Student Performance Q&A:

2002 AP® Biology Free-Response Questions

The following comments are provided by the Chief Reader regarding the 2002 free-response questions for AP Biology. *They are intended to assist AP workshop consultants as they develop training sessions to help teachers better prepare their students for the AP Exams*. They give an overview of each question and its performance, 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 included. Consultants are encouraged to use their expertise to create strategies for teachers to improve student performance in specific areas.

Question 1

What was intended by the question?

In part (a), students were asked about three procedures/techniques frequently used in molecular genetics and about the contributions of each of these to the understanding of the science of genetics. This allowed students to demonstrate recall of the essential steps in the procedures, as well as applications or contributions of the technology to the science. Many students have done one of the procedures in the school laboratory — cloning of a segment of DNA in a bacterial plasmid. Many students have also had some experience in making restriction fragments and separating them via electrophoresis. Fewer of them have had firsthand experience with PCR; however, the level of detail about each process expected by the question was fairly minimal. The explanation section for each was essentially a science, technology, and society theme question, asking students to reflect on the practical and theoretical values of these technologies.

In part (b), students were confronted with the apparent contradiction between the similarities in the coding sequences of human DNA and the uniqueness of a DNA fingerprint. A certain amount of higher order thinking was required in order to recognize the origin of the differences, the reasons for the similarities, and/or the means by which the similarities and differences might be elucidated.

How well did students perform?

This question was quite difficult, especially part (b), which required students to explain an apparent contradiction with which they may never have grappled. This required comparison of two ideas that students may have learned separately.

The mean score on this question was about 2.2, out of a possible 10 points. The number of blank answers was high, and about 40 percent of the students wrote a response that did not receive points. A considerable number of students were not well prepared for this question.

What were common errors or omissions?

Some students did not know that the AP "transformation" lab was about cloning. Other students confused bacterial cloning with human cloning. Students were very poorly prepared to answer the choice about PCR. Some students were able to earn 1 or 2 points because they knew that polymerase is used for replication and they had some idea of the procedure. The idea of the automation of the process of PCR and its requirement for heat stable enzymes eluded all but the very best students.

Many students who chose the RFLP alternative seemed confused about the need to separate fragments by length as well as the uses to which such information might be put. Almost no one had a good understanding of the nature of the DNA fingerprinting methods currently in use.

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

Students should be reminded not to paraphrase the question. No points are awarded for this. Students also need help in relating the procedures they have been taught with the reasons why such procedures are important.

Question 2

What was intended by the question?

The intent of the question was two-fold: first, it required students to think about the observed behavior of an organism in a creative way, and second, it tested students' experimental design skills. The choice of a fictional mammal, bombats, rather than a particular kind of animal that might be more familiar to some students on a regional basis, allowed all students to enjoy a "level" playing field.

How well did students perform?

Students who described the given curve, managed to give some explanation of how or why the factor affected the bombat and resulted in the activity cycle shown, and then gave several basic features of any good experiment (changing the independent variable, keeping confounding variables constant, establishing a good sample size, measuring the dependent variable quantitatively, etc.) could garner 6-7 points without a great deal of sophistication in their answers. The question had a mean of about 4.4. Most students earned 2-3 points on part (a) and 2-3 points on part (b). The fact that there were few zeros and blank papers indicated that most students were able to score points on the question, but just under 10 percent of the scores were in the 8, 9, and 10 range.

What were common errors or omissions?

Many students were under the impression that in a temperate environment, the temperature will be highest when the light is brightest. This led them to suggest relationships between temperature and bombat behavior that would be inconsistent with the shape of the given curve.

Identifying a proper control group was a challenge for many students. Putting bombats in total darkness would be, in essence, creating an experimental group and not actually addressing the effect on the cyclic behavior. Many other students, however, were able to recognize that the control should be the bombat in its "natural" or "normal" conditions.

A number of students designed natural observation procedures like the kind that might produce the observed cycle of bombat activity, but failed to design an actual controlled experiment to evaluate the effect of one variable on that cycle. Also, an alarming number of students put only one bombat into their control and experimental groups.

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

Teachers should continue to emphasize the importance of designing controlled experiments. Students should be encouraged to be thorough on their answers. They should think in depth and write in depth. When introducing new material, asking students to probe into the hows and whys of the material they study as well as its connection to other big ideas is consistent with a thematic approach and important in terms of exam preparation.

Question 3

What was intended by the question?

Question 3 asked students to describe what structures relate to the function of specific biological processes that occur throughout three phyla of the animal kingdom. The student could choose two out of four biological processes given, and describe the structures that allow the process to occur. The function had to be given for the structures. One point for the description of the structure was awarded only after a link between structure and function had been made. The adaptive values of the structures given for each phylum needed to be explained.

How well did students perform?

Many answers were very vague and superficial. Many wrote on the transport section in a generalized way. Most students never related transport to any particular material, so it was difficult for them to give specific functions to a structure and describe the structure. Though many students did receive a structure/function point for a process under a particular phylum, many never attempted to describe the structure.

In gas exchange, many students never wrote on the type of gases being exchanged in their answer; it was insufficient to simply repeat the term "gas exchange." For those answers that did identify the types of gases being exchanged to be complete, the diffusion of oxygen going into the body wall, or skin, or lung had to be coupled with proper concentration gradients that allow for exchange to occur. With respect to transport of materials, students often made the same mistake, and never specified the materials transported. Some students misinterpreted locomotion to mean moving a leg in humans or tentacles in hydra to capture food, rather than the organism moving from point A to point B.

Students described response to stimuli fairly well with cnidarians but poorly in annelids and chordates. Many students never discussed the structures as they related to function, again possibly showing that structure and function relationships are not well understood by many students. Because the mean score for this question was about 1.3, it appears that students were not prepared to give biological information that addressed the question.

What were common errors or omissions?

Many students are still under the assumption that oxygen turns into carbon dioxide and vice versa. Very few points were awarded for a description of a structure because students did not include this in their answers.

Repeating what was in the question as a means of giving function for a structure was not acceptable. For example, "the lung is used as an organ for gas exchange in chordates," was a common structure/function statement. This statement does not explain how the lung is involved in gas exchange.

Students sometimes wrote on only two phyla and interchanged the two processes being discussed. The first two processes that were chosen for one phylum were the processes that needed to follow for the other phyla listed.

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

Teachers can help students with structure and function questions by listening to how students describe structure and function in the classroom and by having students practice writing answers to these types of questions. In many instances, student writing was poor, and failed to clearly link structure to an adaptive value. Practice will help students learn how to elaborate on an answer and to address the specific question that is asked.

Question 4

What was intended by the question?

The purpose of the question was to determine students' ability to analyze data from a NaCl diffusion experiment, make predictions based upon these data, and to apply the concepts of molecular movement. Students were first asked to graph a set of five data points. This required them to identify the independent and dependent variables and place each on the correct axis. To successfully complete the graph, students also had to label the axes with the name of the variable and provide the units of measurement; correct scaling of the units also was necessary. To complete part (a) of this question, students then had to plot the data. The objective of this part of the question was to assess the students' ability to correctly represent data in graphical form.

The second part of the question asked students to make predictions based upon analysis of the data presented in part (a). Students were required to add three additional lines to the graph. They were expected to recognize the relationship between solute concentration and rate of diffusion, and be able to express this relationship in a graphical format. They were then asked to explain their predictions; this required the students to be able to justify the expected outcomes in a written format. Students also needed to understand that if no solute was present, diffusion could not occur.

To earn points in the third part of the question, students needed to exhibit an understanding of osmosis and water potential and be able to apply this to a real-life environmental problem. Students had to demonstrate an understanding of the effect that increased soil salinity would have on water movement in plant cells and the effect that this would have on crop production. This section of the question required students to understand that seawater in the soil would increase the concentration of solutes in the soil, so that the cells would now have a higher water potential than the soil. As a result of this higher water potential, the plants would lose water due to osmosis. Students then had to connect this water loss to specific effects on cells and on crop production.

How well did students perform?

Overall the students did quite well, as reflected by a mean score of about 5.1. A very high percentage of the students attempted to answer at least some portion of the question and these students were likely to earn some points. In general, students demonstrated a good understanding of basic graphing skills and could construct appropriate curves for the data provided. Lower-scoring essays generally earned all of their points in part (a) and the graphing part of part (b).

The majority of students who attempted to graph their predictions for part (b) were able to do so correctly even though they may have had the orientation of the variables reversed. Fewer students were able to provide a correct textual explanation for their predictions. This section of the question was the one most likely to be left blank.

The last part of the question required application of the principles of osmosis to plant cells in a saline environment. While the majority of students attempted this part of the question, students were less likely to earn points from this section.

What were common errors or omissions?

Approximately one quarter of the students incorrectly placed the dependent variable on the x axis. A similar number of students incorrectly extended the five percent NaCl line beyond the last data point. Problems with missing units on the labels and scaling of the axes were less frequent.

Because the relationship between NaCl concentration and time is a rate, the best graphical representation of this data would be a line of best fit. (A scatter plot or a line connecting the data points was also accepted here.) Very few students drew a line of best fit. A few students drew bar graphs, which received no points since the relationship between NaCl concentration and time is continuous.

Many students did not provide an explanation for their predictions in part (b). Of the students who did, approximately one quarter used a purely mathematical approach stating that since ten percent NaCl is twice as much as five percent NaCl, then the amount of salt leaving the bag would be twice as much. A large number of these students commented only upon the amount of NaCl that would leave the bag without an indication of the time it would take; they did not recognize that the question was asking for an estimation of the rate of diffusion. Many other students tried to relate this experiment to one they performed in lab where the movement of water, not NaCl, was measured.

While some students were able to correctly demonstrate an understanding of osmosis, few students could articulate the role of water potential in the determination of the direction of water flow. While many students stated that seawater would dehydrate plants, only about one quarter of the students who attempted part (c) could provide specifics about the effect on plant cells. Statements connecting water loss to crop damage tended to be general and state only that plants would be harmed. When students provided specific effects, they tended to focus on photosynthesis. A number of them stated that the saltwater would change the pH of the soil; many of these students more specifically said that the soil would become acidic. This misconception most likely results from confusion of the salt in seawater with the formation of salts when acids and bases combine. Many students were confused about water potential and defined it as the potential to absorb water and thus concluded that the saline soil would have a higher water potential than the plant.

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

Basic graphing skills as described in Appendix II of the AP Biology Lab Manual should continue to be stressed. Asking students to provide written explanations of their graphs would also help teachers to discover misunderstandings.