AP® Biology
2011 Scoring Guidelines

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Question 1

During an investigation of a freshwater lake, an AP Biology student discovers a previously unknown microscopic organism. Further study shows that the unicellular organism is eukaryotic.

(a) **Identify** FOUR organelles that should be present in the eukaryotic organism and **describe** the function of each organelle.
(5 points maximum)

Identify organelle (1 point for listing FOUR)	**Describe corresponding function (1 point for each function)**
Nucleus	Contains hereditary information/DNA/chromosomes or is the site of RNA synthesis.
Ribosomes	Site of protein synthesis.
ER (endoplasmic reticulum)	Internal transport or compartmentalization.
Rough ER	Protein synthesis/packaging/transport.
Smooth ER	Lipid synthesis or detoxification or transport.
Mitochondria	ATP synthesis or aerobic/cellular respiration.
Chloroplasts, plastids	Light absorption/photosynthesis/carbohydrate synthesis.
Vacuole, vesicles	Storage or transport.
Cilia/flagella	Motility.
Basal bodies	Support cilia/flagella.
Centrioles	Assist chromosome movement in mitosis.
Golgi bodies	Protein modification/packaging/transport.
Lysosomes	Enzymatic hydrolysis of wastes/metabolites/pathogens.
Peroxisomes	Catalase/peroxidase function or detoxification.

(b) Prokaryotic cells lack membrane-bound organelles found in eukaryotes. However, prokaryotes must perform many of the same functions as eukaryotes. For THREE of the organelles identified in part (a), **explain** how prokaryotic cells carry out the associated functions.
(3 points maximum)

Eukaryotic organelle	**Explain how prokaryote carries out function (1 point each)**
Nucleus	Hereditary information/DNA/chromosomes or RNA synthesis in cytosol.
Ribosomes	Site of protein synthesis.
ER (endoplasmic reticulum)	Diffusion of molecules in cytosol.
Rough ER	Protein synthesis/transport in cytosol; may be linked to transcription.
Smooth ER	Lipid synthesis or detoxification occurs in cytosol.
Mitochondria	Other membranes or cytosolic molecules function in ATP synthesis.
Chloroplasts	Other membranes or cytosolic molecules function in light absorption/photosynthesis/carbohydrate synthesis.
Plastids	Pigments are distributed throughout cytosol or are associated with membranes.
Vacuole, vesicles	Inclusion bodies/granules/large molecules in cytosol.
Cilia or flagella	Motility via bacterial flagella.

Question 1 (continued)

Basal bodies	Other structures support flagella.
Centrioles	Enzyme-mediated chromosome movement.
Golgi bodies	Protein modification/packaging/transport in cytosol.
Lysosomes	Secreted enzymes hydrolyze wastes/metabolites/pathogens.
Peroxisomes	Production/secretion of catalase or detoxification.

(c) According to the endosymbiotic theory, some organelles are believed to have evolved through a symbiotic relationship between eukaryotic and prokaryotic cells. **Describe** THREE observations that support the endosymbiotic theory.
(4 points maximum)

Describe three observations (1 point each)

- Mitochondria contain their own DNA.
- Chloroplasts contain their own DNA.
- Mitochondria can self-replicate.
- Chloroplasts can self-replicate.
- Mitochondrial chromosomes are circular.
- Chloroplast chromosomes are circular.
- Mitochondrial chromosomes lack histones.
- Chloroplast chromosomes lack histones.
- Mitochondria contain ribosomes that are similar to bacterial ribosomes.
- Chloroplasts contain ribosomes that are similar to bacterial ribosomes.
- Inner membrane of mitochondria is similar the membrane of prokaryotes.
- Inner membrane of chloroplasts is similar the membrane of prokaryotes.
- Mitochondria can perform transcription and translation.
- Chloroplasts can perform transcription and translation.
- First amino acid in the polypeptides in mitochondria is fMet (N-formylmethionine).
- First amino acid in the polypeptides in chloroplasts is fMet (N-formylmethionine).
- Mitochondria are approximately the size of bacteria.
- Chloroplasts are approximately the size of bacteria.
- Mitochondria use many prokaryote-like enzymes.
- Chloroplasts use many prokaryote-like enzymes.
- Many antibiotics (e.g., rifampicin) interfere specifically with mitochondrial protein synthesis.

General description of endosymbiotic theory (1 point)

- Prokaryotic cells have been engulfed by and are living within ancestral/precursor eukaryotes.

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Question 2

Organisms utilize a diversity of methods to obtain proper nutrition.

(a) Some organisms digest food intracellularly, while others digest food extracellularly.
(4 points maximum)

- **Identify** ONE nonvertebrate organism that digests food intracellularly and **describe** the process.
- **Identify** ONE nonvertebrate organism that digests food extracellularly and **describe** the process.

	Organisms include, but are not limited to (1 point each)	**Identify process (1 point each)**
Intracellular	Protozoa, sponges, flatworms, Cnidaria	Breakdown/hydrolysis of food inside the cell.
Extracellular	Fungi, bacteria, invertebrates with a gut, Cnidaria, carnivorous plants, flatworms	Breakdown/hydrolysis of food in the gastrovascular cavity, gut, or outside of the organism.

(b) **Describe** TWO structural features of the human stomach and/or small intestine. For each, **explain** how the structure relates to the function.
(4 points maximum)

	Structural feature	**Description (1 point each)**	**Explanation of structure/function relationship (1 point each)**
Stomach	Lining	Mucus layer	Protection from acid damage.
	Wall	Muscular	Mechanical digestion/churning/movement.
	Shape	Saclike	Food reservoir/storage.
		Rugae	Expansion/increase of surface area and secretions.
	Sphincter	Muscular ring	One-way movement through the system.
Small intestine	Villi	Fingerlike or hairlike	Increases surface area to increase absorption.
	Microvilli	Fingerlike or hairlike	Increases surface area to increase absorption.
	Duodenum	Tubular passageway	Enzyme-mediated digestion or nutrient absorption.
	Length/size	Long or folded	More area and time for absorption.

Question 2 (continued)

(c) Plants have a variety of mechanisms for obtaining nutrients. **Describe** TWO plant structures and **explain** how each structure is utilized in nutrient uptake.
(4 points maximum)

	Description of plant structure (1 point each)	**Explanation of mechanism (1 point each)**
Root	Branched or fibrous	Increases surface area for absorption.
	Taproot	Increases soil penetration to reach deep nutrients.
	Nodules	Nitrogen uptake.
Root hairs	Hairs, thin extensions	More surface area for water/mineral absorption.
Leaf	Stomata/pores/openings in leaf	Carbon dioxide uptake, transpiration drives water/mineral uptake.
Trap	Chamber for catching/digesting prey	Breakdown of prey into nutrients absorbed through chamber wall.

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Question 3

Reproduction can be either asexual or sexual.

Note: Points must be earned from parts (a), (b), and (c) in order to earn a maximum score of 10.

(a) Using a specific example, **describe** how organisms can reproduce asexually.
(3 points maximum)

Specific examples (include but are not limited to)	**Describe corresponding reproduction (1 point each)**
Bacteria, archaea, protists	Binary fission splits cell into two cells.
Yeast, sponges, hydra, jellyfish	Budding by mitosis.
Fungi, conidia	Produce haploid spores.
Fungi, sponges	Fragments form new individual.
Rotifers, nematodes, flatworms, gastropods, insects, crustaceans, fish, amphibians, reptiles, bees, wasps, ants, Komodo dragon	Parthenogenic development of unfertilized eggs.
Strawberries	Runners or modified shoots.
Irises, bamboo, beach grasses, rushes, sand verbena	Modified shoots/stolons/rhizomes.
Potato tubers	Modified shoots with buds/eyes.
Kalanchoe leaves	Leaves generate new plants.
Black locust, pear, apple, cherry, blackberry, aspen	Runners/root sprouts/suckers.
Lilies, tulips, onions, daffodils, garlic	Bulbs or corms form modified underground buds.
Crocus, *Gladiolus*, *Cyclamen*, taro	Short, erect underground stems.
Dandelions, blackberries, citrus trees, Kentucky bluegrass	Apomixis produces seeds without pollination.
Agricultural crops	Grafting/cutting/cell culture.

Discuss TWO evolutionary advantages of asexual reproduction.
(2 points)

- It is successful at low population density.
- It eliminates the energy cost of finding a mate.
- It exploits stable environments.
- It is rapid and efficient.
- It eliminates the energy cost of fertilization/pollination.
- It eliminates the need for pollinators in plants.

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Question 3 (continued)

(b) **Identify** THREE ways that sexual reproduction increases genetic variability. For each, **explain** how it increases genetic diversity among the offspring.
(6 points maximum)

Identification (1 point each; 3 points maximum)	**Explanation (1 point each; 3 points maximum)**
Crossing over or recombination	Generates new combinations of alleles.
Independent assortment	Random alignment on metaphase plate during meiosis.
Random fertilization	Nonspecific gamete selection.
Random mating	Nonspecific mate selection.
Diploidy or polyploidy	Harmful recessive mutations may not be expressed.

(c) **Discuss** TWO prezygotic isolating mechanisms that prevent hybridization between two species. Include in your discussion an example of each mechanism.
(4 points maximum)

Discussion of isolating mechanism (1 point each) with a reasonable example (1 point each)	
Habitat/ecological isolation	Preferences for living/mating in different habitats/microenvironments.
Geographical isolation	Living or mating in different geographic areas with a physical barrier.
Mechanical isolation	Structural differences of reproductive organs.
Temporal isolation	Different mating time of day or season of year.
Behavioral isolation	Different mating rituals between species.
Gametic isolation	Molecular incompatibilities between sperm and egg OR Chemical incompatibilities limit sperm viability.

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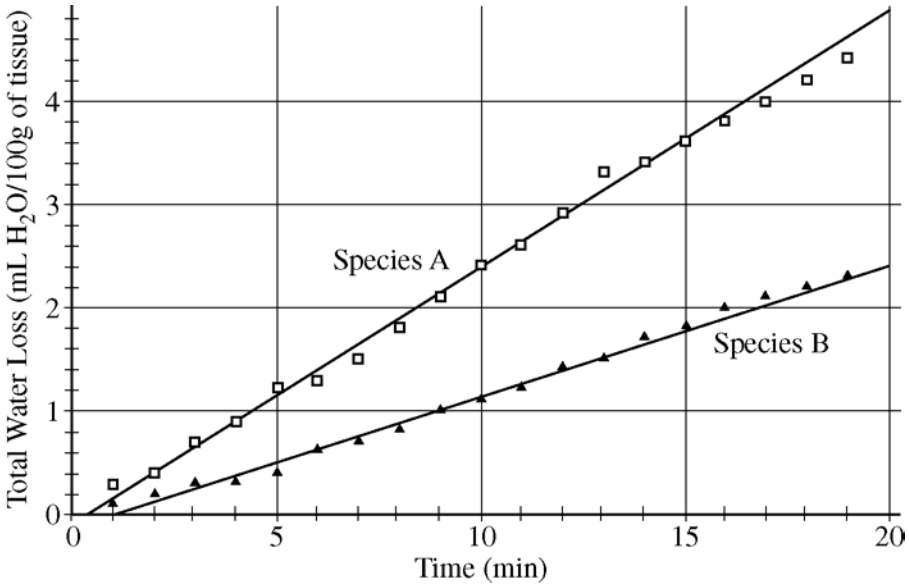
Question 4

The regulation of transpiration is an important homeostatic mechanism in plants.

(a) Under controlled conditions, a transpiration experiment was conducted using two plant species. The data collected are shown in the figure below. Using the data from the experiment, **calculate** the rate of transpiration for species A and species B between the times of 5 and 15 minutes (show your work). **Summarize** the difference between the two transpiration rates.
(3 points maximum)

WATER LOSS VERSUS TIME FOR TWO PLANT SPECIES



- Calculate transpiration rates, with units *(1 point each; 2 points maximum)*.
- Correct setups with incorrect results *(1 point maximum)*.

Species A
(1 point)

$\frac{3.6 \text{ mL } H_2O - 1.2 \text{ mL } H_2O}{15 \text{ minutes} - 5 \text{ minutes}} = 0.24 \text{ mL } H_2O/100g/\text{min } (\pm 0.02)$

OR

$\frac{3.6 - 1.2}{15 - 5} = 0.24 \text{ mL } H_2O/100g/\text{min } (\pm 0.02)$

OR equivalent

Question 4 (continued)

Species B
(1 point)

$\frac{1.8 \text{ mL } H_2O - 0.4 \text{ mL } H_2O}{15 \text{ minutes} - 5 \text{ minutes}} = 0.14 \text{ mL } H_2O/100g/min \ (\pm 0.02)$

OR

$\frac{1.8 - 0.4}{15 - 5} = 0.14 \text{ mL } H_2O/100g/min \ (\pm 0.02)$

OR equivalent

Summarize the difference between the rates *(1 point).*

- Species A is losing water or transpiring faster than species B.

(b) **Identify** and **explain** THREE different structural or physiological adaptations that could account for the different transpiration rates of species A and B.
(6 points maximum)

Identify adaptation (1 point each; 3 points maximum)	**Explain effect and specify directionality (1 point each; 3 points maximum)**
Cuticle	Thicker cuticle decreases transpiration.
Stomata number	Increased number increases transpiration.
Stomata location	Underside location decreases transpiration.
Stomata size	Larger stomata increase transpiration.
Surface area of leaves	Increased surface area increases transpiration.
Root size or structure	Affects rate of water absorption, amount of water lost.
Root hairs	Increased number increases transpiration.
Leaf hairs	Presence decreases transpiration.
Stomatal crypts or recessed pits	Presence decreases transpiration.
C_3 photosynthesis	Requires more water than C_4.
C_4 photosynthesis: CO_2 concentrated as 4-carbon acid	Requires less water than C_3.
CAM photosynthesis: stomata open at night	Reduced water loss during day.
Abscissic acid	Closes the stomata, slows transpiration.
Guard cell regulation	Turgidity opens stomata, increasing transpiration.

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Question 4 (continued)

(c) Water potential (Ψ) is described by the following formulas.

$$\Psi = \Psi_p + \Psi_s$$

$$\Psi = -iCRT$$

Discuss the variables in both formulas and how they affect water potential.
(4 points maximum)

Variables in $\Psi = \Psi_p + \Psi_s$		**Discussion of effect on water potential (1 point each; 2 points maximum)**
Ψ_p	Pressure potential	Water will move from the area of high pressure to the area of low pressure.
Ψ_s	Solute potential	Water will move from the area of high solute potential (low solute concentration) to the area of lower solute potential (higher solute concentration).

	Variables in $\Psi = -iCRT$	**Discussion of effect on water potential (1 point each; 2 points maximum)**
i	Ionization constant	Greater ionization decreases water potential/increases water movement, OR Decrease in ionization increases water potential/decreases water movement.
C	Concentration	Increase in concentration decreases water potential/increases water movement, OR Decrease in concentration increases water potential/decreases water movement.
R	Pressure constant	No change in water potential/movement.
T	Temperature	Increase in temperature decreases water potential/increases water movement, OR Decrease in temperature increases water potential/decreases water movement.

- Discussion stating that the formula allows osmotic potential or water movement to be calculated or predicted *(1 point).*