CollegeBoard
Advanced Placement Program

# Student Performance Q&A:

## 2006 AP® Biology Free-Response Questions

The following comments on the 2006 free-response questions for AP® Biology were written by the Chief Reader, Dwayne Wise of Mississippi State University in Mississippi State, Mississippi. They give 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 tested students' knowledge of structures in prokaryotic and eukaryotic cells. The three-part question asked students to describe the structure and function of two membrane-bound organelles, to discern structural differences in two out of the three listed nonmembranous components common to prokaryotic and eukaryotic cells, and to explain and discuss the endosymbiotic theory of the origin of eukaryotic cells.

#### *How well did students perform on this question?*

Students could earn a maximum of 4 points for each of parts (a) and (b) and a maximum of 2 points for part (c), for a total of 10 points. The mean score was 4.36. Only 4 percent of students left the question blank, and 6 percent received a score of zero. On the whole, students marshaled an impressive amount of information in parts (a) and (b) but provided less detail in part (c).

#### *What were common student errors or omissions?*

The most common errors were describing the structure/function of the cell *membrane* rather than the cell *wall*, stating that DNA is single-stranded in prokaryotes but double-stranded in eukaryotes, and confusing the nucleus with the nucleolus. Also, many students omitted a description of the structure of an organelle when describing its function.

***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?***

In general, students did a good job organizing their answers for each part of the question. When questions ask for "differences," they should make explicit reference to both items being contrasted. For example, if comparing the structure of eukaryotic and prokaryotic DNA, they should state that prokaryotic DNA is circular *but* eukaryotic DNA is linear. It is not sufficient to say prokaryotic DNA is circular. When students make analogies (e.g., "mitochondria are the powerhouse of the cell"), they should realize that no points will be earned without an explanation of what this analogy means.

## Question 2

***What was the intent of this question?***

This question dealt with species interactions, the competitive exclusion principle, and the niche concept. Parts (a) and (b) required ecological interpretations of a population density graph. Part (c) asked for a prediction based on the graph and a justification of the prediction. Part (d) asked a more general question about the characteristics of invasive species.

***How well did students perform on this question?***

Overall, comprehension of this question at a basic level was good. Students understood the aspects of the question that related to competition for resources, and this was reflected in their responses about the interactions among the three beetle species. They had more trouble explaining the interactions among species at the niche level. The mean score was 5.04 out of a possible 10 points. Scores were arrayed in an almost perfect bell-shaped curve, with approximately 50 percent of the answers scoring in the 4–6 range. Students who carefully distinguished the different parts of the question using specific responses and who understood the concepts of niches and competitive exclusion did particularly well.

***What were common student errors or omissions?***

The most common error was focusing explanations on individual interactions rather than on the niche level of interactions. Answers reflected a basic understanding of competition and the impact of species C on both species B and A (students frequently responded that species A was not affected by C "because they ate different leaves"), and students also recognized the role of competition between species B and C (the responses often suggesting that "they ate the same leaves"); however, they did not always expand these insights to the level of niche interaction and use competitive exclusion as the theoretical framework for their discussion. Students perceived the interactions between beetle species as, literally, a physical struggle for survival. The idea that species C might eliminate B without the two species' engaging in actual combat was elusive for most students.

A second error was explaining the species interactions as an evolutionary consequence. The graph in the question covered only 40 years, making it unlikely that species C evolved unique mechanisms that resulted in the kind of growth shown on the graph. Although students who made this error could still do well, the idea of a difference between ecological time and evolutionary time was confused often enough to be a concern.

***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?***

The following suggestions address the common errors made by students. Students demonstrate little understanding of the long time periods required for evolutionary change at the population level of complex organisms. Certainly this is not an intuitive concept, leaving teachers with the challenge of helping them understand that the time required for evolutionary change extends far beyond their personal life spans. Emphasis by classroom teachers on overarching themes in ecology would provide an explanatory context for students that would allow a deeper understanding of species interactions.

## Question 3

***What was the intent of this question?***

The survival of plant species is dependent on their ability to obtain and transport water. In part (a) students needed to describe the mechanism of water movement during transpiration in vascular plants. Some explanation of the anatomy of the structures involved and the properties of water that facilitate the movement of water was also expected. In part (b) students were asked to explain how gas exchange affects transpiration. Students earned points for their understanding of the specific gases exchanged at the stomata, if the direction of the exchanges was correct. They also earned points for understanding the effects of specific environmental conditions on the rate of transpiration, as well as the negative consequence of gas exchange with respect to water loss during transpiration. In part (c) students were expected to describe structural or functional adaptations that affect transpiration in a desert environment.

***How well did students perform on this question?***

Overall, students understood that transpiration is the loss of water (vapor) through stomata. In general, they had a good grasp of the properties of water (cohesion, adhesion, polarity, and hydrogen bonding), but a substantial number demonstrated only an elementary knowledge of plant functions. The mean score was 4.43 out of a possible 10 points. Nearly 40 percent of the essays earned scores of 3–6, and 29 percent scored in the 7–10 range. Blank papers accounted for 5 percent of responses, and 9 percent earned scores of zero.

***What were common student errors or omissions?***

Students did not recognize transpiration as a passive process. They wrote that plants "control" or "decide" when to transpire. Some defined transpiration as the movement of water within a plant, with no sense of water leaving the plant. They were also confused about how water enters the plant. Many wrote that the stomates allow water to come into the leaf or that leaves collect the water necessary for transpiration. Student descriptions and terms were often too general to earn points. The terms *xylem* and *stomata* were mentioned frequently, but an explanation of how these related or contributed to the process was commonly missing. Some students clearly do not understand adaptations from an evolutionary perspective, as they confused adaptations with environmental conditions and did not realize that an adaptation is a feature of the organism (desert plant). Many times they did not contrast adaptations of desert plants with plants that do not live in the desert. They wrote that desert plants had cuticles rather than thick cuticles, or they stated that desert plants "need to conserve water" rather than describing specific water-storage sites.

***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?***

Teachers should require students to use concise definitions of terms within the context of the question to convey their understanding to the Reader. Saying that the dead cells of the xylem function as small tubes, for instance, is far superior to simply mentioning xylem. The majority of students who mentioned CAM as an adaptation of desert plants explained that the stomata are closed at night; however, students often confused $C_4$ and CAM metabolism. Teachers should emphasize the distinctions between CAM and $C_4$, perhaps teaching CAM first, followed by $C_4$. In the transpiration lab, students should be given the opportunity to relate the results to how plants function within natural environments. Finally, teachers should be cautious about making analogies to animals (e.g., "stomata are like the loops of Henle," "transpiration is like sweating," or "xylem tubes are like arteries"), because students tend to accept these too literally.

## Question 4

### *What was the intent of this question?*

This question required students to integrate principles of physiology from three mammalian systems. Students were asked to identify specialized structures that facilitate the movement of oxygen (alveoli in lungs, respiratory) and glucose (villi in small intestine, digestion) into the blood (circulatory). The students were asked to explain the transport of oxygen and glucose within the circulatory system and how oxygen and glucose are transferred from the circulatory system into the cells. Finally, the students had to recognize and explain the differences in specialized structures and processes for oxygen and glucose uptake, respectively, as well as the commonalities of both.

### *How well did students perform on this question?*

The mean score was 2.97 out of a possible 10 points, with 12 ways to receive these points. The most common points awarded were in part (a) with identification and descriptions of alveoli and villi. In part (b) the most common point awarded was for a correct description of the transport of oxygen by hemoglobin. Students rarely specified that glucose is transported in the plasma. In part (c) a description of capillary exchange was the most common point earned. Seven percent of the responses were blank, and 21 percent garnered no points.

### *What were common student errors or omissions?*

Students often combined oxygen and glucose in their responses, using one explanation for both rather than distinguishing between the two. They often did not recognize that the emphasis of the questions was on transport into and out of the circulatory system rather than within it, with the result that there was confusion between the anatomical pathway versus the physiology; many described the path of the blood through the body rather than the process of transport. Moreover, students often gave generalized rather than specific answers and failed to earn points. Alveoli and villi, for example, frequently were not described sufficiently to demonstrate any level of understanding. Quite a few students explained cellular respiration in discussing transport and gas exchange, and numerous answers equated facilitated diffusion with active transport. Finally, many students knew that insulin decreases serum glucose but misunderstood the mechanism and said that insulin binds to, stores, or breaks down glucose.

***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?***

Students should not repeat the question when responding. Teachers should urge them to use the reading period to read carefully for content and to identify key points of the question. This will avoid wasting time providing information that is not required, as many did by describing the path of blood throught the heart and lungs. Teachers should remind students not to include extraneous information such as (in this case) transport of $CO_2$, kidney function, or enzymes not related to carbohydrate digestion. Salient points, such as the transport of glucose and that of oxygen, should be described separately, rather than lumped together.

For practice, teachers could have students analyze sample essays and use the AP Biology Scoring Guidelines to assure correct interpretation of the question. Specifically, for membrane transport, students should focus on the types of transport, with examples and associated reasoning. Teachers should stress the differences in transport and cellular exchange of gases and/or other molecules (such as glucose) to help students understand concepts. Teachers should also continue to emphasize the interaction of structure and function.