# Chief Reader Report on Student Responses:

## 2018 AP® Environmental Science Free-Response Questions

- Number of Students Scored 166,433
- Number of Readers 464
- Score Distribution

| Exam Score | N | %At |
|---|---|---|
| 5 | 14,604 | 8.8 |
| 4 | 39,827 | 23.9 |
| 3 | 24,936 | 15.0 |
| 2 | 42,986 | 25.8 |
| 1 | 44,080 | 26.5 |

- Global Mean 2.63

The following comments on the 2018 free-response questions for AP® Environmental Science were written by the Chief Reader, Michele Goldsmith, Southern New Hampshire University. 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 preparation 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.

© 2018 The College Board.
Visit the College Board on the Web: www.collegeboard.org.

## Question #1

**Task:** Document-Based Question
**Topic:** Green Buildings
**Max. Points:** 10
**Mean Score:** 3.90

***What were the responses to this question expected to demonstrate?***

The intent of this question was for students to consider ways to increase the sustainability of Fremont High School by evaluating various initiatives in a potential conversion of an existing building to a green building. Students were asked to read the document provided and to define the term carbon footprint. Students were asked to identify how the school's heating system could be contributing to the carbon footprint and to describe one way to reduce those contributions. These concepts were drawn from the following sections of the course description: V. Energy Resources and Consumption, B. Energy Consumption.

The next part of the question evaluated student understanding of increasing the sustainability of the school. Students were asked to identify environmental benefits of incorporating a living green roof into the design of the new building. Students were asked to describe practices that could decrease the environmental impact in the cafeteria. Students were asked to discuss the benefits of using native landscaping at the school. Students were asked to discuss an environmental benefit of using flooring made of plant material to replace carpeting made of synthetic fibers. The concepts were drawn from the following sections of the course description: IV. Land and Water Use, D. Other Land Use, 4. Land conservation options and 5. Sustainable land-use strategies and V. Energy Resources and Consumption, F. Energy Conservation.

***How well did the response address the course content related to this question? How well did the responses integrate the skills required on this question?***

The mean score for Question 1 was 3.90 out of a possible of 10 points. Students were expected to read and interpret the given document and use that information to address specific green building scenarios. Students had to be knowledgeable about the role of energy and its impact on atmospheric carbon. They also had to identify and discuss several aspects and impacts of sustainable (green) buildings.

- In general, most students were able to read and evaluate the Fremont Daily Times article and apply the information to questions about carbon footprints. Responses clearly defined a carbon footprint as the amount of carbon released by human activities. Most responses were also able to evaluate Fremont High School's current heating system and determine that the burning of fossil fuels was leading to an increase in carbon dioxide. Some responses were able to describe ways to decrease the contributions of the school's heating system to its carbon footprint. Responses included switching to a renewable energy source, such as photovoltaic cells to produce electricity to run heaters or using a programmable thermostat to lower the building temperature during times when school is not in session. Students also described ways to increase the efficiency of the building itself by increasing heat-trapping insulation or remodeling with south-facing windows and dark interior floors to increase the absorption of solar radiation and storage/re-release of thermal energy.
- The next four parts of question 1 (b, c, d, e) required students to apply sustainable (green) building techniques for potential renovations at Fremont High School. In part (b), most responses identified the environmental benefits of a living green roof, such as providing habitat for wildlife or serving as a temporary carbon storage through photosynthesis. In part (c), most responses were able to describe practices the cafeteria could implement to decrease its environmental impacts. Responses indicated that purchasing vegetables from local farms reduces the $CO_2$ emissions from the transport trucks or that composting food waste reduces the amount sent to a sanitary landfill. Many responses suggested using metal tableware, which can be washed and reused, to reduce the amount of plastic tableware that ends up in the landfill.

© 2018 The College Board.
Visit the College Board on the Web: www.collegeboard.org.

- Students were asked to discuss using native plants in the Fremont High School landscape in part (d). Some responses were able to explain that native plants are adapted to the local climate, thus requiring less irrigation and fertilizer. Students understood that planting native species would increase the biodiversity of the area. Then, in part (e), students were asked to discuss the environmental benefits of using plant-based flooring, such as a cork or bamboo, as opposed to the current carpet made of synthetic fibers. Most responses were able to explain how plant-based flooring is compostable or biodegradable while synthetic carpeting is not, and often is sent to a landfill where it persists. Some responses explained that the production of plant-based floors results in fewer toxic chemicals or lower fossil fuel use than petroleum-based synthetic carpeting. Students also described how cork or bamboo floors harbor fewer allergens such as dust mites.
- Most responses that did not earn points in parts of question 1 did not convey enough detail or depth. Some answered that using fossil fuels increased Fremont's carbon footprint, but did not identify that the coal had to be burned or that carbon dioxide specifically was released. Other responses did not link their green-friendly cafeteria plans to a decrease in the school's environmental impact. In part (d), responses may have identified an advantage of using native plants in landscaping, but did not fully describe the benefit of using native plants and therefore did earn a point.

***What common student misconceptions or gaps in knowledge were seen in the responses to this question?***

| *Common Misconceptions/Knowledge Gaps* | *Responses that Demonstrate Understanding* |
|---|---|
| • $CO_2$ is converted into $O_2$ in the process of photosynthesis. | • "Vegetative life on the roof would use this $CO_2$ for photosynthesis to create glucose for themselves, and oxygen as a by-product." |
| • Releasing $CO_2$ from burning fossil fuels destroys the ozone layer. | • "When coal combusts, not only does it give off heat, but it also releases $CO_2$, a greenhouse gas." |
| • Synthetic carpets, made from fossil fuels, can biodegrade. | • "Flooring made out of plant material is often biodegradable and can therefore be much more easily disposed of. Synthetic carpets that are made from fossil fuels can remain in landfills for years and can contaminate groundwater and air in the process." |

***Based on your experience at the AP® Reading with student responses, what advice would you offer to teachers to help them improve the student performance on the exam? [This section is advice to teachers, it's currently written with what students should do, I revised some of the language, however I would suggest reviewing to ensure it's written with advice to teachers]***

- Remind students that when a question asks for two environmental benefits or practices, only the first two benefits or practices will be scored. Students should choose their strongest answers and make that the focus of their discussion. Score items following these guidelines to help students best use their time when answering free-response questions. Emphasize the differences between environmental and economic benefits. If the primary benefit of a practice is economic and the student focuses on financial gain, it is not an environmental benefit. Identifying an economic benefit when the questions asks for an environmental benefit will not earn a point.

© 2018 The College Board.
Visit the College Board on the Web: www.collegeboard.org.

- Students should remember to answer the question completely. Questions that ask a student to discuss their answer should be more descriptive and include more information than a question that simply asks the student to identify an answer. Some students would contradict themselves in an attempt to write more lengthy responses. It is important for students to practice writing out clear detailed responses that do more than identify a concept. In addition, if a question asks for an environmental benefit of using plant-based flooring instead of carpeting made of synthetic fibers, both side of the issue must be discussed.
- Emphasize the differences between climate change and ozone depletion. Some responses discussed that carbon dioxide from the carbon footprint destroys the ozone layer. This is a common misconception. Ask students to explain climate change and ozone depletion as two separate global phenomena.

***What resources would you recommend to teachers to better prepare their students for the content and skill(s) required on this question?***

- Teachers will find sample student responses to exam questions on the exam information page on AP Central, along with specific commentary explaining why each point was or was not earned. Teachers can use these samples to help students become more comfortable practicing and producing responses within the suggested response time.
- Teachers will find scoring guidelines explaining how exam questions were scored on the exam information page on AP Central. Teachers can use and adapt these scoring guidelines throughout the AP year so that students become familiar with how their responses will be scored.
- Teachers can review elements of Q3 from the 2017 exam, Q4 from the 2015 exam, and Q1 and Q2 from the 2014 exam.
- Teachers can use the quantitative skills guide in AP Sciences (2018) to assist students in developing quantitative skills throughout the course.
- The AP Environmental Science Online Teacher Community is active and there are many discussions concerning teaching tips, techniques, and activities that many teachers have found helpful. It is easy to sign up for and you can search topics of discussions from all previous years.
- New teachers (and career changers) might want to consider signing up for an APSI. An APSI is a great way to gain in-depth teaching knowledge on AP Environmental Science curriculum and exam and is also a great way to network with colleagues from around the country.

© 2018 The College Board.
Visit the College Board on the Web: www.collegeboard.org.

## Question #2

**Task:** Calculations
**Topic:** Wind Energy
**Max. Points:** 10
**Mean Score:** 2.52

***What were the responses to this question expected to demonstrate?***

The intent of this question was for students to evaluate a renewable energy resource, wind energy, and to complete several calculations relating to the energy that could be produced by a wind farm. Students were asked to describe an environmental benefit and an economic effect of an offshore wind project. Additionally, students were asked to describe how the oceans, aside from wind energy, could provide renewable energy for the generation of electricity. These concepts were drawn from the following section of the course description: V. Energy Resources and Consumption, G. Renewable Energy.

In the second part of this question, students were asked to calculate the amount of energy the wind project would have to produce in order to meet 80% of the annual consumption of the service area and how much revenue this would generate for the wind power company. Finally, the students were asked to calculate the number of hours the wind turbines would have to operate in order to produce 80% of the annual electricity consumed in the service area. These concepts were drawn from the following sections of the course description: V. Energy Resources and Consumption, A. Energy Concepts and B. Energy Consumption.

***How well did the response address the course content related to this question? How well did the responses integrate the skills required on this question?***

The mean score for Question 2 was 2.52 out of a possible of 10 points. Students were expected to be knowledgeable about the environmental and economic benefits of these renewable energy sources, and to set up and perform simple calculations related to electrical consumption and revenue.

- In part (a), many responses earned a point for explaining how wind power could replace the use of fossil fuels, and therefore result in a decrease in emissions of greenhouse gases or $CO_2$. Many students described wind power as "clean," “renewable,” or “non-polluting,” but did not connect the environmental benefits of wind power to a reduction in fossil fuel use and a subsequent reduction in fossil fuel-related pollutants.
- In part (b), responses often recognized the creation of jobs for design, construction, and maintenance as a potential economic benefit of building an offshore wind farm. Responses also often correctly identified high initial construction and maintenance costs associated with the difficulty accessing the offshore site, and a decrease in electricity costs in the long run due to lower electrical production costs.
- Most responses in part (c) demonstrated an understanding that the movement of water associated with tides or currents can be used to turn turbines and create electricity.
- In the second part of the question, students were required to apply mathematical routines to three different calculations related to electrical consumption and revenue from an off-shore wind farm. Many responses correctly calculated 80% of annual electrical energy required in the area by multiplying $2.0 \times 10^6$ MWh x 0.8. One step in part (e) required students to convert from kWh to MWh to calculate revenue. Some responses correctly included this step in their setup, however some omitted this conversion and therefore did not calculate the correct final answer. Many correctly calculated the number of hours the wind turbines must operate by using dimensional analysis in part (f).

© 2018 The College Board.
Visit the College Board on the Web: www.collegeboard.org.

***What common student misconceptions or gaps in knowledge were seen in the responses to this question?***

| *Common Misconceptions/Knowledge Gaps* | *Responses that Demonstrate Understanding* |
|---|---|
| • The environmental benefit of wind farms is that they do not release any air pollutants. | • "When wind farms are built, less fossil fuels need to be used for energy, leading to the release of fewer greenhouse gases including $CO_2$" |
| • Once construction is complete, wind power costs nothing to generate. | • "After the turbines are built, wind power is less expensive to produce than coal which has to be continually mined. |
| • Wave energy can be harnessed in exactly the same way that tidal energy is harnessed (turbines). | • "The movement of the tides spins turbines and generates electricity."<br>• "Wave energy can be harvested from floating buoy-like structures that move with the motion of the waves and generate electricity." |
| • Metric prefix unit conversion errors.<br>• (e.g. 1 MWh = 10 kWh) | • \$0.20/kWh x (1000 kWh/1 MWh) x (1.6 x $10^6$ MWh) = \$3.2 x $10^8$ |
| • Scientific Notation errors.<br>• (e.g. 1.6 x $10^6$ = 16,000,000 by ignoring the decimal point and simply adding 6 zeros) | • 2.0 x $10^6$ MWh x 0.80 = 1.6 x $10^6$ MWh |

***Based on your experience at the AP® Reading with student responses, what advice would you offer to teachers to help them improve the student performance on the exam?***

- Require students to routinely practice calculations, showing all work, which includes using unit conversions, dimensional analysis and metric prefixes, without a calculator. Allow students to evaluate their answers for accuracy and correct units.
- Emphasize specific pollutants released during the combustion of fossil fuels, and the environmental damage associated with other aspects of fossil fuel use (exploration and extraction, transportation, etc.).
- Reinforce the impacts and the costs of wind-power and other renewable energy sources. Acknowledging these costs leads to a deeper, more sophisticated understanding of how our energy needs can be met. Require students to compare energy generation advantages and disadvantages between different energy sources. Allow students to explain environmental and economic costs and benefits for a variety of energy sources from fossil fuels to nuclear power to renewable resources
- Require students to understand economic terms in environmental context, including revenue and profit.
- Clarify the difference between greenhouse gases and ozone depletion. Emphasize that not all global problems are linked.

© 2018 The College Board.
Visit the College Board on the Web: www.collegeboard.org.

***What resources would you recommend to teachers to better prepare their students for the content and skill(s) required on this question?***

- Teachers will find sample student responses on the exam information page on AP Central, along with specific commentary explaining why each point was or was not earned. Teachers can use these samples to work with students to help them become more comfortable in practicing and producing responses within the suggested response time.
- Teachers will find scoring guidelines explaining how the exam questions were scored on the exam information page on AP Central. Teachers can use and adapt these scoring guidelines throughout the AP year so that students become familiar with how their responses will be scored.
- Teachers can review elements of Q4 from the 2017 exam, Q2 and Q3 from the 2016 exam.
- Teachers can use the quantitative skills guide in AP Sciences (2018) to assist students in developing quantitative skills throughout the course.
- The AP Environmental Science Online Teacher Community is active and there are many discussions concerning teaching tips, techniques, and activities that many teachers have found helpful. It is easy to sign up for and you can search topics of discussions from all previous years.
- New teachers (and career changers) might want to consider signing up for an APSI. An APSI is a great way to gain in depth teaching knowledge on AP Environmental Science curriculum and exam and is also a great way to network with colleagues from around the country.

© 2018 The College Board.
Visit the College Board on the Web: www.collegeboard.org.

## Question #3

**Task:** Synthesis & Evaluation
**Max. Points:** 10
**Topic:** Arctic Food Webs
**Mean Score:** 4.76

***What were the responses to this question expected to demonstrate?***

The intent of this question was for students to evaluate an Arctic food web and to describe the impact of climate change on organisms in the food web. The questions also asked students to describe migration and the impact of human activity on the migration of right whales.

In the first part of the question, the stimulus provided an Arctic food web with several aquatic organisms that was used to assess the students' knowledge of the flow of energy and feeding relationships. Students were asked to identify a primary producer, a primary consumer, and a secondary consumer from the Arctic food web. Students also had to describe what was indicated by the directions of the arrows in the food web. These concepts were drawn from the following section of the course description: II. The Living World, B. Energy Flow.

Students were then asked to describe how the loss of sea ice in the Arctic was affecting the ability of polar bears to hunt and feed. Students were also asked to explain how the melting sea ice leads to a feedback loop that increases Arctic warming. These concepts were drawn from the following section of the course description: VII. Global Change, B. Global Warming.

***How well did the response address the course content related to this question? How well did the responses integrate the skills required on this question?***

The mean score for Question 3 was 4.76 out of a possible of 10 points. Students were expected to be knowledgeable about the energy flow in a food web, as well as the impact of climate change on the web. Students were asked to demonstrate an understanding of positive feedback loops. Students were also asked to apply knowledge about migration and human commercial activity on right whales.

- Most responses correctly identified organisms with their trophic level in the food web in part (a). Some responses that provided incorrect answers appeared to equate "primary consumer" with size or perceived importance (often choosing orca or polar bear).
- Most responses correctly identified that the arrows in the food web in part (b) represented the flow of energy through the food web. Those that missed the question often repeated the question stem by indicating that the arrows represented which organisms were consumed by others. Others that missed the question identified the arrows as showing the process of bioaccumulation.
- Most responses that earned a point in part (c) identified elements of decreasing area of the hunting ground or increasing distances polar bears have to move/swim as impacting polar bear ability to hunt and feed. The majority that did not receive the point correctly identified a change in sea ice habitat, but did not address how the polar bear's ability to find food and successfully feed was impacted. Those responses merely restated the question or indicated that the bear was likely to die from drowning or predation, neither of which is directly related to its hunting ability.
- Many responses were able to identify albedo or describe changes in reflectivity or absorption for the first point in part (d). Fewer earned the second point in the feedback loop because they did not close the loop by indicating how increased absorption leads to increasing temperatures, which then melts more ice. Those that missed both points usually indicated that melting sea ice released global warming gases (e.g., $CO_2$ and $CH_4$) or that melting sea ice raised water levels. Some responses equated sea ice with ice cubes in a drink and thought that the lack of sea ice would automatically lead to warming of the water. Some responses attempted to link an ozone hole to increased input of sunlight that made temperatures warmer. Similarly, many responses confused sea ice with permafrost with explanations about more global warming gases being released when the ice melts. Similarly, many simply said "completing the feedback loop" or "more ice melts" in part (d) without indicating the necessary step of a temperature change to complete the loop or explain how more ice melts.

© 2018 The College Board.
Visit the College Board on the Web: www.collegeboard.org.

- The majority of responses were able to identify a correct reason for species to migrate in (e)(i). While students were not required to indicate that migration is an annual cycle, those whose responses did not receive the point typically described the reason as a one-time event, such as a species being forced out of its home by habitat destruction or total depletion of its resources. Most responses were able to identify a commercial activity, other than whaling, for a point in (e)(ii). If responses did not receive that point, it was often because the activity identified was not specifically commercial. For example, many identified oil spills or plastic waste, which are accidental or illegal impacts, rather than a specific commercial activity. The majority of responses that were able to identify a correct activity in (e)(ii) were usually able to describe a reasonable strategy to limit the impact of that activity. The exception was when responses indicated that there should be a complete ban on the activity. For example, restricting fishing at the breeding grounds during the breeding season is a reasonable strategy, but those that suggested fishing be completely banned from the entire migratory pathway did not receive the point.

***What common student misconceptions or gaps in knowledge were seen in the responses to this question?***

| *Common Misconceptions/Knowledge Gaps* | *Responses that Demonstrate Understanding* |
|---|---|
| • Arrows in the food web indicate amount of nutrient transfer, or biomagnification pathways. | • "The arrows in the diagram represent the flow of energy." |
| • When sea ice melts, it releases stored gases (e.g., $CO_2$, $CH_4$) that contribute to global warming. | • "Melting sea ice leads to a feedback loop that increases Arctic warming by the ice melting into the ocean→sunlight rays do not reflect on ice anymore and are absorbed by the ocean→ocean heats up→more ice melts→Arctic gets warmer." |
| • Indicating that abrupt and new changes in the environment forced animals to migrate rather than understanding that migration is an annual cycle. | • "One reason a species may migrate a long distance is to reach a traditional breeding ground." |

***Based on your experience at the AP® Reading with student responses, what advice would you offer to teachers to help them improve the student performance on the exam?***

- Emphasize the difference between ozone depletion and global warming.
- Encourage students to provide an answer for each part of the question.
- Remind students to provide answers that are not simply restating the question stem as this does not earn points.
- For questions that contain an impact, have students indicate the direction of the change or a description of the cause of the change.
- Provide practice with students writing the steps of positive and negative feedback loops.

***What resources would you recommend to teachers to better prepare their students for the content and skill(s) required on this question?***

- Teachers will find sample student responses on the exam information page on AP Central, along with specific commentary explaining why each point was or was not earned. Teachers can use these samples to work with students to help them become more comfortable in practicing and producing responses within the suggested response time.

© 2018 The College Board.
Visit the College Board on the Web: www.collegeboard.org.

- Teachers will find scoring guidelines explaining how the exam questions were scored on the exam information page on AP Central. Teachers can use and adapt these scoring guidelines throughout the AP year so that students become familiar with how their responses will be scored.
- Teachers can review elements of Q4 from the 2016 exam, Q1 from the 2015 exam, and Q1 and Q2 from the 2014 exam.
- Teachers can use the quantitative skills guide in AP Sciences (2018) to assist students in developing quantative skills throughout the course.
- The AP Environmental Science Online Teacher Community is active and there are many discussions concerning teaching tips, techniques, and activities that many teachers have found helpful. It is easy to sign up for and you can search topics of discussions from all previous years.
- New teachers (and career changers) might want to consider signing up for an APSI. An APSI is a great way to gain -epth teaching knowledge on AP Environmental Science curriculum and exam and is also a great way to network with colleagues from around the country.

© 2018 The College Board.
Visit the College Board on the Web: www.collegeboard.org.

## Question #4

**Task:** Synthesis & Evaluation
**Topic:** Indoor Air Pollution
**Max. Points:** 10
**Mean Score:** 3.35

***What were the responses to this question expected to demonstrate?***

The intent of the question was to measure the students' knowledge regarding indoor air pollution and the potential health effects of indoor air pollution. Students were asked to identify two air pollutants associated with burning biomass indoors and a specific illness related to one of the pollutants they identified. Students were then asked to identify a realistic approach that could be used to reduce the impact of burning biomass indoors on human health and to describe how this approach could reduce the incidence of respiratory illness. Additionally, students were asked to discuss why children under the age of five, as compared to adults, are more susceptible to illness that results from indoor air pollution. These concepts were drawn from the following sections of the course description: VI. Pollution, A. Pollution Types, 1. Air pollution and B. Impacts on the Environment and Human Health, 1. Hazards to human health.

Students were also asked to address indoor air pollutants that typically occur in more developed countries. Given a choice of three common indoor air pollutants (asbestos, radon, and mold), students were asked to choose two of the three pollutants and identify a source for each chosen pollutant. Students were also asked to describe a method that could be used to reduce exposure to the two indoor air pollutants they chose. Student responses could have been recorded in the provided table. These concepts were drawn from the following sections of the course description: VI. Pollution, A. Pollution Types, 1. Air Pollution, 3. Water Pollution, and 4. Solid Waste Pollution as well as from VI. Pollution, B. Impacts on the Environment and Human Health, 2. Hazardous chemicals in the environment.

***How well did the response address the course content related to this question? How well did the responses integrate the skills required on this question?***

The mean score for Question 4 was 3.35 out of a possible of 10 points. Students were expected to be knowledgeable about indoor air pollutants resulting from burning biomass for heating and cooking in less developed countries, a respiratory illness connected to one of those pollutants, and why children are at greater risk of suffering from one of those illnesses. Students were also expected to be knowledgeable about common indoor air pollutants (asbestos, mold, radon) in more developed countries. Specifically, they were expected to know the sources of these pollutants and methods that could be used to reduce exposure to these pollutants.

- In (a)(i), the majority of responses were able to correctly identify indoor air pollutants released from biomass burning in less developed countries. Correct responses included particulate matter (PMs), carbon monoxide (CO), and methane. Some responses included the term "smoke," which is not an adequate identification of an indoor air pollutant; this is a vague, colloquial term. If a response provided more than two pollutants, only the first two identifications were scored. In (a)(ii), many responses identified asthma, bronchitis, and lung cancer as specific respiratory illnesses with a causal relationship to indoor air pollutants identified previously. "Respiratory" or "lung irritation" were not accepted because they are not specific respiratory illnesses. Infectious agents such as tuberculosis were not accepted due to the disease not being a result of indoor air pollutants.
- Responses identified several realistic approaches to reduce the impact of pollutants that result from indoor biomass combustion in part (b). These approaches included ventilation of the noxious gases produced to the atmosphere, improving the combustion device so that less pollution is released, switching energy sources to a cleaner source, or moving cooking stoves outdoors to reduce the amount of pollutant trapped indoors. The goal of all of these strategies was to prevent the polluting products of combustion from being produced indoorsor to eliminate the production of those products at all in the first place. A key word in the question stem is "realistic." Responses that described building a nuclear power plant or eliminating all cooking did not earn a point. Responses that identified devices that burned more efficiently or the construction of a chimney as structural change earned a point. Responses then had to explicitly describe how this approach would reduce respiratory illness/exposure to the pollutant.

© 2018 The College Board.
Visit the College Board on the Web: www.collegeboard.org.

- Students were asked to discuss the particular susceptibility of children to illnesses linked to household air pollutants in (c). Common responses included a discussion of underdeveloped immune systems in young children, high ED50 due to low child body mass, increased exposure due to time indoors, or the relative effect of even a small change on a small respiratory system. Many responses referenced a child's weak immune system, but the term "weak" is too vague and does not fully convey the concept that the immune system is not fully developed. Students need to use appropriate and descriptive scientific vocabulary when needed. (d), students were asked to evaluate indoor air pollution in more developed countries. Students were provided with three common indoor air pollutants - asbestos, radon and mold – and were asked to choose two of the three sources for their response. Students who earned points for discussing asbestos often stated that it was found in building materials and that it must be safely removed or encapsulated. Students who only noted that the asbestos should be removed, did not earn a point; only with appropriate removal techniques can the asbestos be removed without exposure. Removing asbestos incorrectly can actually expose the fibers and increase indoor air pollution. Students who earned points for discussing radon often stated that radon was a nturally occuring gas (from uranium decay in Earth's crust) and that basement slabs must be sealed or areas properly ventilated to reduce or eliminate exposure. Students who did not know that radon was a gas often had difficulty identifying the source and a method to reduce exposure. Student who earned points for discussing mold often stated that mold spores could grow on indoor objects that were not inteneded to be moist/wet and that areas with mold must be replaced or disinfected. Students who incorrectly identified mold as bacteria (rather than a fungus) did not earn a point for methods of reduction that described removing bacteria.

***What common student misconceptions or gaps in knowledge were seen in the responses to this question?***

| *Common Misconceptions/Knowledge Gaps* | *Responses that Demonstrate Understanding* |
|---|---|
| • Carbon dioxide was identified as an indoor air pollutant. | • "Two air pollutants released by burning biomass are particulates and carbon **monoxide**." |
| • Responses identified filtering of pollutants released from biomass burning as a realistic approach. | • "…implement more ventilation by installing a chimney…allows the combustion products to escape outdoors." |
| • Responses restated the prompt that children under the age of 5 are at greater risk for respiratory illness, but do not discuss the anatomy or behaviors that lead to this increased risk. | • "One reason children are at a greater risk for illness is because the dose-response relationship...Children have a smaller body mass which means that fewer air pollutants are necessary to cause illness" |
| • All wet areas in a home will have mold. | • "Pipe leaks that allow water to settle inside walls and under floors where mold can easily grow." |

***Based on your experience at the AP® Reading with student responses, what advice would you offer to teachers to help them improve the student performance on the exam?***

- Emphasize the different types of indoor air pollutants, including the burning of biomass and the impact to health and environmental degradation.

© 2018 The College Board.
Visit the College Board on the Web: www.collegeboard.org.

- Students should know how pollutants can be hazardous to human health and should evaluate different health concerns that result from exposure to various pollutants/chemicals. Teachers should be sure to reinforce that children are not just small adults, but that they are developing and that during the developmental process, children are often more prone to harm from pollutants. Reinforce with students to only identify what the question asks for. In this case, only the first two responses would be scored. Allow students to practice using scientific language appropriately. If students are cannot recall a specific term, encourage them to describe the concept in language they understand rather than not earn points through misapplication of vocabulary.
- Practice with students describing the command terms in the question stem. If the term in the stem is "describe" or "discuss," they need to provide evidence or reasoning to support their response.

***What resources would you recommend to teachers to better prepare their students for the content and skill(s) required on this question?***

- Teachers will find sample student responses on the exam information page on AP Central, along with specific commentary explaining why each point was or was not earned. Teachers can use these samples to work with students to help them become more comfortable in practicing and producing responses within the suggested response time.
- Teachers will find scoring guidelines explaining how the exam questions were scored on the exam information page on AP Central. Teachers can use and adapt these scoring guidelines throughout the AP year so that students become familiar with how their responses will be scored.
- Teachers can review elements of Q1 from the 2017 exam, Q2 from the 2016 exam, Q2 and Q3 from the 2015 exam, and Q1 and Q2 from the 2014 exam.
- Teachers can use the quantitative skills guide in AP Sciences (2018) to assist students in developing quantative skills throughout the course.
- The AP Environmental Science Online Teacher Community is active and there are many discussions concerning teaching tips, techniques, and activities that many teachers have found helpful. It is easy to sign up for and you can search topics of discussions from all previous years.
- New teachers (and career changers) might want to consider signing up for an APSI. An APSI is a great way to gain in-depth teaching knowledge on AP Environmental Science curriculum and exam and is also a great way to network with colleagues from around the country.

© 2018 The College Board.
Visit the College Board on the Web: www.collegeboard.org.