Student Performance Q&A:
2001 AP® Environmental Science Free-Response Questions

The following comments are provided by the Chief Faculty Consultant regarding the 2001 free-response questions for AP Environmental Science. *They are intended to assist AP workshop consultants as they develop training sessions to help teachers better prepare their students for the AP Exam*. 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

Standards

In part (a), students were given a series of conversion factors and asked to calculate (from the provided data) the number of cubic feet of natural gas required to heat the house for one winter. Students were required to show all the steps of their calculations, including units. They were to use their answer from (i) to calculate the cost of heating this house. The calculation itself was a simple multiplication problem with 1 point awarded for the proper setup with correct units and the correct answer. To avoid penalizing a student twice for an incorrect answer, the point was given if the student performed the calculation correctly using their incorrect answer from (i).

In part (b), students earned 1 point for each action and description for a total of 3 points. Since the question asked for three actions, only the first three were considered. In situations where the student listed more than three actions and the first two were incorrect, only 1 point was awarded. Answers that were too simplistic to provide an adequate description (i.e., better insulation) and one-word answers were not acceptable since the question clearly asked for a description of the action.

In part (c), students were asked to discuss the positive and negative environmental impacts of using a wood-burning stove as a supplemental heat source in the house being heated by natural gas. Students earned 1 point for the discussion of one positive impact and 1 additional point for the discussion of an appropriate consequence. Likewise, students earned 1 point for the discussion of one negative impact and 1 additional point for the discussion of an appropriate consequence. If a student discussed more than one positive or negative impact, only the first one was given credit since the question asked for only one of each. For example, if a student discussed more than one positive impact and the first one was incorrect, no positive impact point was awarded. A student could begin the discussion with an appropriate consequence and earn 1 consequence point; if they continued the discussion and included a positive impact then a second

point would be awarded. Regardless of which way the student began the discussion, the impact and consequence had to be linked.

Appropriateness of Student Preparation and Some Misconceptions

In part (a), one major misconception involved students' perception of what a reasonable cost is for heating a house — answers ranged from $0.004 to $640,000,000,000 for one winter. An unreasonable answer should have suggested that they had made an error in their calculations.

In part (b), most students were able to provide adequate descriptions of three actions.

A major misconception was seen when students confused photovoltaic cells that are used to generate electricity with the use of solar collectors that are connected to a water circulating system that is used to supply heat energy. A few students also thought that electric space heaters would be more efficient and less expensive than using natural gas. Some students thought that the 80 percent efficient furnace could be replaced with a 100 percent efficient furnace, which contradicts the Second Law of Thermodynamics. Some students discussed cooling strategies and air conditioning systems, which are not applicable to conserving heat energy during a Midwestern winter.

In part (c), students were better able to discuss consequences than they were to connect the two or more ideas needed to discuss a specific impact. Misconceptions surfaced when students stated that all cutting of trees leads to deforestation, loss of biodiversity, or habitat loss. Deforestation is not an issue if the wood is obtained from a tree plantation, especially one that is established on land previously cleared for another purpose. Forests can be maintained more sustainably if selective cutting and strip cutting are used instead of clear cutting.

What Teachers Can Do to Improve Performance

Teachers should give students problems that help them increase their facility with calculations. Students will be better able to tackle these problems if they are comfortable with scientific notation.

Question 2

Standards

In part (a), students were to read the document and from the information contained therein, construct a food web. Students were expected to be able to correctly identify the components and relationships of the organisms, and to put this information into the form of a food web. To earn the first 2 points for this section, the student was expected to be able to both identify the organisms involved in the food web and show the connections between these various components. At this point, the student needed to show only lines (not necessarily arrows) connecting the various organisms. It was not necessary to include lyme disease on the web.

There were two additional ways in which students could earn points in this section. One point could be earned for placing arrows on the food web showing the direction of energy flow (as does the standard food web). This point could be earned even if the student missed one of the connections between organisms (for example, if the student missed the connection between the

oak tree and the gypsy moth). A student could not earn this point if one of the arrows was in the wrong direction.

Part (b) of the question tested the student's understanding of what constitutes a scientific experiment. The student could earn 1 point for the hypothesis if the hypothesis was connected to the question and the experiment. The student could earn up to 3 points for an experiment that addressed the relationship between moth population and acorn production even if they did not receive the hypothesis point. One point was earned for an experiment that clearly indicated measurement over a "reasonable" amount of time (both must be discussed to earn this point). One point could be earned for a clear indication of experimental control. Finally, 1 elaboration point was possible and could be earned by the student who extended his/her experimental design to include a description of what the expected results of the experiment might be, and how they would analyze the data collected in order to determine if there were statistically significant correlations between the components of the experiment.

In part (c) the student's understanding of what constitutes Integrated Pest Management was tested. Up to 3 points could be awarded for three different (acceptable) methods of control. One additional point could be earned if a student went on to describe a third technique for tick control. If the student described at least two methods of control (indicating at least a basic understanding of IPM) he/she could earn 1 point each (up to 2 points) for elaboration of a method of control.

Appropriateness of Student Preparation and Some Misconceptions

A common mistake was missing one of the connections between organisms. The connections most often missed were either between the oak tree and the gypsy moth, or between the gypsy moth and the mouse. Another relatively common error was identification of the acorn as the producer, and having gypsy moths eating acorns. Finally, the organism most frequently omitted completely from the food web was the tick.

The hypothesis point was often the only point the student earned on the second section of the question. Most students were able to recognize that the hypothesis needed to test a specific relationship between acorn production and moth population. A student did not earn a point for a hypothesis which was simply a restatement of the question (e.g., "My hypothesis is that there is a relationship between acorn production and gypsy moth population"). A significant number of students gave a relatively reasonable hypothesis, but then proceeded to describe an experiment that couldn't possibly test the hypothesis.

What Teachers Can Do to Improve Performance

Students should have the experience of designing a laboratory or field experiment, and understand the components of such an investigation. They should practice formulating hypotheses, and deciding whether a particular experimental design will test a stated hypothesis.

Question 3

Standards

One point was awarded for each specific indoor air pollutant, if students accurately discussed one or more of the items asked for in (i), (ii), (iii), or (iv). No points were earned for merely identifying one or two pollutants, with no other information discussed. The point was awarded for

the first two pollutants discussed, with an internal maximum of 9 points on part (a). In (a) (i), the type of building discussed had to be appropriately linked to the source (a) (ii) of the pollutant specified. For example, "older buildings often contain asbestos in the form of a spray-on ceiling coating". In (a) (iii), students were asked to discuss the pollutant's effects on human health. In part (b) (i), 1 point was awarded for appropriately explaining what is meant by the term "sick building"; and 1 point was awarded in (b) (ii) for an accurate description of the criteria used for determining whether a building is "sick".

Appropriateness of Student Preparation and Some Misconceptions

Overall, most students were able to identify at least one specific indoor air pollutant and to appropriately respond to one or more parts of the question. Some students confused the identification of the pollutant and the source of the pollutant. For example, some students identified "air fresheners" as a specific indoor air pollutant, when they should have discussed a pollutant such as para-dichlorobenzene as a specific indoor air pollutant that is contained in air fresheners.

Some students organized their response in an outline form, giving one, two, and three-word answers. Such responses lack sufficient discussion, explanation, and description. The directions for the free-response section of the exam clearly and specifically state **NOT** to address these questions in outline form. Students should respond in prose form, with answers as comprehensive as time permits.

What Teachers Can Do to Improve Performance

Teachers should give students practice in carefully reading questions and responding appropriately. When questions ask the student to describe, discuss, or explain, students should go beyond listing and identifying. Students who use outline form or one or two word answers do not demonstrate the depth of their knowledge.

Question 4

Standards

In part (a), 1 point was given for indicating that animal waste was likely to be contaminating the water if the student supported his/her assessment with reference to the data provided. One point was given for each correctly linked scientific rationale.

In part (b), students earned 1 point for each stated test and its appropriate pattern, and 1 point for a description of the testing method or testing parameter.

In part (c), 1 point was awarded for each step in the sequence that linked the presence of animal waste to an example of an ecological change in a body of water.

Appropriateness of Student Preparation and Some Misconceptions

In part (a), students were generally able to correctly identify the contamination of the stream by the animal waste and provide scientific evidence to substantiate their assessment.

Misconceptions surfaced when students failed to provide a scientific basis for their assessment; for example, some students simply assumed the stream must be polluted because it ran through a hog farm, or suggested that the stream was not contaminated but then provided evidence to the contrary. Some students discussed contamination caused by fertilizer runoff rather than the hog waste.

In part (b), most students were able to link their suggested tests to a pattern from sites A to D. Fewer students described in detail the testing parameter for each of their suggestions, or gave any description of the actual testing procedure. Those who did describe a procedure most often described using a Secchi disc to measure turbidity.

In part (c), most students were able to describe a sequence of ecological changes that occur from nutrient enrichment which lead to the eutrophication of a body of water. The most common step cited was that the increased nitrate/phosphate levels, due to their presence in animal waste, resulted in the proliferation of algae or an algal bloom. Fewer students described how this led to lower dissolved oxygen levels and a concomitant shift in biodiversity of the body of water. The major student error was listing the ecological changes in a haphazard order without any linkage from one step in the sequence to the next.

What Teachers Can Do to Improve Performance

Students should have experience describing spatial patterns of environmental change and the stepwise sequence of ecological events that accompany such changes. Teachers also need to help students interpret data sets scientifically.