AP® BIOLOGY
2012 SCORING GUIDELINES

Question 4

Note: At least 1 point must be earned from each of parts (a), (b), and (c) in order to earn a maximum score of 10.

The element carbon is contained in all organic compounds.

(a) **Discuss** the role of photosynthesis and cellular respiration in carbon cycling in the biosphere. *(2 points maximum)*

	Discussion (1 point per box)
Photosynthesis	• Removes CO_2 from the atmosphere. • Reduces (or uses) CO_2. • Fixes carbon into organic molecules (sugars).
Cellular respiration	• Metabolizes (oxidizes, catabolizes) organic molecules (sugars). • Returns CO_2 to the atmosphere. • Releases CO_2.

(b) For THREE of the following, **predict** and **explain** the effect on the carbon cycle if:

- decomposers were absent
- deforestation occurred
- volcanic dust accumulated in the atmosphere
- the average ocean temperature increased

(6 points maximum)

	Prediction (1 point per box; 3 points maximum)	**Explanation (1 point per box; 3 points maximum)**
Decomposers absent	• Less CO_2 in atmosphere. • More carbon stored in dead organisms.	• CO_2 is not released. • Organic material is not degraded.
Deforestation	• More CO_2 in atmosphere. • Fewer carbon compounds in organisms.	• Decreased photosynthesis.
Volcanic dust in atmosphere	• More CO_2 in atmosphere. • Fewer carbon compounds in organisms.	• Less solar radiation causes less photosynthesis.
Average ocean temperature increased	• More CO_2 in atmosphere. • Less CO_2 in ocean.	• Increased decomposition/rate of respiration. • Decreased CO_2 solubility (less photosynthesis).
	• Less CO_2 in atmosphere.	• Increased photosynthesis (e.g., algae blooms). • Decreased O_2 solubility, resulting in decreased respiration.
	• No net change in CO_2 reservoirs.	• Increased photosynthesis **AND** respiration.

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Question 4 (continued)

(c) **Explain** how increased CO_2 in the atmosphere results in greater acidification of oceans and **describe** the effect on marine organisms. **Include** in your discussion TWO examples of how human activity can increase atmospheric CO_2.
(4 points maximum)

Explanation (1 point)	• CO_2 dissolves, forming an acid (carbonic acid); the release of H^+ ions decreases pH. ($CO_2 + H_2O \rightleftarrows H_2CO_3 \rightleftarrows H^+ + HCO_3^-$)
Effect (1 point)	• Decreases ability to make corals/shells/exoskeletons. • Decreases availability of CO_3^{2-} for formation of $CaCO_3$ because more H^+ combines with CO_3^{2-}. • Decreases efficiency of enzymes in suboptimal pH.
Examples (1 point each; 2 points maximum)	• Combustion of gasoline/diesel. • Combustion of coal. • Combustion of natural gas. } **OR** Combustion of fossil fuels. • Combustion of wood. • Combustion/decomposition of wastes. • Deforestation reduces photosynthesis.

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4. The element carbon is contained in all organic compounds.

4A1

(a) **Discuss** the role of photosynthesis and cellular respiration in carbon cycling in the biosphere.

(b) For THREE of the following, **predict** and **explain** the effect on the carbon cycle if:

- decomposers were absent
- deforestation occurred
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Calcium Carbonate

$Ca^{+2}CO_3^{-2}$ $CaCO_3$

(c) **Explain** how increased CO_2 in the atmosphere results in greater acidification of oceans and **describe** the effect on marine organisms. **Include** in your discussion TWO examples of how human activity can increase atmospheric CO_2.

a.) Photosynthesis and cellular respiration are complementary reactions. Photosynthesis fixes carbon using energy obtained from light into G3P, which is then converted to glucose and other molecules. Respiration is when glucose and other products are broken down to release energy. Thus, Photosynthesis fixes carbon (in CO_2 out O_2) and respiration (in O_2 out CO_2) releases it. This allows for a fairly constant rate of cycling between CO_2 being taken in from atmosphere to organic matter by photo. and CO_2 being released from organic matter to the atmosphere by respiration

b.) If decomposers were absent, the carbon fixed in dead organic matter would not be released. This would cause a build up of carbon on the Earth and a significant depletion of it as CO_2 in the atmosphere. If deforestation occured, much less photosynthesis would take place because of the destruction of cells that would photosynthesize in leaves and thus CO_2 build up in the atmosphere would ensue because of less fixation of carbon into organic matter. Finally, if volcanic dust built up in the atmosphere, less light would reach the Earth, thus less photosynthesis would occur and carbon fixation would once again deplete. This would cause a build up of carbon as CO_2 in the atmosphere.

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ADDITIONAL PAGE FOR ANSWERING QUESTION 4

c) With increased CO_2 in the atmosphere, diffusion of CO_2 into water increases. When this occurs, more CO_2 is converted into H_2CO_3, or carbonic acid in the ocean. This acid increases the acidity of the ocean by adding hydrogen ions (protons) to the surrounding water. HCO_3^- is left, which can act as an acid again and release its other H^+, leaving CO_3^{-2}. With more build up of CO_3^{-2}, more CO_3^{-2} is converted back to HCO_3^- and H_2CO_3. Corals have exoskeletons made of calcium carbonate ($CaCO_3$). With decreased levels of carbonate, therefore, lack of calcium carbonate ensues, and corals are not able to form their exoskeletons and die. One way CO_2 levels are increased by humans is by burning fossil fuels. This burning of fossil fuels releases (organic matter) CO_2 which before was stored in the organic matter into the atmosphere. Another way humans increase the levels is by deforestation. With less trees around to photosynthesize, less CO_2 is fixed into organic matter and thus more stays in the atmosphere.

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4B,

4. The element carbon is contained in all organic compounds.

(a) **Discuss** the role of photosynthesis and cellular respiration in carbon cycling in the biosphere.

(b) For THREE of the following, **predict** and **explain** the effect on the carbon cycle if:

- decomposers were absent
- deforestation occurred
- volcanic dust accumulated in the atmosphere
- the average ocean temperature increased

(c) **Explain** how increased CO_2 in the atmosphere results in greater acidification of oceans and **describe** the effect on marine organisms. **Include** in your discussion TWO examples of how human activity can increase atmospheric CO_2.

a) Photosynthesis uses carbon dioxide in the atmosphere along with water to produce sugar and oxygen. Thus, it decreases the availability of carbon in the atmosphere. Cellular respiration has an opposite effect of photosynthesis. CO_2 is produced as glucose is broken down to pyruvates during glycolysis and eventually released as six CO_2 molecules. Thus, cellular respiration increases the concentration of CO_2 in the atmosphere.

b) Deforestation: after a deforestation, less plants are present in a forest to carry out photosynthesis and thus take up the atmospheric CO_2. Thus, atmospheric CO_2 concentration will increase.

Decomposers were absent: when decomposers decompose organic materials, they release CO_2 into the atmosphere

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4B2

• When ocean temperature increases, less CO_2 will dissolve in the ocean. (Gases dissolve in liquid more easily in colder temperature) Since less CO_2 is captured in the water, atmospheric CO_2 will increase ~~more CO_2 in the~~

All of these 3 factors increase CO_2 level in the atmosphere, therefore more CO_2 can be turned into O_2 by plants' photosynthesis.

c) CO_2 in the atmosphere dissolves in the oceans and decreases the pH of the oceans because CO_2 in water forms Carbonic acid (H_2CO_3) Human activities such as burning of fossil fuels in factories and use of cars ~~increase the~~ release a huge amount of CO_2 and increases the concentration of CO_2 in the atmosphere, which in turn, causes the acidification of ocean water. Acidic environment is not a suitable habitat for marine organisms. Acidification of ocean H_2O will either have a fatal effect on

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4B3

these organisms or result in mutation. ~~uptake of acid water will denature by the mar~~

~~Examples of two human activities that can increase atmosphere CO_2 are burning fossil fuels and use of vehicles.~~

When marine animals take in acid H_2O, the acid H_2O will denature their enzymes and Since enzymes cannot function properly to carry out vital processes such as protein formation, the organism will eventually die. Acid H_2O uptake may also ~~affect their~~ disorient their DNA, causing mutation.

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4C1

4. The element carbon is contained in all organic compounds.

(a) **Discuss** the role of photosynthesis and cellular respiration in carbon cycling in the biosphere.

(b) For THREE of the following, **predict** and **explain** the effect on the carbon cycle if:

- decomposers were absent
- deforestation occurred
- volcanic dust accumulated in the atmosphere
- the average ocean temperature increased

(c) **Explain** how increased CO_2 in the atmosphere results in greater acidification of oceans and **describe** the effect on marine organisms. **Include** in your discussion TWO examples of how human activity can increase atmospheric CO_2.

Photosynthesis and cellular respiration work hand in hand. If not for photosynthesis, there would be no oxygen in the air for breathing. If our cells did not go through cellular respiration we would not give off CO_2 for plants to use in photosynthesis to make O_2.

If deforestation were to occur, photosynthesis could not take place. There would probably be an increase in the amount of CO_2 in the atmosphere which would potentially harm the population of living, breathing organisms because there would not be any O_2 to breathe because of the lack of photosynthesizing plants. Also if volcanic dust were to accumulate in the atmosphere there would be a decrease in sunlight. This would probably cause plants to not be able to complete the light-dependent reactions of photosynthesis. These reactions are necessary to produce O_2 for us to breathe. If volcanic dust filled the atmosphere plants would die which would cause breathing organisms

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4C2

ADDITIONAL PAGE FOR ANSWERING QUESTION 4

to die as well.

Increased CO_2 in the atmosphere would result in greater acidification of oceans because photosynthesis could not occur fast enough to get rid of it all. Marine organisms like fish would be poisoned and the plants would not be able to produce oxygen to help them breathe. The aquatic ecosystem would most likely die out. Two ways human activity could increase CO_2 in the atmosphere are the cutting down of forrests to build cities and towns. This would decrease the amount of photosynthesizers to produce O_2 from the CO_2 in the atmosphere. Another way would be air pollution which would block the sun from getting to the plants so that they can photosynthesize to get rid of the CO_2. Humans could do this by making factories, driving, and even polluting the water w/ chemicals can cause an increase in CO_2 because the aquatic plants will die.

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AP® BIOLOGY
2012 SCORING COMMENTARY

Question 4

Overview

This question allowed students to demonstrate an understanding of the global carbon cycle and to discuss human impacts on the carbon cycle. In part (a) they were asked to discuss the role of photosynthesis and cellular respiration in carbon cycling. In part (b) students chose three out of four given perturbations and were required to predict and explain the effects of each perturbation on the carbon cycle. Part (c) asked students to explain how increased atmospheric CO_2 results in greater acidification of the oceans and to describe the effect of acidification on marine organisms. Students were also asked to include two examples of how human activity can increase atmospheric CO_2.

Sample: 4A
Score: 10

In part (a) 1 point was earned for stating that the role of photosynthesis is to fix carbon into G3P. One point was earned for discussing how respiration occurs "when glucose and other products are broken down to release energy." In part (b) 1 point was earned for explaining that "[i]f decomposers were absent, the carbon fixed in dead organic matter would not be released." One point was earned for predicting the depletion of carbon as CO_2 in the atmosphere if decomposers were absent. One point was earned for explaining that "[i]f deforestation occured [*sic*], much less photosynthesis would take place." One point was earned for predicting that if deforestation occurred, "CO_2 build up in the atmosphere would ensue." One point was earned for explaining that if volcanic dust accumulated, "less light would reach the Earth, thus less photosynthesis would occur." One point was earned for predicting that volcanic dust would cause a build up of carbon as CO_2 in the atmosphere. In part (c) 1 point was earned for explaining that CO_2 in the atmosphere diffuses into the water and "is converted into H_2CO_3, or carbonic acid." One point was earned for describing how acidification "decrease[s] levels of carbonate, therefore, lack of calcium carbonate ensues, and corals are not able to form their exoskeletons and die." Two additional points could have been earned for including two examples of human activity that can increase atmospheric CO_2, but the maximum score of 10 points had already been reached.

Sample: 4B
Score: 8

In part (a) 1 point was earned for indicating that "[p]hotosynthesis uses carbon dioxide." One point was earned for discussing how CO_2 is produced in cellular respiration. In part (b) 1 point was earned for explaining that "after a deforestation, less plants are present in a forest to carry out photosynthesis." One point was earned for predicting that with deforestation, "atmospheric CO_2 concentration will increase." One point was earned for predicting that when ocean temperature increases, less CO_2 will dissolve in the ocean; the response also predicted that atmospheric CO_2 would increase, but the prediction point for increased ocean temperature had already been earned. One point was earned for explaining that "[g]ases dissolve in liquid more easily in colder temperature," implying decreased solubility of CO_2 in warm waters. In part (c) 1 point was earned for explaining that "CO_2 in the atmosphere dissolves in the oceans and decreases the pH of the oceans because CO_2 in water forms carbonic acid (H_2CO_3)." One point was earned for including the burning of fossil fuels as an example of human activity that can increase atmospheric CO_2. No additional point was earned for mentioning the use of cars, because the point had already been earned for including the burning of fossil fuels.

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Question 4 (continued)

Sample: 4C
Score: 6

In part (a) 1 point was earned for discussing cellular respiration: "If our cells did not go through cellular respiration we would not give off CO_2." One point was earned for indicating that CO_2 is used in photosynthesis. In part (b) 1 point was earned for explaining that "[i]f deforestation were to occur, photosynthesis could not take place." One point was earned for predicting that with deforestation "[t]here would probably be an increase in the amount of CO_2 in the atmosphere." One point was earned for explaining that "if volcanic dust were to accumulate in the atmosphere there would be a decrease in sunlight," leading to an inability in plants "to complete the light-dependent reactions of photosynthesis." In part (c) 1 point was earned for including the clearing of forests as an example of human activity that would increase the amount of CO_2 in the atmosphere.

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