CollegeBoard
Advanced Placement Program

Student Performance Q&A:

2005 AP® Biology Free-Response Questions

The following comments on the 2005 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?

The intent of this question was to test students' ability to construct a graph, interpret the role of enzymes in respiration, and design a feasible controlled experiment. Students were asked to analyze data from the graph and to determine the optimal temperature for respiration. Additionally, they had to demonstrate knowledge of how temperature related to the results that were described.

How well did students perform on this question?

The mean score was 4.88 out of a possible 10 points. For the most part, students received some points for the graph itself. Students did well with pH and enzyme action in the experimental design part of the question, and they understood that extreme acidity or alkalinity might render the enzyme inactive. Students who included the sugar and the organism in their experiments usually earned points for the details and almost always received the point for a prediction of their results. A poor experimental design, if feasible, could still receive the prediction point. Some students suggested using absorption spectrophotometry or titration, with correctly described procedures, and earned a point.

What were common student errors or omissions?

The most common graphing errors in part (a) were the omission of a title and confusion of the x- and y-axes with a resultant incorrect orientation of the graph. Many students confused the terms "optimum" and "maximum." Students who used the term "maximum" but showed a clear understanding of what was intended (i.e., maximum number of bubbles at 30°C) were not penalized.

In part (b) many students analyzed the graph in terms of a single point rather than in terms of activity increasing or decreasing over the temperature range. Often, students stated that enzyme shape changed at low temperatures instead of providing a kinetic explanation. Many students connected the increase in temperature with increased release of bubbles to the maximum rate but did not mention what happened at temperatures beyond the optimum temperature.

Denaturation was not well understood; many students suggested that peptide or covalent bonds break. A common misconception was that the enzyme was "killed" at the temperature extremes. Many understood that denaturation would prevent the enzyme from functioning properly at high temperatures, but the concept of a decrease in kinetic energy or fewer collisions below optimum temperatures was often lost. There were examples that identified yeast as the substrate or sugar as the enzyme. The gas that was released was sometimes identified as oxygen, and the yeast as a plant. Students frequently interchanged oxidative phosphorylation and alcoholic fermentation. They also had problems with the source of the gas, which was evidenced by the misconception that the process of boiling created the gas bubbles, or that the sugar was respiring.

In part (c) many students failed to include an energy source (sugar) and a source of enzymes (an organism) in their experiments. Such experiments were not feasible. Students confused a control with maintaining constant variables except for the one tested. Some students tried unsuccessfully to apply experiments from the *AP Biology Laboratory Manual;* some described experiment 5, which uses germinating peas. They stated they would vary the pH of solutions of sugar and add it to the peas, a response that did not address the question that had been asked. Specifics about how the experiment was to be set up were often missing (e.g., a specific pH range). A hypothesis, if stated correctly (i.e., if X, then Y), could have been used as the prediction, but students often wrote a very general hypothesis that did not give a prediction.

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?

Continue to have students practice making graphs, identifying variables, and understanding differences between constants and controls. Accurate labeling should be stressed. When analyzing and explaining experimental data, emphasize the importance of cause, effect, and result. Have students practice designing and performing their own experiments. Also, stress the use of proper units (e.g., rate/min) and analysis of results with explanations connected to the data.

Question 2

What was the intent of this question?

The intent of this question was to allow students to demonstrate knowledge of the eukaryotic chromosome by describing the structure and function of its components (part [a]), explaining the evolutionary significance of organizing genes into chromosomes (part [b]), and discussing differences in the function and structure of the prokaryotic chromosome and the eukaryotic chromosome (part [c]). Parts (a) and (c) were concerned with chromosomal, rather than cellular, structure and function, while part (b) required applying knowledge of the structure and function of chromosomes to the evolutionary significance.

In part (a) students were expected to describe, not simply name, the parts of a eukaryotic chromosome. They could approach this task from any level of organization (molecular, chromatin form, and/or metaphase chromosome). The structure and function points were not linked; students could earn their points from any combination of structural and/or functional descriptions, but they could not earn more than 1 point from either the structure or the function of the chromatin form.

Part (b) required students to synthesize information across several areas of the curriculum. They could not earn points for simply stating that variation could be increased by crossing over or by independent assortment without a brief description of the mechanism.

In part (c) no points were earned for discussion of plasmids. They are not unique to prokaryotes, and they are not part of the prokaryotic chromosome.

How well did students perform on this question?

The mean score was 3.07 out of a possible 10 points. Students earned more points on chromosomal structure than on the function of the chromosome components. Readers frequently awarded points for the structure of chromatids, nucleosomes, chromatin form, and DNA. Students also did well on base pairing (A-T, C-G), double helix structure, hydrogen bonding, and antiparallel strands. Most students indicated that DNA exists in different forms (coiled/uncoiled). Readers frequently awarded function points for centromeres and kinetochores.

Nearly all students related chromosomal structure to an increase in genetic variation. Students who elaborated on crossing over and independent assortment showed an understanding of how these mechanisms lead to genetic variation. Many also showed an understanding of genetic stability (e.g., daughter cells receive identical information). Many students wrote that prokaryotes (bacteria) have circular DNA that is simpler than eukaryotic DNA (chromosomes). Some wrote in detail about gene regulation via operons in prokaryotes. Many also indicated that the structure of the prokaryotic chromosome was less complex and generally had few or no introns, and that the majority of the genome was expressed.

What were common student errors or omissions?

Readers found the following problems in part (a).

- Students indicated that a chromosome could be X-shaped but often failed to recognize that this represents duplicated information or that it is a metaphase chromosome.
- Many students thought sister chromatids had genes from both parents.
- Students thought an X-shaped chromosome had four chromatids joined by the centromere.
- Students had difficulty relating DNA structure to its function. They indicated that DNA codes for phenotypes (e.g., blue eyes, brown hair, traits) rather than for proteins or RNA.
- Some students confused the structure and function of centromeres and kinetochores.
- Many students described the processes of mitosis and meiosis very clearly; however, these processes were not relevant at the chromosomal level and did not receive points.

Readers found the following problems in part (b).

- When discussing crossing over or independent assortment, some students confused homologous chromosomes with sister chromatids.
- Many students mistakenly thought that crossing over normally causes mutations and diseases.
- Some students described evolution as an event (i.e., a change in the environment) that causes the organism to actively change its genetic makeup (e.g., "chromosomes adapt to their environment").
- Many students wrote the following statements about science and technology: "because genes are on chromosomes, scientists can locate them"; "karyotypes can be made"; and "genes can be spliced together."

Readers found the following problems in part (c).

- Students often discussed prokaryotes as being less complex *organisms* rather than addressing the question of the *chromosome*.
- Students wrote that prokaryotic DNA is single-stranded as opposed to double-stranded eukaryotic DNA. Readers did not award points for descriptions of plasmids or viruses.
- Students confused gene regulation in the two cell types, often referring to operons in eukaryotes rather than prokaryotes.

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?

Remember to teach across the themes and to have students reflect on and discuss how the themes are integrated in the study of biology. Give students practice throughout the year in answering essay questions that require them to look into other areas of the curriculum. Expose students to timed exam conditions and remind them that if specific words elude them, they can often successfully substitute a description—drawings are for clarification of their descriptions and should be discussed in their answers. Make every effort to use recent textbooks.

Question 3

What was the intent of this question?

The main focus of this question was the evolution of life cycles and reproductive strategies in plants. In part (a) students were asked to describe four angiosperm structures involved in reproduction and the evolutionary significance of each. Part (b) asked how the anatomy and reproductive strategies for mosses limit their distribution, which pointed students in the direction of the role of water in the bryophyte life cycle. Part (c) required an explanation of alternation of generations in angiosperms or mosses. Although students could choose either group of plants, all plant types share a common life cycle. Therefore, the scoring guideline was applicable to either student choice, as it stressed the basic biological processes of fertilization and meiosis in the formation of sporophytes and gametophytes. An additional point could have been earned for a more detailed explanation of the specific life cycle chosen.

How well did students perform on this question?

The mean score was 3.63 out of a possible 10 points. Many students were able to earn points in part (a) by discussing the reproductive functions of structures involved with angiosperm reproduction. Not as many students earned points on the adaptive (evolutionary) significance of each structure. The scoring guidelines took a broad perspective, accepting not only the four modified whorls of leaves that form the sepals, petals, stamens, and carpels of a flower, but the seeds and fruits as well. Students could also use more specific reproductive structure examples like the stigma, style, and ovary. Since each specific structure has its own adaptive significance, the guidelines offered students numerous possible ways to earn points.

Students consistently earned points in part (b). In part (c) many students demonstrated familiarity with the concept of alternation of generations in plants and earned several points; almost all of the best responses included this life cycle characteristic. Students who were unfamiliar with the alternation concept were imaginative in their attempts to describe it, but few earned points with their responses.

What were common student errors or omissions?

One common error was not answering the second part of part (a), which concerned the adaptive (evolutionary) significance of angiosperm reproductive structures. Most students could name some reproductive structures and functions, but many did not explain the evolutionary significance of the structures. Another common omission was the failure to address parts (b) or (c). Many students appeared to conceptualize the biology of plants based on their knowledge of animals. For example, it was common for students to define pollen as sperm. Similarly, they expected meiosis to lead directly to gametes rather than to multicellular gametophytes that form gametes by mitosis. The biological uniqueness of plants was lost for many students.

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?

Include plants and plant evolution in the course syllabi. Evolution, as the central theme in biology, should be integrated into each unit that is presented; otherwise, much of biology becomes an endless series of facts and figures without unification. The success of angiosperms, for example, only makes sense in the light of their unique evolutionary history.

Developing the skills to write coherent biology essays requires practice. Give students the opportunity to answer essay questions throughout the year, and score their responses with the same rigor as they will be scored on the AP Biology Exam. Finally, remind students to address *all* parts of the question.

Question 4

What was the intent of this question?

This question required students to recall specific processes that are found in the immune system in vertebrates. Four independent parts of the question were presented in a bulleted fashion, and students needed to answer only three of the four options. The first option was an explanation of how the nonspecific immune response functions; for the second option, students were asked to relate how T and B cells are activated in response to an infection; the third option asked how vertebrates respond to a later exposure to the same infectious agent; and the fourth option asked students to describe how a vertebrate distinguishes self from nonself.

How well did students perform on this question?

The mean score was 2.78 out of a possible 10 points. Many students avoided answering the second part (activation of T and B cells) and the last part (distinguishes self from nonself). Not surprisingly, when students did answer these parts, they earned fewer points than they did in the other parts. Students knew the most about the nonspecific immune response. Most students knew that the skin is a physical barrier to foreign substance, that macrophages are phagocytic, that the secondary immune response is rapid and mediated by memory cells, and that cells have unique molecular signatures, or "tags"; they also knew how mucous membranes function in preventing infection.

What were common student errors or omissions?

A common group of misconceptions included the idea that antibodies are on the same level of organization as the cell, that antibodies are long-lived, and that antibodies are an active part of the nonspecific immune system. Many students indicated that the immune system is under the control of the brain or nervous system. Students frequently stated that skin, nose hair, or the heat from a fever "kill" bacteria. Many students wrote that DNA is "read" or scanned to determine self from nonself. Finally, students showed a poor understanding of the roles of T and B cells in the immune system.

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?

Advise students not to depend on analogies alone to provide answers; confusing analogies do not earn points. Encourage students to answer the question that has been asked and not merely respond with memorized material that includes irrelevant information. Students at the AP Biology level are confronted with a huge number of technical terms that makes biology one of the more difficult subjects to learn. Emphasize the need to learn this vocabulary and use it with precision. When students cannot remember precise terms, encourage them to clearly describe the processes or structures to which they refer. Finally, remind students that when three examples are asked for, but more than three are given, only the first three will be scored.