AP® BIOLOGY
2011 SCORING GUIDELINES

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.

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.

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   (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.

a) four organelles that ~~are~~ Should be present in the eukaryotic organisms are nucleus, that houses the genetic material and has a nucleolus that has the instructions for making ribosomal RNA; lysosome, that contains hydrolytic enzymes that breakdown macromolecules or organelles that are no longer functional; mitochondria, which busies itself with ATP production (energy production); and chloroplast, that synthesizes glucose using light energy.

b) Prokaryotic cells have genetic material but lack a nucleus instead their genetic material is located in an unbound region called the nucleoid. ~~The genetic material is duplicated in a similar fashion, however, the~~ The prokaryotes produce energy through glycolysis that occurs in the cytosol, also their electron transport chain is located in the plasma membrane instead of the mitochondria, hence, ATP is produced but not by

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ADDITIONAL PAGE FOR ANSWERING QUESTION 1

the mitochondria. For sugar synthesis, the prokaryotes have ~~the~~ the metabolic machinery in the plasma membrane instead of the chloroplast, thus they have pigments that absorb light but are located in the plasma membrane instead of the chloroplast. ~~However, some prokaryotes under~~

c) Endosymbiotic theory is supported by the fact that ~~chlor~~ choloroplast and mitochondria have tiny amounts of genetic material - thus, they must have been a free-living organism. Moreover, they can synthesize some of their own proteins - which is achieved by all organisms - Their membranes are structurally different from other membranes found in ~~chlor~~ other organelles.

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   (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.

1a. Eukaryotic organisms are different from bacterial organisms in the fact that they have membrane bound organelles and an organized nucleus. A Eukaryotic cell has a defined nucleus. The nucleus is composed of a nuclear membrane, which holds the chromatin and nucleolus (condensed chromatin). The nucleus holds the cell's genetic information. The cell's DNA is located here.
A Eukaryotic cell also has membrane-bound organelles called lysosomes. Lysosomes use hydrolytic enzymes to break down matter in the cell. They have a membrane so that the enzymes do not escape and destroy other parts of the cell.
A Eukaryotic cell has mitochondria. These are membrane bound organelles which produce energy for the cell. They go through a process called aerobic respiration and produce ATP, which power the cell.
Eukaryotic cells also have centrioles, which are made of bundles of microtubules. These organelles are very important because they are needed to pull the cell's sister chromatids apart during anaphase of mitosis.

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1B2

ADDITIONAL PAGE FOR ANSWERING QUESTION 1

1b. Although prokaryotes lack membrane bound organelles, they still have to perform many of the same functions, although in different ways.
Prokaryotes are well known for their lack of a defined nucleus. The organism's genetic material is contained in one long circular strand, called a plasmid. It does not condense into chromosomes like the DNA of a eukaryote would. Prokaryotes also lack lysosomes, which break down matter in the cell. Prokaryotes can get rid of matter they do not need by the process of exocytosis.
Prokaryotes lack centrioles, which pull sister chromatids apart during anaphase, so they are unable to undergo mitosis. Instead, they go through a process called binary fission in which the cell's plasmid doubles in size, then the cell divides into two new cells.

1c. The endosymbiotic theory suggests that some of the organelles evolved through symbiotic relationships.
Chloroplasts provide plant cell's with energy. Chloroplasts have their own DNA, which might suggest that at one time, they lived on their own as prokaryotic organisms. They could have been autotrophs.
Mitochondria are another example of an organelle that could have originated as a prokaryote. They too have their own DNA. They can produce ATP, which could be used as an energy source.
Peroxisomes are organelles which break down harmful chemicals, such as $2H_2O_2$ to $2H_2O + O_2$. They have their own membrane, which suggests that they might have lived on their own.

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1C1

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SECTION II
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1(a). Some organelles that would be found in the eukaryotic organism would be Ribosomes, cytoplasm, mitochondria, and Rough Endoplasmic Reticulum. Ribosomes create the proteins that are needed for the organism. The cytoplasm holds all the organelles in place and stabilizes them. Mitochondria are the powerhouse of the organism. They supply ATP and provide energy. The Rough E.R. modifys the protins that were made by the Ribosomes.

1(b). Prokaryotic cells lack membrane-bound organelles that the eukaryotes have, but they still need some of the same organelles to function. Prokaryotic cells have Ribosomes to create protins. They also have cytoplasm to hold everything in place. Mitochondria is

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needed in prokaryotic cells because energy and ATP needs to be supplied.

1(C). One way that supports the embiosis theory is that the prokaryotic cell engulfed the eukaryotic cell. Scientists discovered this because they found mitochondria in cells but it has its own DNA, so they think that prokaryotic and eukaryotic cells combined. Another way to support the embiosis theory is that prokaryotic and eukaryotic used each other and became one cell. Another way to support would be since scientists found that mitochondria had its own DNA that there had to be two organisms that combinded with each other

AP® BIOLOGY
2011 SCORING COMMENTARY

Question 1

Overview

This question provided an opportunity to describe the biology of eukaryotic and prokaryotic cells and to examine evidence for the endosymbiotic theory of eukaryotic origins. In part (a) the hypothetical discovery of a freshwater, unicellular eukaryotic organism provided an opportunity to demonstrate knowledge of the identity and function of any four cellular organelles. In part (b) the functions of three of the selected eukaryotic organelles described in part (a) were the basis for providing an explanation of how prokaryotic cells manage to carry out the functions even though they lack the organelles. In part (c) the description of three observations that support the endosymbiotic theory was requested. Evidence could be from structure, biochemistry, or processes — particularly involving similarities between prokaryotes and mitochondria or prokaryotes and chloroplasts. An elaboration point could be earned for describing the specifics of the endosymbiotic theory.

Sample: 1A
Score: 10

The response earned the maximum of 5 points in part (a). One point was earned for describing the function of the nucleus, which "houses the genetic material." One point was earned for describing the function of the lysosome ("contains hydrolytic enzymes that breakdown macromolecules"), and 1 point was earned for describing the function of the mitochondrion, "which busies itself with ATP production." One point was earned for describing the function of the chloroplast, which "synthesizes glucose." One point was earned for identifying four correct organelles (nucleus, lysosome, mitochondrion, chloroplast), which did not need to be in a list.

The response earned the maximum of 3 points in part (b). One point was earned for describing how prokaryotes carry out the function of a nucleus ("have genetic material … [in] the nucleoid"). One point was earned for describing how prokaryotes carry out the function of mitochondria, by stating that "their electron transport chain is located in the plasma membrane." One point was earned for describing how prokaryotes carry out the function of chloroplasts, by stating, "For sugar synthesis, the prokaryotes have the metabolic machienry [*sic*] in the plasma membrane instead of the chloroplast."

In part (c) 1 point was earned for the observation that chloroplasts have "tiny amounts of genetic material," and 1 point was earned for the observation that mitochondria have "tiny amounts of genetic material." The response could have earned 1 more point for a third observation, by explaining that chloroplasts and mitochondria "can synthesize some of their own proteins" or for noting that "[t]heir membranes are structurally different from other membranes found in other organelles" — but the maximum of 10 points had already been reached.

Sample: 1B
Score: 8

The response earned the maximum of 5 points in part (a). One point was earned for describing the function of the nucleus, "which holds the chromatin." The response earned 1 point for describing the function of lysosomes, which "use hydrolytic enzymes to break down matter in the cell." One point was earned for describing the function of mitochondria ("produce ATP"), and 1 point was earned for describing the function of centrioles ("to pull the cell's sister chromatids apart"). One more point was earned for identifying four correct organelles (nucleus, lysosomes, mitochondria, centrioles).

Question 1 (continued)

In part (b) 1 point was earned for describing how prokaryotes carry out the function of centrioles through "binary fission."

In part (c) 1 point was earned for the observation that "[c]hloroplasts have their own DNA," and 1 point was earned for the statement that "[m]itochondria … have their own DNA."

Sample: 1C
Score: 5

In part (a) the response did not earn a point for correctly identifying four correct organelles, because one of the four components listed is incorrect ("cytoplasm"). One point was earned for describing the function of ribosomes by stating that "[r]ibosomes create the proteins," and 1 point was earned for describing the function of mitochondria: "They supply ATP." One point was earned for describing the function of the rough endoplasmic reticulum ("[t]he Rough E.R. modifys [*sic*] the proteins").

In part (b) 1 point was earned for explaining that prokaryotes have ribosomes (the response had previously explained the function of ribosomes).

In part (c) 1 point was earned for the observation that mitochondria "has its [*sic*] own DNA."