



Mini-SAS

Objectives:

Students will be able to:

- Identify acids and bases
- Explore buffering of seawater and model CO₂ chemistry and seawater pH
- Create an experiment showing the relationship between dissolved CO₂ and acidity
- Use pH meters and indicators of acidity

Standards:

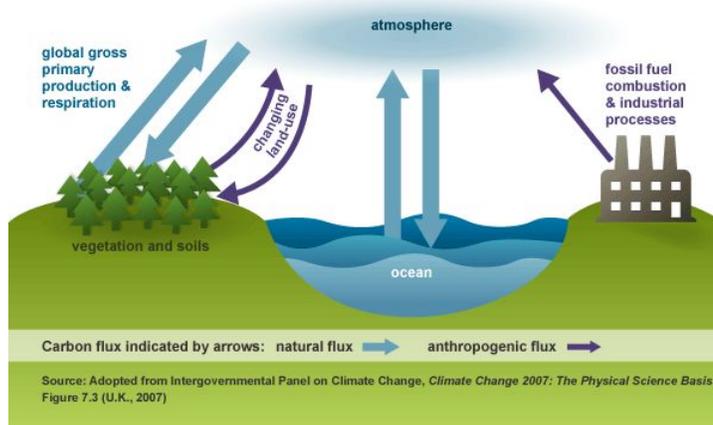
- **SC.912.L.17.16:** Discuss the large-scale environmental impacts resulting from human activity, including waste spills, oil spills, runoff, greenhouse gases, ozone depletion, and surface and groundwater pollution.
- **SC.912.E.7** - The scientific theory of the evolution of Earth states that changes in our planet are driven by the flow of energy and the cycling of matter through dynamic interactions among the atmosphere, hydrosphere, cryosphere, geosphere, and biosphere, and the resources used to sustain human civilization on Earth.

Overview:

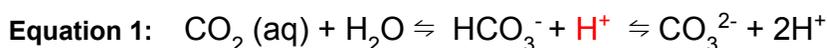
This goal of this lesson is to reinforce basic scientific principles taught in the classroom and applying them to increase students comprehension of ocean acidification, an environmental issue that is threatening marine ecosystems. Students will first learn about pH and buffering capacity of solutions such as oceans. They will explore the influence of humans and marine animals and plants on the acidity of the oceans. Lastly, students will learn how natural resources and the historical rise in the use of fossil fuels has contributed to increasing atmospheric CO₂ and ocean acidification.

Background:

Human related increases in anthropogenic carbon dioxide in seawater, termed ocean acidification (OA), comprises the delicate balance of marine ecosystems and marine life. OA is the ongoing decrease in pH of the Earth's ocean. A common misconception about seawater is that it is neutral, (pH = 7), but it is actually slightly basic (pH > 8). This change is largely driven by the **carbon cycle**, which is the flux of carbon dioxide (CO₂) between our oceans, terrestrial biosphere, lithosphere, and the atmosphere. As humans burn fossil fuels, CO₂ is released into the atmosphere.



As carbon dioxide accumulates in the atmosphere, it dissolves and reacts with ocean water that results in an increase in the hydrogen ion (H⁺) concentration in the ocean, and thus decreases ocean pH as follows:



- **HS-PS1-2:** Construct and revise an explanation for the outcome of a simple chemical reaction
- **SC.912.ESS3.A:** Natural Resources - Energy and fuels that humans use are derived from natural resources, and their use affects the environment in multiple ways.

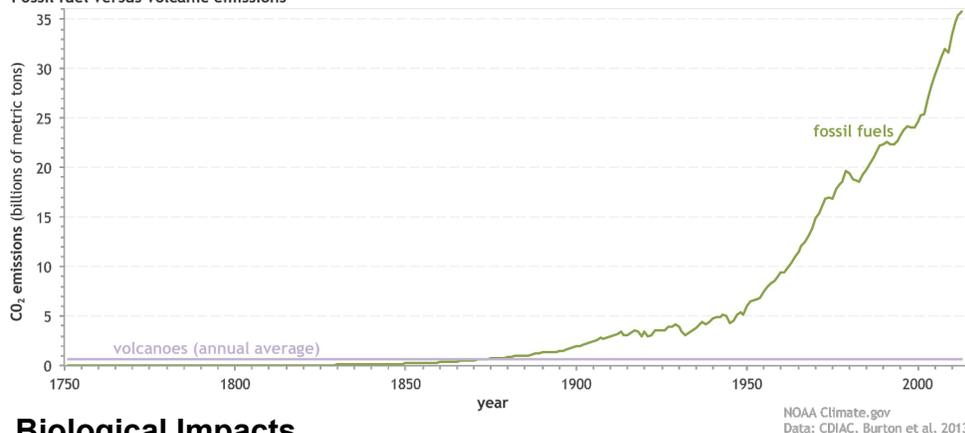
Vocabulary

- **Anthropogenic** - Environmental pollutants originating in human activities
- **Deforestation** - is the removal of a forest or stand of trees where the land is thereafter converted to a non-forest use.
- **Industrial Revolution** - a transition to new manufacturing processes in the period from about 1760 to sometime between 1820 and 1840. This transition included going from hand production methods to machines, new chemical manufacturing and iron production processes, the increasing use of steam power, the development of machine tools and the rise of the factory system
- **Photosynthetic** - a plant or other organism that gains energy by converting light energy to chemical energy that can later be released to fuel the organisms activities.
- **Calcium Carbonate** - is a chemical compound with the formula CaCO_3 , and is the main component of pearls and the shells of marine organisms, snails, and eggs.

Historical Context

Human activity releases 60 or more times the amount of carbon dioxide released by volcanoes each year. The burning of fossil fuels like coal, oil, and gas, but also cement production, **deforestation** and other landscape changes are known as **anthropogenic** sources of carbon dioxide. Since the **industrial revolution** began, more than 2,000 billion metric tons of carbon dioxide have been added to the atmosphere by anthropogenic activities¹.

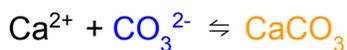
Fossil fuel versus volcanic emissions



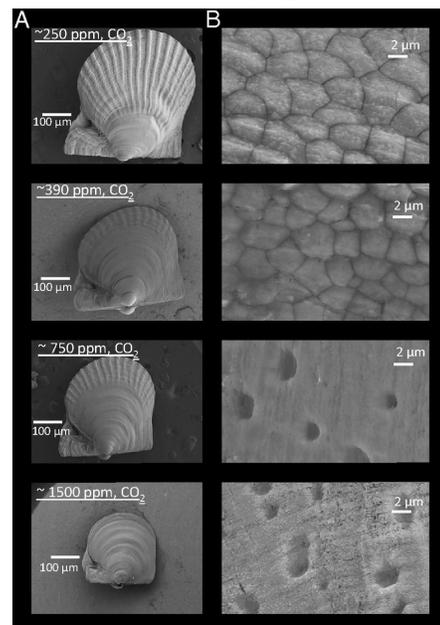
Biological Impacts

Ocean acidification is expected to impact ocean species to varying degrees. Excess carbon dioxide enters the ocean and reacts with water that decreases ocean pH as shown in equation 1 (i.e., makes seawater less basic), and lowers **carbonate ion** (CO_3^{2-}) concentrations. Organisms such as corals, clams, oysters, and some plankton use carbonate ions to create their shells and skeletons. Decreases in carbonate ion concentration will make it difficult for these creatures to form shells and skeletons because these parts are made of **calcium carbonate** (equation 2: CaCO_3).

Equation 2:



The images here show the sea shell *Argopecten irradians* grown in laboratory conditions with different levels of CO_2 . The increasing CO_2 concentrations reduced the size of the shells, thickness, hinge structure, and the outer shell has holes, pockmarks and crevices².

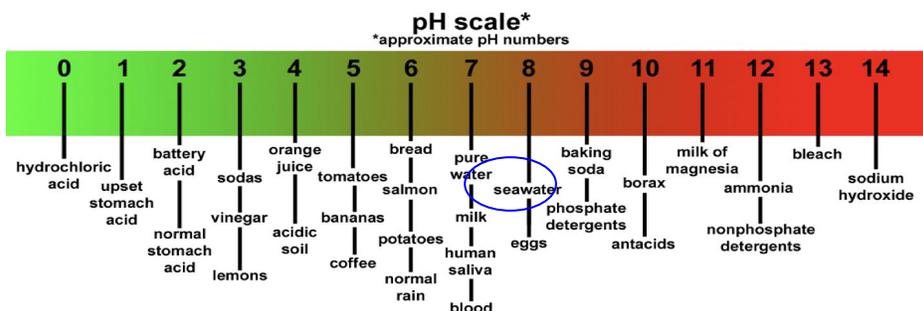


¹ Global Carbon Project <http://www.globalcarbonproject.org/carbonbudget/15/data.htm>

² Talmage, SC & Gobler, CJ (2010) Effects of past, present, and future ocean carbon dioxide concentrations on the growth and survival of larval shellfish.

- Teacher notes: (if needed use space below)

Introduction to Acids and Bases



What is an acid?

Acid definition: An acid is a substance that yields an excess of hydrogen ions (H^+) when dissolved in water.

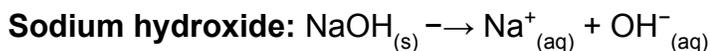


The term acid was first used in the seventeenth century; it comes from the Latin root *ac-*, meaning “sharp”, as in *acetum* or vinegar. Acids have long been recognized as a distinctive class of compounds whose aqueous solutions exhibit the following properties:

- A characteristic sour taste
- ability to change the color of litmus paper from blue to red
- react with certain metals to produce gaseous H_2
- react with bases to form a salt and water.

What is a base?

Base definition: a base makes hydroxide ions (OH^-) when dissolved in water.



The name base has long been associated with a class of compounds whose aqueous solutions are characterized by:

- a bitter taste
- a “soapy” feeling when applied to the skin
- ability to restore the original blue color of litmus that has been turned red by acids

How do we measure acidity?

The **pH** of a solution is a measure of the molar concentration of hydrogen ions in the solution and as such is a measure of the acidity or basicity of the solution. The letters pH stand for “power of hydrogen” and numerical value for pH is just the negative of the power of 10 of the molar concentration of H^+ ions.