CollegeBoard
Advanced Placement Program

Student Performance Q&A:

2008 AP® Biology Free-Response Questions

The following comments on the 2008 free-response questions for AP® Biology were written by the Chief Reader, John Lepri of the University of North Carolina at Greensboro. The comments 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 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 knowledge of protein structure and function. Students were asked to describe the bonds and chemical interactions underlying protein structure and to then apply their knowledge of protein structure to specific functions of proteins, such as muscle contraction, cell signaling, and enzyme regulation. Students were expected to integrate molecular genetics, biochemistry, and population biology while discussing sickle cell anemia as a disease caused by a change in protein structure.

How well did students perform on this question?

Protein structure and function have been prominent themes in biology for decades, and the scoring structure of this question provided 12 possible points for the maximum score of 10 points. The overall mean score was 2.13 out of 10 possible points; excluding blank exam booklets and scores of 0 (38 percent of the students!), the mean jumped to 3.45 out of 10 possible points. Many students earned their only points in part (c) by discussing how resistance to malaria is conferred by the sickle cell allele, a process in which a point mutation changes the sequence of amino acids in hemoglobin. In parts (a) and (b) higher-scoring students reported details of protein structure regarding myosin–actin interactions, G protein-linked signaling, and allosteric regulation.

What were common student errors or omissions?

In answering part (a) some students confused primary, secondary, tertiary, and quaternary structures with types of bonds (peptide and disulfide covalent bonds, ionic bonds, hydrogen bonds, and van der Waals forces). Some students mistakenly described DNA's hydrogen bonds and its helical struture. Other students inappropriately wrote about phosphate, phosphodiester, amino, and polypeptide bonds. A few students discussed integral and peripheral proteins in cell membranes, while others described transcription and translation.

In part (b) many students wrote about muscle contraction but focused on neurotransmitters and the release of calcium ions, failing to earn points for describing actin–myosin interactions. Some students discussed enzymatic activity as active site–substrate interactions, rather than addressing regulation. Many described cell–cell recognition but did not associate this with protein structure.

In answering part (c) many students confused hemophilia or HIV with malaria and did not correctly describe the relationship between sickle cell anemia and malaria. Some students wrongly attributed the onset of the disease to X-linkage, pollution, poor nutrition, inbreeding, and low or high levels of dissolved oxygen.

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 discuss protein structure and function across diverse sections of the AP Biology course, including neuronal/sensory systems, organismal movement, and gas exchange. The lock-and-key description of enzymatic activity should be replaced by the "induced fit" model. Teachers should make it clear that "immunity" implies that the activity of the immune system protects against a disease; in contrast, persons with the sickle cell trait can become infected with malaria, but their increased likelihood of surviving the infection is not a sole function of the immune system. Providing objective information about sickle cell anemia and malaria as they relate to the climate/environment rather than to ethnicity is an important objective for teachers. Lab 8 ("Population Genetics and Evolution") in the *AP Biology Lab Manual for Students* covers heterozygote advantage, using the example of sickle cell anemia and malaria.

Question 2

What was the intent of this question?

The question focused on the energy-flow principles of primary productivity in an aquatic ecosystem, with special attention to the laboratory procedures used to estimate productivity. Students were first asked to differentiate between gross and net primary productivity (GPP and NPP, respectively) and then to describe a method for determining GPP and NPP of an aquatic ecosystem. This portion of the question addressed the objectives of Lab 12 ("Dissolved Oxygen and Aquatic Primary Productivity") in the *AP Biology Lab Manual*. There was also a graphical analysis portion to the question in which students were asked to provide metabolic explanations to interpret a graph of NPP versus depth in a freshwater pond. This allowed students an opportunity to tie the concept of the availability of sunlight at various depths to its effects on net productivity.

Finally, students were asked to predict how the relationship between depth and productivity as displayed in the graph might differ if the data were collected in mid-summer rather than spring as was originally indicated.

How well did students perform on this question?

Most students attempted to answer this question, and there were relatively few blank exam booklets. The overall mean score was 2.83 out of 10 possible points; omitting blank booklets and scores of 0, the mean rose to 3.49 out of 10 possible points. The points most commonly earned were those awarded for identifying dissolved oxygen as an environmental variable that estimates productivity and the general explanation of the trend in data of the graph. Many students correctly wrote that productivity declines at increasing depths due to decreasing light or lower photosynthetic rates. Points were also earned for describing a plausible prediction in part (d). Although students seldom earned points for their definitions of GPP, they were better at describing NPP: even if students did not correctly define GPP, they often stated that "NPP was equal to GPP minus respiration." Although 7 possible points were available for earning a maximum of 4 points in part (b), few students were able to accurately outline a methodology for determining productivity in an aquatic ecosystem.

What were common student errors or omissions?

In part (a) students had difficulty with the definitions of GPP and NPP. They were often unsure of exactly what is being "produced" when we talk of productivity. Few students were able to discuss the idea that productivity is actually a measure of the "conversion" of energy from light to chemical in the form of organic molecules. Some students stated that primary productivity is the total "oxygen" that is produced in an ecosystem. In addition, many students wandered from the central idea of *primary productivity* and included the role of consumers in their answer. A common answer was that net productivity is what remains after "subtracting what the consumers use up" in an ecosystem.

Part (b) provided a clear scoring opportunity for students who had performed Lab 12, but many were not able to outline a proper procedure for determining GPP and NPP. Unusual and implausible lab procedures were suggested, including some that tested the entire ecosystem. Those students who attempted an explanation of Lab 12 sometimes neglected to discuss how the samples were treated or tested, saying only "collect samples . . . test for amount of productivity. . . ." Still other students confused this lab procedure with Lab 4 (the determination of photosynthetic rate).

Common errors observed in part (c) related to an incomplete understanding of the question, which asked for an explanation of the graphed data, "including" a description of the metabolic explanations. Students often provided a clear interpretation of the graph ("productivity declines as depth increases") but then failed to link the explanation to any statement about light availability or photosynthetic rates. Those who correctly identified the photosynthetic connection behind the part of the graph above the zero point often reverted to a discussion of consumers when the graph reached that point ("NPP is zero because only consumers are consuming energy" or "photosynthesis has stopped").

Finally, part (d) contained the most commonly earned points, although many students neglected to tie their predictions of changes in net productivity to *depth* as the question asked. Some students lost focus on the central idea of this question (light and productivity) and attempted to answer it based on changes in temperature. Although latitude was allowed in this part of the question for plausible predictions that used temperature, most students again wrote from the perspective of the consumers, stating that "consumer metabolism increased," while ignoring the fact that producer metabolism (photosynthesis) will increase as well.

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 clearest message from the student responses is that students can benefit from performing all 12 of the labs in the Lab Manual. The scoring guidelines for part (b) are quite specific in their adherence to the objectives for Lab 12. Students should also keep in mind that when designing or describing experiments they need to be sure the design is realistic. They can also benefit from opportunities to generate and graph data, as well as opportunities to interpret graphs.

Question 3

What was the intent of this question?

The goal of this question was to have students describe the functional mechanisms of regulation or control in various biological processes. The concept of regulation (a unifying theme) was applied to processes given to students from key content areas: cells, endocrine system, reproduction, and ecology. The students were asked to first **describe** a specific process, e.g., cell cycle, metabolic rate, ovarian cycle, prey population dynamics, and ecological succession, and then **discuss** how that process would be altered if the indicated regulator was disrupted. Students were required to select and address four of the five listed regulator/process pairings.

How well did students perform on this question?

Most students were able to describe the basic idea of the role of the regulator, but few students demonstrated detailed understanding. The mean score was 3.42 of 10 possible points. For each of the regulator/process pairings, up to 4 possible points could be earned: what the regulator does (1 point), how the regulator does its regulating (cause-and-effect mechanism, 1 point), and what the consequences of increased (1 point) and decreased (1 point) levels of the regulator are. Many students provided evidence that showed they understood that regulation of the process is important, but more often they did not provide any details about the mechanism underlying the regulation. Many students erred by generally restating the question, noting that the regulator regulates the process and that a disruptor disrupts the process. Rarely did students correctly explain the fundamental concept of negative feedback as it applied to a specific process. Most students chose to address the predator/prey population dynamics and the fire/ecological succession pairings. Less popular choices were the cyclins/cell cycle, FHS/ovarian cycle, and thyroxine/metabolic rate pairings, in that order. An accessible point earned by nearly all students was that predators reduce prey populations by eating the prey.

What were common student errors or omissions?

Many students simply restated the question. A second problem was that students misinterpreted the term "disrupted," failing to address a situation in which there was too much or too little of the regulator.

Cyclin/Cell Cycle: The most frequently earned point was received for stating that cyclins move the cell cycle forward. Many students equated the cell cycle with mitosis, rarely discussing G_1, S, G_2, and G_0 phases. Few students earned the points available for describing the role of cyclin-dependent kinases in controlling the cell cycle. Many students did not describe what changes in the concentration of cyclins would provoke: too much cyclin was incorrectly described as halting the cell cycle, and too little cyclin was described as causing the cell to become cancerous. Cyclins were also described as controlling the *size* of cells.

Thyroxine/Metabolic Rate: Some students clearly understood what thyroxine does, but many did not. Many did not have a clear understanding of an increased metabolic rate. Thyroxine was wrongly described as a digestive enzyme or a signal that controls digestion. Some students misidentified the source of thyroxine as the thymus gland, thalamus, hypothalamus, or pituitary gland. Many students discussed insulin and glucagon instead of thyroxine. Only a small percentage of students provided correct discussion of the negative feedback mechanism involving TRH, TSH, and thyroxine.

FSH/Ovarian Cycle: Many students earned a highly accessible point by stating that without FSH no eggs would be produced and a woman could not get pregnant. The biggest misconception was that FSH directly causes ovulation or that it directly causes the thickening of the uterine lining. Another misconception was that FSH is involved in hair growth ("hair follicles"). Although many students accurately described the pathway of the egg from ovaries to fallopian tube to uterus, this information was not part of the question and did not earn points. Students stated that if there was no FSH the human population would cease to exist or go extinct. Again, there was very little correct discussion of negative feedback involving estrogen/progesterone and FSH.

Predators/Prey Population Dynamics: Many students earned 3 points for correctly stating that predators limit the size of prey populations and for discussing how an increase or decrease in predator population leads to a decrease or increase, respectively, of the prey population. Some students wrongly reversed the relationship and discussed how the amount of prey regulates the predator population size. Many students described the prey as primary consumers and the predators as secondary consumers. Many students included diagrams of food webs and food chains, but only infrequently did a student provide a correct diagram showing the lag/fluctuation between predator and prey population cycles. Students often described the predator as improving the gene pool of the prey and thus acting as a driving force in natural selection; however, that information was not sought in this question, so it earned no points.

Fire/Ecological Succession: Many students earned a point for noting that fire adds nutrients to the soil or that heat allows certain types of seeds to germinate. Indicating that some plants and animals replace other plants and animals as the community matures or ages demonstrates a superficial understanding of succession and was not an adequate description for receiving any points. Fire as the regulator was often described as "destroying everything." Very few students earned points for discussion of the disruption of succession (by dramatic increases or decreases in fires) and the resulting impact on the community.

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?

Provide practice in essay writing and remind students not to include introductory paragraphs or a simple restating of the question. Students would benefit from practice in recognizing what is given in the stem of the question and from being more specific in their discussions. Students need to write clear descriptions of cause-and-effect mechanisms, including feedback systems, and should become adept at analyzing what happens when these are disrupted. The fundamental mechanism of control of the cell cycle (cyclin and cyclin-dependent kinases), and not simply the stages involved (G_1, S, G_2), should receive greater attention in the classroom.

Question 4

What was the intent of this question?

The biological theme of this question was evolution. The question began by asking students to describe the process of fertilization in flowering plants. Since pollination is necessary for fertilization to occur, the second part of the question asked students to discuss two mechanisms of pollen transfer and the evolutionary adaptations that facilitate each mechanism. The third part of the question asked students to discuss an evolutionary advantage of preventing self-fertilization. Finally, the fourth part of the question asked students to describe two mechanisms that prevent self-fertilization.

How well did students perform on this question?

The overall mean score was 4.59 out of 10 possible points; without blank exam booklets and scores of 0, the mean increased to 5.02 out of 10 possible points. Most students wrote about pollen transfer and the evolutionary advantage of preventing self-fertilization. Students received most of their points from correctly addressing part (b) and part (c); fewer points were earned in part (d), and fewest in part (a). Flowering plants have a unique process of reproduction (double fertilization), and students did not indicate a clear understanding of this process. Many students embellished their responses by bringing in parts of their answers to the previous questions: proteins and enzymes from question 1, sunlight and photosynthesis from question 2, and parts of the cell cycle from question 3.

What were common student errors or omissions?

Many students used "buzz words" in their answers but did not provide an appropriate context and so did not earn points. The question specifically asked students to *describe* the process of fertilization in flowering plants; it was not sufficient to simply state that flowering plants reproduce by a double fertilization process. Some students confused the process of fertilization with the process of pollination and even germination. Many answers evidenced confusion between sperm, spores, seeds, and pollen. Some confused angiosperms with gymnosperms, ferns, and mosses. Many students failed to describe double fertilization and how this process is unique to flowering plants. Specifically, students were confused about the formation of the pollen tube, with some writing that this is a pre-existing shaft in the style where pollen goes to reach the egg. A common misconception was that pollen fertilizes the egg, or the ovule, or even the ovary. Some students wrote about the fruit being food for the embryo, even calling it the endosperm. Finally, many students provided a detailed anatomical view of a flower without earning credit.

The question asked students to **discuss** two mechanisms of pollen transfer, not just list them, and to *discuss* two adaptations that faciliate each mechanism (part b). Two readily accessible points were earned by discussing wind and animal transfer of pollen. Students often confused seed dispersal with pollen dispersal; a common error was the use of dandelions to discuss wind dispersal of pollen when the student was actually discussing seed dispersal. Rarely, students discussed coevolution and how plants make nectar and scents to attract pollinators.

Students were asked to **discuss** an evolutionary advantage of preventing self-fertilization; it was not sufficient to state that this would enable genetic variability (part c). Some students wrongly described self-fertilization as a method of asexual reproduction in plants. Some students proposed that an advantage of preventing self-fertilization is that it provides the opportunity to increase the genetic diversity of an individual plant, rather than of the plant population. Some students stated that increasing genetic diversity decreases the occurrence of mutations.

Students were asked to **describe** two mechanisms that prevent self-fertilization (part d), not to simply list the two mechanisms. Some students incorrectly used the mechanical removal of flower parts as a method of preventing self-fertilization. Some students wrote about male and female flower parts being separate, but it was not clear in many of those answers that they understood this arrangement as occurring on separate flowers or plants. Flowers' closing their petals was occasionally described incorrectly as a mechanism that prevents self-fertilization.

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?

Teach students about plants—not only plant anatomy and photosynthesis but also important physiological processes, such as double fertilization in flowering plants. Stress that answers should contain only the information the question asks of them. Students wrote answers to the question they expected (plant pollination or plant flower anatomy) rather than the question that was actually being asked. Remind students that it is better to spend their time writing the answer than drawing the answer.