distribution.

- **Hypothesis** — proposes a relationship between one abiotic factor and the distribution of millipedes.
- **Prediction/expected results** — states what should be observed if the hypothesis is supported. Can be in an "if … then" format.
- **Design** — describes an experiment that manipulates one abiotic independent variable/factor.
- **Constants** — explicitly holds all other factors constant.
- **Control** — indicates a valid control group that serves as a comparison for experimental groups.
- **Data collection** — describes what observations will be collected or how they will be collected, or both.
- **Sample size** — indicates test of multiple millipedes or replicates.
- **Statistical analysis** — suggests a mathematical and/or statistical comparison of control and experimental groups or of observed and expected. A specific statistical test need not be mentioned.
- **Feasibility** — experiment could be performed and would yield data that would answer the question posed.

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Question 4 (continued)

(c) Suppose that you were examining the distribution of a plant, instead of the millipede. **Describe** modifications in the experiment that you designed in (b) that would be required to determine whether the abiotic factor you chose affects the distribution of the plant. **(1 point each; 3 points maximum)**

Must be *reasonable* adaptation of experiment

- Modifications **(up to 2 points)** — description of the change(s) made.
- Control — description of changes in control group, if any.
- Explanation — why factor would affect a plant.
- Feasible design — experiment can be performed.