

Lesson: The Synthesis of Photosynthesis

Recommended Grade Level/Band: K-HS

Focus Area-Photosynthesis for energy transfer, cleaning air and water, plant structure

Focus Question(s)-

- How do plants clean the air and water through photosynthesis? Remove Carbon Dioxide (pollution) from it by “breathing it in” or absorbing it during photosynthesis and converting it to food for itself.
- How does carbon dioxide make the water unsafe for some animals? Turns it to Carbonic Acid and some organisms like corals, snails, zooplankton species and phytoplankton cannot grow and can dissolve in that carbonic acid.
- How does carbon dioxide make the air unsafe or pollute it? It builds up, trapping heat on the planet and causing some areas to get hotter, and causes the normal climate patterns to shift or change-like get hotter, colder, wetter or drier than historically usual, at different times during the year.
- How can plants (and algae) help to slow down the effects of carbon Dioxide? They absorb it and convert it to food for themselves and oxygen for us and other animals, thus cleaning the air and water and making the air and water safer.

Lesson/Activity Time Frame-

- 40 minutes (experiment has to run for about 30 minutes)

Materials Needed:

- 1 straws,
- 1 small bottle with a lid-100ml or less,
- Water,
- 1 bottle of phenol red,
- Water plants such as hydrilla or chara in container of water ,
- A sunny spot by a window or outside,
- Diagram showing photosynthesis with CO₂, water and sun being taken in by the plant and oxygen and sugar being made.

Key Words/Vocabulary

- Photosynthesis
- Climate
- Weather
- Plant
- Roots
- Stem
- Leaves
- Carbon Dioxide
- Oxygen
- Ocean Acidification

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■ Greenhouse Gas

Activity Summary

- Students will create a model of the air and the ocean in a bottle by adding additional carbon dioxide into a model system. Once they see the change by way of a color (pH) change, they will learn how plants (or algae) can reverse the amount of Carbon Dioxide (CO₂) in a system, thus mitigating ocean acidification and changes in climate.

Learning Objectives

- Actually see photosynthesis work
- Test
- Test hypotheses
- Learn about pH (older students)
- Learn about Ocean acidification
- Learn about impacts of CO₂ on climate
- Learn how planting plants or growing algae can help reverse some environmental issues we all face today

NGSS Alignment and Performance expectations

| Grade | NGSS Standards | Performance Expectations |
|-------|---------------------------------|--|
| K | K-LS1-1 K-ESS3-1 K-ESS3-3 | -Understand what plants and animals need to survive, show how humans can adapt their surroundings (using plants) to help survive, use a model to demonstrate interdependence, communicate solutions to reduce impacts. |
| 1 | 1-LS1-1. | -Use materials to design a solution to a human problem by mimicking how plants and/or animals use their external parts to help them survive, grow, and meet their needs |
| 2 | 2-LS2-1. | -Plan and conduct an investigation to determine if plants need sunlight and water to grow |
| 3 | 3-LS4-4. | -Make a claim about the merit of a solution to a problem caused when the environment changes and |

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| | | the types of plants and animals that live there may change |
| 4 | 4-ESS3-2 | -Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans. (Ocean acidification and acid rain can be natural process) |
| 5 | 5-LS1-1. 5-ESS2-1 | -Support an argument that plants get the materials they need for growth chiefly from air and water. -Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact |
| MS 6-8 | MS-LS2-3 MS-LS2-5. | -Develop a model to describe phenomena the cycling of matter and flow of energy among living and nonliving parts of an ecosystem. Evaluate competing design solutions for maintaining biodiversity and ecosystem services.* |
| 9-12 | HS-LS2-5. HS-LS2-7. | -Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere. -Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity. |

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Background Information (educator and/or student)

- Plants, a part of the biosphere, utilize Carbon Dioxide (CO₂) from the atmosphere or hydrosphere, water from the hydrosphere, nutrients from the geosphere (or lithosphere) and sunlight to perform photosynthesis during which those elements are converted into sugars that are food for the plant and plants release oxygen back into the atmosphere. This process not only provides food for the plants, but starts the transfer of energy from the sun and up the food chain and throughout the food web. Moreover, the process cleans CO₂ (a pollution) out of the air and water. Plant-like organisms called algae also remove CO₂ from the water through photosynthesis. A build-up of CO₂ in the air and water causes impacts such as warming of the globe due to the greenhouse affect and acidification of our oceans by creating carbonic acid. Plants and algae can be used to combat these impacts. This experiment demonstrates how plants can be used to remove CO₂ from water and air.

Preparation

- For single experiment or demonstration at the front of the room (suggested for younger students):
 - Gather 1 set of materials
- For duplicate experiments:
 - Set up desks so that students sit in teams of 4
 - Place 1 set of materials at each team station

Procedure

- For single experiment or demonstration at the front of the room (suggested for younger students):
 - Gather 1 set of materials
 - Invite 4 volunteers to the front of the room
 - Explain that we are making a model of the ocean and the air, whatever happens in our experiment in this water, something similar also happens in the air.
 - Give student 1 the phenol red, student 2 a straw, student 3 the bottle and student 4 wait until it is their turn.
 - Ask student 1 with the bottle to fill it $\frac{3}{4}$ way full with water
 - Then explain that this is water with normal, safe amounts of CO₂ in it. We are going to use the phenol red, which changes color according to how much CO₂ is in the water (or changes color based on pH for older students). Pinkish/red means normal (or “safe” or “basic” depending on age group), yellow means too much CO₂ (or “acidic”).
 - Ask student 2 with phenol red to add enough drops to turn the water pinkish-red (3-5 drops should suffice).
 - Hold the bottle up to show the class-ask what color it is and explain what that means again.
 - Then tell them that they will be adding extra CO₂ to the water. This will be a model of how we add extra CO₂ into the air and water by “polluting” the air and water through different activities we do such as driving cars, buying new stuff

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which is made in factories, using electricity and eating beef. All of these activities add a lot of CO₂ into the air and water.

- Explain that the burning of fossil fuels for these activities creates CO₂ as does us breathing (aka respiration). Therefore, if we blow bubbles into this water, it will add extra CO₂ into it!
- Ask student 3 with the straw to blow bubbles into the Pink water. Keep blowing until it changes color. Make sure all of the students can see the water clearly so they can see the change.
- Have a discussion about this, and explain again that this shows water with too much CO₂ in it (H₂O + CO₂), it has turned into Carbonic Acid (H₂CO₃)! That makes the water unsafe. Remember this is also a model of the air-although we cannot turn the air colors with phenol red, so assume that since this is a model of the air as well, whatever happens in this bottle, also happens in the air with regards to the amount of CO₂ is in it. Ask, if photosynthesis is real, and plants “breathe” in CO₂ during photosynthesis, then how do we remove the extra CO₂ from our model? Add plants!!!!
- Have the 4th student add lots of plants (pack them in) into the now yellow water in the bottle and put a lid on it and place it in the sun. Wait about 40 minutes and the water will turn pinkish again.
- Discuss with the class what this means. If CO₂ is a pollution in the air and water, what can we do to remove that CO₂ from the air and water in our schoolyard or at home? Plant plants-especially plants like trees and shrubs. The woodier the plant is, the more CO₂ it removes from the air. In the water, we can plant water plants, or whatever trees grow in the swamps in your area.
- For duplicate experiments:
 - Set up desks so that students sit in teams of 4
 - Place 1 set of materials at each team station
 - Assign roles to each student and walk them, step by step, through the experiment and discussion.

Assessment

- Pre and Post test

Extensions

- For older students, the lessons can be amplified by testing different variables, like placing some bottles with plants in the light and some in the dark. Rates of photosynthesis can be calculated by adding more plants in certain bottles and less in others and comparing times that it takes for the color to change. The photosynthetic rates of different species of water plants can be compared.
- [National Ocean Service Education: For Educators](https://oceanservice.noaa.gov/education/for-educators.html) (<https://oceanservice.noaa.gov/education/for-educators.html>)
- Schedule a hands-on virtual Sea and Me-Prevent a CO₂ Calamity class with Youth Environmental Alliance. www.youthenvironmentalliance.com

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Additional Links/Resources

- Contact Youth Environmental Alliance- [TAKE ACTION | Youth Environmental](https://www.youthenvironmentalalliance.com/take-action)
(<https://www.youthenvironmentalalliance.com/take-action>)

References

- [What is Ocean Acidification?](https://oceanservice.noaa.gov/facts/acidification.html) (<https://oceanservice.noaa.gov/facts/acidification.html>)
- [Understanding the basics of carbon dioxide - NOAA Research](https://research.noaa.gov/understanding-the-basics-of-carbon-dioxide/)
(<https://research.noaa.gov/understanding-the-basics-of-carbon-dioxide/>)
- [Photosynthesis - Wikipedia](https://en.wikipedia.org/wiki/Photosynthesis) (<https://en.wikipedia.org/wiki/Photosynthesis>) consult references in this article for more information