

# The Dynamics of Carbon Dioxide in the Aquarium

Adapted from	https://petsintheclassroom.org/wp-content/uploads/2017/08/Ben nett-Colvin-Aquarium-6th-8th.pdf		
Pet: fish		Class: 6-9	

<b>Brief Overview:</b>	Lesson Breakdown
Students become citizen scientists, diving deep into	Lesson 1: What is Carbon
the mysteries of carbon dioxide (CO <sub>2</sub> ) within their	Dioxide?
classroom aquarium. Through hands-on	Lesson 2: Build a Carbon
experiments, and data analysis, they will explore the	Dioxide Reactor
complex relationship of carbon dioxide in the	Lesson 3: Test it Out!
aquatic environment.	Lesson 4: Sum It Up!
<b>Essential Question</b> How does CO2 act as both a building block and a danger within our classroom aquarium ecosystem?	

Subjects Science ELA Math STEM Art Other	Stem Connections Science: ecosystems, human interactions Technology: 3d design software (optional) Engineering: creation of carbon dioxide reactor Math: data gathering graphing, data analysis

# Performance Expectations/ Standards

### NGSS Standards:

**MS-LS1-A:** Structure and Function (understanding photosynthesis and respiration) **MS-LS2-C:** Ecosystem Dynamics, Matter and Energy in Living Systems (exploring interactions between organisms and the environment)

MS-ESS3-C: Human Impacts on Earth Systems (recognizing human activities affecting CO2 levels)

# CCSS Math and English Standards:

Math: MP.2, MP.4 Reason abstractly and quantitatively, model with mathematics English: W.7.1, W.8.1 Write arguments to support claims, write informative/explanatory texts

### I CAN statements

- identify the different roles of plants, fish, and decomposers in the aquarium ecosystem.
- design and conduct simple experiments to measure the impact of CO2 on plants, fish, and water chemistry.
- record and analyze data accurately, using charts and graphs to visualize changes over time.
- identify connections between CO2 levels, photosynthesis, respiration, and the overall health of the aquarium.
- use evidence from my experiment to construct a logical argument about my role in maintaining the aquarium's carbon balance.
- listen respectfully to different perspectives and engage in a constructive debate about CO2's impact.
- connect human activities to rising CO2 levels in our local waterways and their potential threat to aquatic ecosystems.
- brainstorm solutions and responsible actions to minimize CO2 pollution and protect the delicate balance of life in water.
- design and implement an "Aquarium Advocacy Project" to share my knowledge and inspire others to become responsible stewards of the environment.
- explain the complex relationship between CO2 and the aquarium ecosystem in a clear and informative way, using multiple communication formats.
- I can think critically and creatively, applying my knowledge of the carbon cycle to understand other environmental issues.

# Materials

Carbon Dioxide Exploring its Impact on the Environment and Aquariums - Presentation The Dynamics of Carbon Dioxide in the Aquarium - Student Worksheet Per group Empty plastic or glass bottle Balloon 1 cup of vinegar ½ cup of baking soda Funnel Assorted materials- two liter bottles, aquarium tubing, super glue, etc. Goggles (per student)

# Teacher Background What is Carbon Dioxide?

Carbon dioxide ( $CO_2$ ) is a naturally occurring gas composed of one carbon atom and two oxygen atoms. It is colorless, odorless, and slightly heavier than air.  $CO_2$  plays a crucial role in various biological processes, including:

- **Photosynthesis:** Plants and algae utilize CO<sub>2</sub> as a building block to create organic matter (sugars) through photosynthesis, a process also releasing oxygen.
- **Respiration:** All living organisms, including fish, plants, and decomposers, release CO2 as a byproduct of respiration, the process of converting energy from food.
- **Carbon Cycle:** CO<sub>2</sub> is constantly exchanged between the atmosphere, living organisms, and the oceans in a complex cycle known as the carbon cycle.

# CO<sub>2</sub> and its Effects on Ecosystems:

While CO<sub>2</sub>is essential for life, its concentration in the environment significantly impacts ecosystems:

- Increased CO<sub>2</sub>:
  - $\circ~$  Ocean acidification:  $\rm CO_2$  dissolves in water, increasing acidity and harming marine life.
  - Changes in plant and algal growth: Some species benefit from increased CO<sub>2</sub>, while others struggle.
  - Disruption of food webs: Changes in plant and algae productivity can affect the entire food chain.
- **Decreased CO<sub>2</sub>:** Lower CO<sub>2</sub> levels can limit plant growth and productivity, impacting the entire ecosystem.

# Sources of Carbon Dioxide:

- **Natural sources:** Volcanic eruptions, forest fires, and respiration of living organisms are natural sources of CO<sub>2</sub>.
- Human activities: The burning of fossil fuels like coal, oil, and gas is the primary human-caused source of CO<sub>2</sub> emissions.

**Implications for a Classroom Aquarium:** A balanced  $CO_2$  level is essential for plant growth and fish health.

- Excess CO<sub>2</sub>:
  - Can limit oxygen availability for fish, leading to stress and health problems.
  - Can promote algae growth, disrupting the ecosystem's balance.
- Insufficient CO<sub>2</sub>:
  - Can limit plant growth and productivity.
  - May impact the entire ecosystem's health.

Lesson 1: What is Carbon Dioxide?			
Time	Materials	Activity	
5 mins		Start with a "Whodunit" scenario: the fish in the aquarium are acting sluggish, and the plants seem pale. What's the culprit?	
		Introduce carbon dioxide (CO <sub>2</sub> ) as the mystery element.	
15 mins	<u>Carbon Dioxide</u> <u>Exploring its</u> <u>Impact on the</u> <u>Environment and</u> <u>Aquariums -</u> <u>Presentation</u>	Engage the class in a conversation about carbon dioxide. Stress that correct levels of both carbon dioxide and oxygen are vital to a healthy planet and to a healthy aquarium. Explain its dual nature: a building block for life through photosynthesis and a potential threat in excess.	
5 mins	<u>The Dynamics of</u> <u>Carbon Dioxide in</u> <u>the Aquarium -</u> <u>Student</u> <u>Worksheet</u>	Explain that in this activity they will produce pure carbon dioxide using baking soda and vinegar. They will use an endothermic chemical reaction and the resulting carbon dioxide caused by mixing baking soda and vinegar to inflate a balloon.	
20 mins	The Dynamics of Carbon Dioxide in the Aquarium - Student Worksheet Per group Empty plastic or glass bottle Balloon 1 cup ofvinegar ⅓ cup of baking soda Funnel Goggles (per student)	Review the instructions with the students and monitor their progress during the lab to ensure safety measures are being taken.	

Lesson 2: Build a Carbon Dioxide Reactor				
Time	Materials	Activity		

45 - 90 mins	The Dynamics of Carbon Dioxide in the Aquarium - Student Worksheet Assorted materials- two liter bottles, aquarium tubing, super glue, etc.	For this lesson, students will design and build a contraption that will produce carbon dioxide that can be added to the aquarium and used in an experiment to determine the effect of carbon dioxide on the aquatic environment. Allow students time to brainstorm on their own some ideas before asking them to share with a small group. In their small groups, they will decide which of the projects to present to the class. Guide the class to decide on one of the designs to build together.	
		This is an example of a Carbon Dioxide reactor described in the lesson: The Dynamics of Carbon Dioxide in the Aquarium . The author recommends the reactor be set to dose small amounts (1 bubble every 2 seconds) into the aquarium.	

Lesson 3: Test it Out			
Time	Materials	Activity	
10 mins	Carbon dioxide reactor	Set up the carbon dioxide reactor.	
10 mins	Thermometer Ruler pH stripsGather data daily for 1- 2 weeks. Have students take turns with the different data collections. <u>The Dynamics of Carbon Dioxide in</u> <u>the Aquarium -</u> <u>Student</u> <u>Worksheet</u>	Gather baseline data for the aquarium. Demonstrate for the students how to use the pH strip and explain that when there is an increase of CO2 in water the pH will decrease because when CO2 dissolves in water, a part of it reacts with water to become carbonic acid (H2CO3)	

Lesson 3	3: Test it Out	
10 mins		Allow the reactor to run for about an hour and have the students observe and record their data.
10 mins		

Lesson 4: Sum It Up!			
Time	Materials	Activity	
25 mins	<u>The Dynamics of</u> <u>Carbon Dioxide in</u> <u>the Aquarium -</u> <u>Student</u> <u>Worksheet</u>	Have the students graph the pH data on a bar or line graph, answer the analysis questions and summarize the experiment in the worksheet.	
20 mins		Conduct a class discussion about the project - what went well? What would they change if they were to do this lab again? How could what they learned be important to scientists? Why?	

# Differentiation

### For students who need additional support

- provide visuals and manipulatives to represent the carbon cycle.
- Offer sentence starters for arguments and scaffolded data analysis questions.

# For students who need an additional challenge:

- Have them research specific pond organisms and their unique roles in CO<sub>2</sub> exchange. Encourage them to propose solutions to local pond-related issues.
- Research and report on current technologies and initiatives tackling CO<sub>2</sub> pollution in aquatic ecosystems

Assessment				
Criteria	4 - Exemplary	3 - Proficient	2 - Developing	1 - Beginning
Data Table	All data is accurately recorded	Most data is accurately recorded	Some inaccuracies in data recording	Major inaccuracies or missing data in the data table
Graph	Graph is accurately constructed and	Graph is mostly accurate and well-constructed	Some inaccuracies in graph construction	Major inaccuracies or missing graph construction
Analysis Questions	Thorough and insightful responses demonstrating deep understanding of concepts and implications	Adequate analysis with some insightful points Clear understanding of concepts and implications	Superficial analysis with limited insight	Minimal or no analysis; demonstrates lack of understanding
Summary	Clearly identifies the main objective and key findings of the lab Presents the information accurately, reflecting understanding of the scientific concepts involved. Paragraph is organized logically and flows smoothly.	Key findings are presented and the information is presented accurately. Some understanding of the scientific concepts involved is included.	Some key findings are missing or are incorrect. Scientific understanding of the concepts is lacking	Key findings are not identified. No attempt at understanding the scientific concepts is included.

### Extension

- Research the role of CO<sub>2</sub> in climate change and its impact on different ecosystems.
- Investigate alternative energy sources that produce minimal CO<sub>2</sub> emissions.