



**Your Carbon Footprint/Ocean
Acidification**

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Objective

Students will learn about how human activities (e.g. carbon emissions) affect the balance of the ocean, and how this influences organisms and their environment.

Standards Met: NGSS

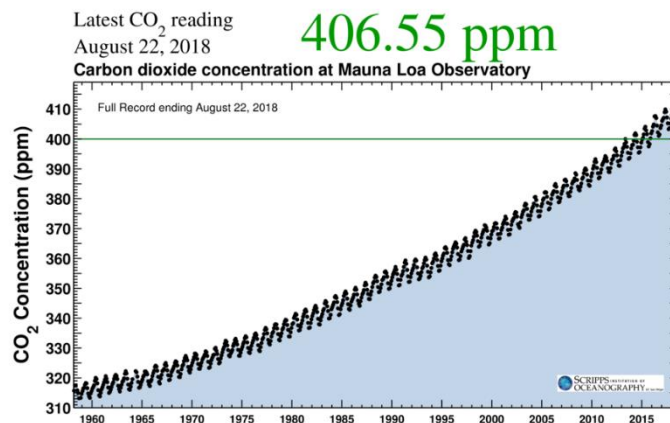
- *HS-PS1-6. Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.*
- *HS-LS2-1. Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.*
- *HS-LS2-7. Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity*

Use this lesson after introducing or to complement theory around pH.

Background

Oceans cover 70% of the Earth's surface, and provide a habitat and resources for many different species, including humans. When humans burn fossil fuels (oil, gasoline, coal), it produces greenhouse gases, mainly

consisting of large amounts of carbon dioxide (CO_2) which then dissolve into the seawater. These gases occur naturally, but human activities have caused them to rise beyond a natural level. This changes the ocean's composition and disrupts the lives of many marine organisms. For example, starfish, snails, and corals all have a hard outer shell made from calcium carbonate ($CaCO_3$), which is degraded by high levels of carbon dioxide. In addition, rising levels of these gases can affect the climate, causing extreme

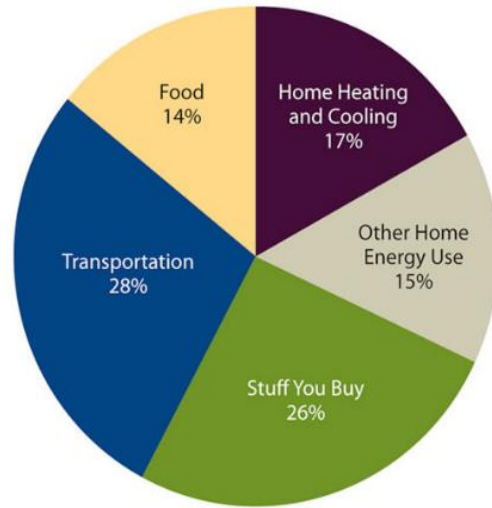




temperatures and natural disasters. As the climate warms and ice melts, floods can destroy animal and human habitats.

Every person has a carbon footprint, which refers to the amount of greenhouse gases produced because of your activities. Energy use, waste, diet, and many more things all contribute to your carbon footprint. Use this website to calculate your carbon footprint, and then brainstorm things you can do to lower it.

Where the Average American's Carbon Emissions Come From



Union of Concerned Scientists

Your Carbon Footprint

Calculate your carbon footprint here: <http://www.footprintcalculator.org/signup>

and discuss about the ways to lower your impact on carbon emissions. Examples:

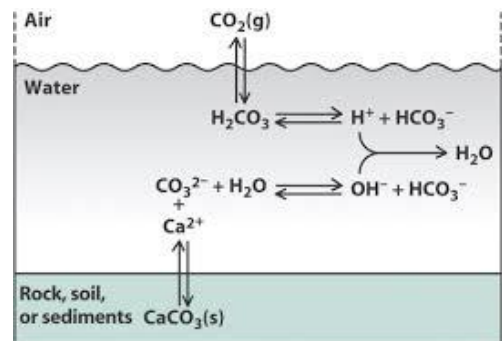
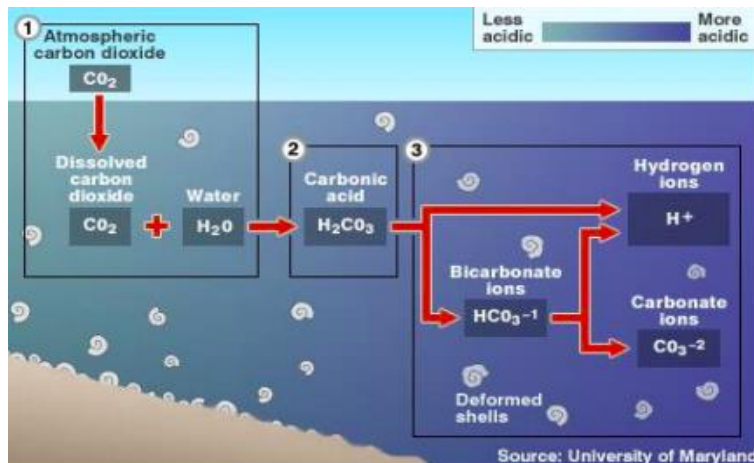
- Walk or ride your bike instead of using a car, or carpool/use public transportation
- Turn off lights when you're not using them
- Don't set your thermostat too high or low
- Add solar panels to your roof at home
- Reuse and recycle
- Minimize purchases of new products
- Reduce consumption of animal products
- _____
- _____

Ocean Acidification Lab

Carbon dioxide (CO_2) impacts the ocean by binding to water molecules and producing carbonic acid (H_2CO_3), which then dissociates into hydrogen ion (H^+) and bicarbonate (HCO_3^-) and carbonate (CO_3^{2-}).



pH refers to the concentration of H^+ ions, and it ranges from 1 - 14, with 7 being neutral. More H^+ ions means a lower pH, therefore being more acidic. pH is measured on a logarithmic scale, and a small change from 8.2 to 8.1 reflects about a 30% increase in acidity. This lowering of pH in the ocean is known as **ocean acidification**.



Ocean acidification dissolves organisms' like corals, shellfish, and mollusks that are made from calcium carbonate ($CaCO_3$). Before the industrial revolution, the ocean had a pH of 8.2. Currently, the ocean's pH is 8.0, and it is predicted to decrease to 7.8 in the next 80 years if we continue our projected CO_2 emissions. This seemingly small decrease of pH reflects a doubling in acidity!



Experimental part

Materials

- TUMS
- Vinegar
- Beakers
- Seawater (available in pet stores)
- Straw
- pH probe/test kit (affordable digital pH meter brand: Pancellent)

Procedure

Part 1: Have students bring in one solution from home that they would like to obtain the pH value. Record the pH values of each student's solution in a table.

Solution	pH

Discuss which solutions' pH values would be suitable to support living systems in the ocean, and which would be a hazard.

Part 2: Fill three beakers with 50 mL of seawater and mark each beaker as 1, 2 and 3. Use the pH probe to measure the initial pH of the seawater (measure only in one since the seawater is the same). Then, use the straw and blow into the beaker 1 for 5 seconds after which you should measure pH. Then use the straw and blow into the beaker 2 for 10 seconds and record pH. Finally, use the straw and blow into the beaker 3 for 20 seconds and record pH (you can do it in 10 seconds increments). Keep beakers for Part 3.

Initial pH	pH (Beaker 1)	pH (Beaker 2)	pH (Beaker 3)



1. Based on measured pH values and knowing that $\text{pH} = -\log[\text{H}^+]$ calculate concentration of H^+ in each sample.

2. What do you notice after introducing CO_2 into beakers?

Part 3: Prepare beaker with 50 mL of vinegar and measure pH. Add one TUM to each beaker from previous part as well as the one containing vinegar. TUMs are made from calcium carbonate, just like the shells of many marine animals. Wait 10 minutes and record what happens to TUMs in these solutions.

1. How does this relate to the impacts of CO_2 dissolution in the ocean?

Take Home Message

Human activities are influencing the ocean's chemistry by producing excessive amounts of greenhouse gases, and we can take measures to each reduce our carbon footprint.



Lesson adopted from:

[http://www.cisanctuary.org/ocean-acidification/PDFs-WorkshopPage/Hands_on_activities/Oceans Recipe for Success Lesson Plan.pdf](http://www.cisanctuary.org/ocean-acidification/PDFs-WorkshopPage/Hands_on_activities/Oceans_Recipe_for_Success_Lesson_Plan.pdf)

https://www.teachengineering.org/lessons/view/cub_footprint_lesson1

<http://www2.hawaii.edu/~himbed/forms/HIMB-Ocean-Acidification-Lab.pdf>

http://www.cisanctuary.org/ocean-acidification/PDFs-WorkshopPage/Hands_on_activities/OA_dry_ice_demo.pdf

http://www.cisanctuary.org/ocean-acidification/PDFs-WorkshopPage/Impacts%20of%20Carbonated%20Sea%20Water%20on%20Mussel%20and%20Oyster%20Shells_Oct_%202015.pdf

<http://www.globalstewards.org/reduce-carbon-footprint.htm>



TAKE ACTION - How can you reduce your carbon emission?

Recycling: If you recycle paper, it will be used again instead of cutting down trees and producing additional greenhouse gases.

Lab example:

<http://www.discovere.org/our-activities/single-activity-detail/Paper%20Recycling>

Reducing Energy Use: You can save energy by turning off lights (or using compact light bulbs), unplugging electronics, and even the color your house is painted can have an effect.

Lab example:

https://www.sciencebuddies.org/science-fair-projects/project-ideas/EnvEng_p012/environmental-engineering/can-the-color-of-your-house-reduce-your-energy-footprint#procedure

Reducing Water Use: Make sure to turn your sink faucet off when not using it, use a dishwasher (and don't rinse before loading) and shorten your shower times. You can even buy an adaptor for your faucet to save water, and test out which one saves the most!

Lab example:

https://www.sciencebuddies.org/science-fair-projects/project-ideas/EnvEng_p011/environmental-engineering/how-can-your-faucet-save-water#procedure

Ocean Health in the Media

Watch Zoey Deschanel talk about the problems caused by plastic pollution in the ocean.

<https://www.youtube.com/watch?v=KFvNQ2vIJFA>