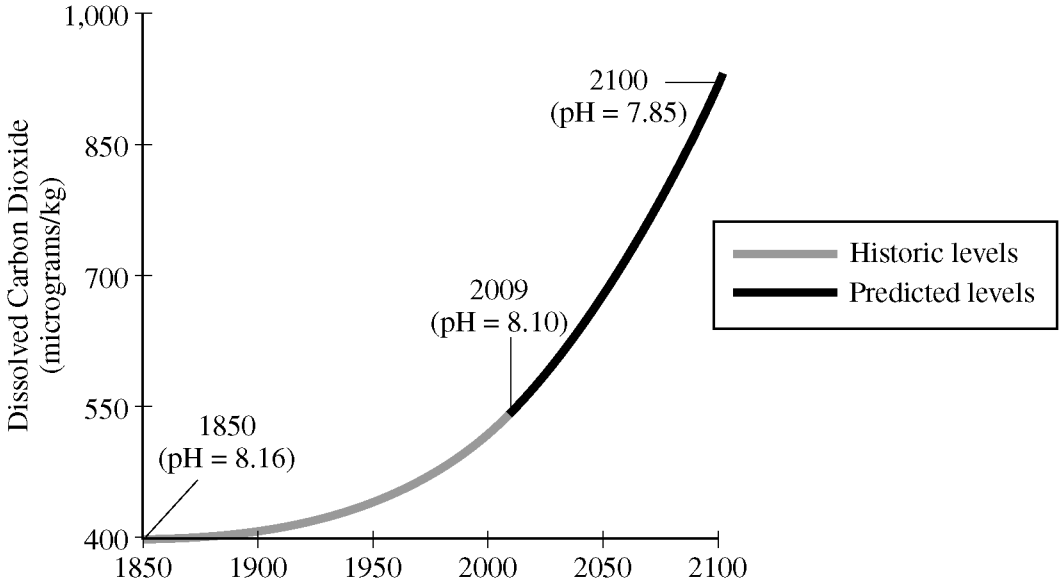
(b) The widespread death of trees leads to a series of changes in a forest ecosystem. Identify TWO physical changes that occur in the forest ecosystem as the result of the death of mature trees. For each physical change you identify, describe an impact of that change on the forest ecosystem.

(c) As the article states, the number of managed honeybee colonies has dropped significantly over the past few decades. Describe TWO specific economic consequences of the collapse of the managed honeybee colonies.

(d) Pollination by native insects is considered an ecosystem service. Identify a different ecosystem service and explain how that service benefits human society.



2. Coral reefs are produced when corals acquire calcium ions (Ca^{2+}) and carbonate ions (CO_3^{2-}) from seawater and deposit solid $CaCO_3$ to form their exoskeletons. Scientists are concerned that relatively rapid decreases in ocean water pH will hinder the deposition of $CaCO_3$. The graph above shows the amount of CO_2 dissolved in ocean water and ocean water pH (shown in parentheses) since 1850 and the predicted changes through 2100.

(a) Explain how an increase in the amount of dissolved CO_2 in ocean water results in a decrease in the pH of ocean water.

(b) Explain why the movement of carbon into the ocean has been increasing since 1850.

(c) In order to model the effects of ocean acidification on coral reefs, some simplifying assumptions can be made. Use the assumptions in the table below to perform the calculations that follow.

Assume that the total global area of corals growing in reefs is 2.5×10^{11} m^2.
Assume that corals grow only vertically and that the average vertical growth rate of corals is 3 mm/year.
Assume that the average density of $CaCO_3$ in corals is 2×10^3 kg/m^3.

(i) Calculate the current annual global increase in volume, in m^3, of $CaCO_3$ in coral reefs. Show all steps in your calculation.

(ii) Calculate the current annual global increase in mass, in kg, of $CaCO_3$ in coral reefs. Show all steps in your calculation.

(iii) Because of ocean acidification, it is expected that in 2050 the mass of $CaCO_3$ deposited annually in coral reefs will be 20 percent less than is deposited currently. Calculate how much less $CaCO_3$, in kg, is expected to be deposited in 2050 than would be deposited if ocean water pH were to remain at its current value.

(d) Identify and describe one likely negative environmental impact of the loss of coral reefs.

(e) Identify one environmental problem (other than one due to ocean acidification or loss of coral reefs) that affects marine ecosystems on a global scale.

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Question 2

(a) Explain how an increase in the amount of dissolved CO_2 in ocean water results in a decrease in the pH of ocean water.
(*1 point for the following*)

- When carbon dioxide dissolves in the ocean, it forms an acid (carbonic acid or H_2CO_3).

(b) Explain why the movement of carbon into the ocean has been increasing since 1850.
(*2 points; 1 point for each of the following*)

- The concentration of carbon or carbon dioxide in the atmosphere has increased.
- The source of the increase in carbon or carbon dioxide concentration in the atmosphere is the burning of fossil fuels.

(c) In order to model the effects of ocean acidification on coral reefs, some simplifying assumptions can be made. Use the assumptions in the table below to perform the calculations that follow.

Assume that the total global area of corals growing in reefs is 2.5×10^{11} m^2.
Assume that corals grow only vertically and that the average vertical growth rate of corals is 3 mm/year.
Assume that the average density of $CaCO_3$ in corals is 2×10^3 kg/m^3.

(i) Calculate the current annual global increase in volume, in m^3, of $CaCO_3$ in coral reefs. Show all steps in your calculation.
(*2 points; 1 point for a correct setup and 1 point for the correct answer*)

Units are not required in the answer; however, students must show the calculation in order to receive credit for the correct solution.

$$2.5 \times 10^{11}\ \text{m}^2 \times \frac{3\ \text{mm}}{\text{year}} \times \frac{1\ \text{m}}{1 \times 10^3\ \text{mm}} = 7.5 \times 10^8\ \text{m}^3/\text{year}$$

Or

$$2.5 \times 10^{11}\ \text{m}^2 \times \frac{3 \times 10^{-3}\ \text{m}}{\text{year}} = 7.5 \times 10^8\ \text{m}^3/\text{year}$$

Notes
- Students who write the answer as a word problem may earn points.
- Solutions to the question that use alternative setups that produce a correct answer also earn points.
- Equivalent correct answers (e.g., 750,000,000 m^3) are acceptable.

Question 2 (continued)

(ii) Calculate the current annual global increase in mass, in kg, of $CaCO_3$ in coral reefs. Show all steps in your calculation.
(*2 points; 1 point for a correct setup and 1 point for the correct answer*)

Units are not required in the answer; however, students must show the calculation in order to receive credit for the correct solution.

$$\frac{7.5 \times 10^8 \text{ m}^3}{\text{year}} \times \frac{2 \times 10^3 \text{ kg}}{1 \text{ m}^3} = 1.5 \times 10^{12} \text{ kg/year}$$

Notes

- Students who write the answer as a word problem may earn points.
- Solutions to the question that use alternative setups that produce a correct answer also earn points.
- Equivalent correct answers (e.g., 1,500,000,000,000 kg or 15×10^{11} kg) are acceptable.
- Incorrect answers transferred from (c)(i) can still earn full credit if used correctly.

(iii) Because of ocean acidification, it is expected that in 2050 the mass of $CaCO_3$ deposited annually in coral reefs will be 20 percent less than is deposited currently. Calculate how much less $CaCO_3$, in kg, is expected to be deposited in 2050 than would be deposited if ocean water pH were to remain at its current value.
(*2 points; 1 point for a correct setup and 1 point for the correct answer*)

Units are not required in the answer; however, students must show the calculation in order to receive credit for the correct solution.

$$0.2 \times 1.5 \times 10^{12} \text{ kg} = 3 \times 10^{11} \text{ kg}$$

Notes

- Students who write the answer as a word problem may earn points.
- Solutions to the question that use alternative setups that produce a correct answer also earn points.
- Equivalent correct answers (e.g., 300,000,000,000 kg or 0.3×10^{12} kg) are acceptable.
- Incorrect answers transferred from (c)(ii) can still earn full credit if used correctly.

Question 2 (continued)

(d) Identify and describe one likely negative environmental impact of the loss of coral reefs.
(*2 points; 1 point for correctly identifying a negative impact and 1 point for a correct description of that impact. Only the first answer is scored.*)

The impact must be environmental — economic and societal impacts are not acceptable. The impact and the description must be correctly linked; however, students can earn a point for a description without earning a point for an impact.

Impact	Description
Loss of habitat	• Elimination of a food source for marine life • Loss of breeding grounds for fish and bird species • Loss of shelter/hiding places
Loss of biodiversity or species diversity/richness/evenness	• Extinction or decrease in populations of marine organisms
Decreased protection of coastal areas from waves/storm surges	• Destruction of coastal habitats • Accelerated erosion of shoreline habitat
Loss of carbon sink	• Less carbon storage in coral reefs

(e) Identify one environmental problem (other than one due to ocean acidification or loss of coral reefs) that affects marine ecosystems on a global scale.
(*1 point; only the first answer is scored.*)

Any of the following are correct responses:
- Overfishing
- Destructive fishing practices (e.g., bottom trawling, drift netting)
- Increased ocean temperatures
- Introduction of invasive species
- Nutrient pollution/Eutrophication
- Hypoxia/Dead zones
- Garbage/plastic debris (e.g., Great Pacific Garbage Patch)
- Oil spills/Off-shore oil drilling
- Mercury pollution

Note: Ocean acidification and loss of coral reefs are not acceptable answers.