CollegeBoard AP

Student Performance Q&A:

2011 AP® Biology Free-Response Questions

The following comments on the 2011 free-response questions for AP® Biology were written by the Chief Reader, John Lepri of the University of North Carolina Greensboro. The comments provide an overview of each free-response question and of how students performed on the question, including typical student errors. General comments regarding the skills and content that students frequently have the most problems with are included. Some suggestions for improving student performance in these areas are also provided. Teachers are encouraged to attend a College Board workshop to learn strategies for improving student performance in specific areas.

Question 1

What was the intent of this question?

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.

How well did students perform on this question?

The mean score was 4.87 out of a possible 10 points. The observation that mitochondria and/or chloroplasts contain DNA was frequently delivered, often making the connection between DNA and self-replication. The double membranes of mitochondria and chloroplasts were often described, and the more accurate descriptions likened the inner membrane's similarity to the prokaryotic membrane. The endosymbiotic theory was often supported by reports that prokaryotic cells may have been engulfed by an ancestor of the first eukaryotes.

What were common student errors or omissions?

Many essays included descriptions of more than four organelles or identified additional cellular structures, though it was not possible to earn points for descriptions beyond the first four organelles described. Many essays correctly identified an organelle but then incorrectly described its function (e.g., "Golgi bodies make proteins"). Many analogies for organelle functions were

provided (e.g., "the nucleus is the brain of the cell"), but students neglected to further describe the actual cellular function the organelle performs. A common misconception was that chloroplasts took the place of mitochondria in plants.

In part (b) explanations of how prokaryotes carry out functions associated with eukaryotic organelles were often omitted, except in the case of ribosomes. Students sometimes claimed that prokaryotes are simpler than eukaryotes and therefore do not need organelles to complete the same complex tasks as eukaryotes do. The genetic material of prokaryotes was often incorrectly described as single-stranded DNA, or found only in plasmids, or exclusively as RNA. Students often confused the nucleoid with the nucleolus.

There were incorrect claims that prokaryotes have mitochondria because all cells need to have energy; other incorrect claims included the argument that prokaryotes lack ribosomes because they do not have nuclei. Some students incorrectly described bacteria as capable of undergoing endocytosis and forming vesicles or expelling wastes via exocytosis.

In part (c) many students wrote that mitochondria and chloroplasts can exist outside the cell.

Based on your experience of student responses at the AP Reading, what message would you like to send to teachers that might help them to improve the performance of their students on the exam?

- A solid understanding about the origin and function of organelles is the requisite foundation for understanding cell biology. Help students to better understand what constitutes an organelle and explain the functions of each organelle.
- Discuss the endosymbiotic theory with students, being sure to provide evidence that supports the theory.
- Help students to connect endosymbiosis with an explanation for the emergence of eukaryotic cells.
- Recommend that students use the 10-minute reading time in the exam session to carefully plan their answers to each question. To best answer this question, students needed to carefully choose eukaryotic organelles for which they could explain the role in eukaryotic cells, as well as the analogous process in prokaryotic cells. Students who just described the first organelles that came to mind in part (a), without first planning their answer for part (b), may have been deeply challenged to explain how prokaryotes carried out the corresponding functions of the eukaryotic organelles.
- Encourage students to look for relationships and linkages that develop as the prompt proceeds in parts (a), (b) and so forth.

Question 2

What was the intent of this question?

This question focused on nutrition. Part (a) requested the distinctions between intracellular and extracellular digestion, along with one example of an invertebrate organism that utilizes each type of digestion. In part (b) the focus changed to human digestion by requesting a description of structural features of the stomach and small intestine, along with an explanation of structure and function. In part (c) the focus shifted to plants, with a request for the description of two plant structures used for obtaining nutrients, again with an explanation of structure and function.

How well did students perform on this question?

The mean score was 4.15 out of a possible 10 points. In part (a) there was often the correct identification of an organism that digests its food extracellularly, for example, fungi or flatworms. In part (b) points were often earned for describing the small intestine as long and folded and explaining how this allowed more surface area for absorption of nutrients. In part (c) many essays correctly described root hairs as thin extensions and explained that root-hair structure provides a large surface area for absorption of nutrients from the soil.

What were common student errors or omissions?

The most common misconception in part (a) concerned the difference between intracellular and extracellular digestion. Referring to the entire organism rather than the individual cells of the organism was a problem that led to the incorrect generalization that extracellular digestion is simply digestion *outside the body*, whereas intracellular digestion is simply that digestion that occurs *inside the body*. This error was compounded by incorrect examples of organisms that demonstrate each type of digestion. For an organism that carries out intracellular digestion, students often chose invertebrates that have a gut or digestive tract into which they take food, because by doing so they are taking it *into their body*. Finally, even though the question asked for a nonvertebrate example for each type of digestion, some essays included discussion of human, or other vertebrate, digestion in part (a).

In part (b) there were some incorrect descriptions of the anatomy of the human digestive system. Many essays had lists of chemicals, such as acids or enzymes, as structural features of the stomach and intestine. Discussion of structural features often left out the functional descriptions. Likewise, essays that provided only the function without relating it to structure did not earn all possible points in this section. For example, when using villi as an example, students often stated simply that villi absorb nutrients, rather than more fully explaining that villi are fingerlike folds that increase the surface area available for absorption in the small intestine.

In part (c) sunlight was occasionally described erroneously as a nutrient, along with descriptions of the leaf structures that aid in gathering sunlight. There was some confusion about nutrient *uptake* versus nutrient *transport*, with xylem and phloem inadequately described as structures for nutrient uptake.

Based on your experience of student responses at the AP Reading, what message would you like to send to teachers that might help them to improve the performance of their students on the exam?

- Remind students to provide only the number of examples asked for in the question. In parts (b) and (c) many students described or listed more than two structural features. This wastes time that students could better spend on the other questions.
- Instruct students to read the question carefully and be sure they understand the difference between such terms as “describe,” “identify” and “summarize.”

Question 3

What was the intent of this question?

This question offered the opportunity to compare asexual and sexual reproduction in specific organisms. Part (a) requested the description of a specific organism that reproduces asexually, along with a discussion of two evolutionary advantages to this type of reproduction. Part (b) requested the identification of three ways that sexual reproduction increases genetic variability, as well as discussion of how each increases genetic diversity among the offspring. Part (c) requested the discussion of two prezygotic isolating mechanisms in sexual reproduction, along with the provision of examples in the discussion.

How well did students perform on this question?

The mean score was 4.84 out of a possible 10 points. In part (a) many essays earned points for describing binary fission as an asexual reproductive strategy in bacteria. In part (b) many essays earned points for describing the low biological cost and the high speed and efficiency of asexual reproduction. In part (c) many essays earned points for explaining that chromosomal cross-over generates new combinations of alleles and increases genetic diversity.

What were common student errors or omissions?

In part (a) essays stated the misconception that bacteria reproduce asexually using mitosis or meiosis, rather than stating the correct method of reproduction, binary fission. Self-pollination in plants was wrongly described as asexual reproduction, as was self-fertilization in hermaphroditic organisms. Some essays wrongly equated asexual reproduction to external fertilization. Although budding by mitosis correctly constitutes a form of asexual reproduction, it was erroneously attributed to various plant species. In the second section of part (a), some essays incorrectly suggested that an advantage of asexual reproduction is that mutations are not possible.

In part (b) natural selection was posited to be a mechanism that increases genetic variability in sexually reproducing species. When chromosomal cross-over was discussed as a mechanism that increases genetic variability, some essays suggested that it occurs after fertilization. Students wrongly identified Punnett squares as examples of genetic variability rather than discussing the underlying mechanisms that generate diversity.

In part (c) the distinction between prezygotic and postzygotic reproductive isolating mechanisms was not always clearly portrayed. Incorrect examples of prezygotic isolating mechanisms included the bottleneck effect and founder effect, both of which were said to limit reproduction, and allopatric speciation was sometimes equated with geographic isolation. Many essays used the same species for both examples of prezygotic isolation, and many did not distinguish between geographic or physical barriers and temporal or time barriers.

Based on your experience of student responses at the AP Reading, what message would you like to send to teachers that might help them to improve the performance of their students on the exam?

- Remind students to read the question more than once in order to fully understand what is being asked, and to take time to organize their responses before they begin to write.
- Students should pay special attention to the boldfaced terms, such as “describe,” “identify” and “summarize.”

- Use specific examples when discussing the differences between asexual and sexual reproduction.

Question 4

What was the intent of this question?

This question presented an opportunity to demonstrate knowledge of transpiration and water potential in plants. In part (a) a graph of transpiration data for two populations of plants was provided and was intended to be used to calculate the rates of transpiration. In part (b) there was a request to identify and explain the structural or physiological adaptations that could account for the differences in transpiration rates in two populations. Part (c) provided two formulas for water potential and requested a discussion of the component factors in those equations.

How well did students perform on this question?

The mean score was 3.98 out of a possible 10 points. Many essays scored points for correctly extracting data from the graph to setup and calculate the rates of transpiration. Most essays scored the point for summarizing the differences in transpiration rates. In part (b) many essays scored points for correctly explaining how structural adaptations such as differences in the cuticle thickness or stomata number or stomata size affect the transpiration rate. CAM photosynthesis was the most common physiological adaptation discussed.

What were common student errors or omissions?

Common calculation errors in part (a) included not showing the setup, choosing data points other than the 5- and 15-minute interval specified in the question, or not providing units in the answers. A common error involving units was to leave out mL or not specify the unit of time. There appears to be a widespread unfamiliarity with the simple math needed to calculate rate from the slope of a graph.

In part (b) many essays did not accurately describe how C_3, C_4 and CAM photosynthesis affect transpiration, often, for example, incorrectly stating that both C_4 and CAM plants open their stomata mostly at night. Some essays described environmental factors as the explanation for the differences in transpiration rates, even though the question specified that the data were collected under controlled environmental conditions, with an expected assumption that these were identical for both populations.

In part (c) there was widespread omission of meaningful discussion of water potential and the variables in the equation. In those cases where the equations were discussed, many essays also misidentified what the variables represented, stating, for example, that "T" was "time" rather than temperature or "R" was "rate" rather than a constant.

Based on your experience of student responses at the AP Reading, what message would you like to send to teachers that might help them to improve the performance of their students on the exam?

- Give students practice and experience in basic graphing and calculation skills by offering multiple opportunities for students to generate graphs by hand, practice analysis of graphed data, and calculate rates from graphed data. Emphasize showing work and including full units in calculations.

- Although most students appeared to have conducted the plant transpiration lab, they had difficulty in extending their knowledge to the structure and functions of plants. Look for ways to demonstrate how structure is of adaptive value to function in all content areas of the course.
- Teach the formulas that are in the curriculum and look for ways to link mathematics to biological applications.