The Carbon Cycle & The Great Barrier Reef

Unit: **Carbon Cycle** **Biology 1.3**	**Utah SEEd Standard / NGSS Performance Expectation Standard Bio. 3.1** Analyze and interpret data to determine the effects of photosynthesis and cellular respiration on the scale and proportion of carbon reservoirs in the carbon cycle. Emphasize the cycling of carbon through the biosphere, atmosphere, hydrosphere, and geosphere and how changes to various reservoirs impact ecosystems. Examples of changes to the scale and proportion of reservoirs could include deforestation, fossil fuel combustion, or ocean uptake of carbon dioxide. (PS3.D, LS1.C, LS2.B)	**Time:** **140-150 min** **2-3 class periods**

Access to all material for this lesson: Lesson Folder

Anchor Phenomenon	Great Barrier Reef is experiencing significant amounts of bleaching. GBR Video (Atmospheric carbon dioxide concentration has increased over the past six decades. (See graph picture)
Driving Question(s)	- Based on observations of the GBR, what is happening to it? Why? How? - What is the bleaching of coral? - How might these changes (bleaching) affect other living things in this ecosystem? How might these changes affect you? - What is the trend of carbon dioxide concentration? - Why might this trend be important to humans? And other living things? - Will this trend be harmful or helpful? Why? - Why has the carbon dioxide concentration increased over the past six decades?)
Performance Task	Through participation as a carbon atom in the Carbon game, students will investigate trends/patterns in CO2, temperature, and pH levels of the Great Barrier Reef and the causes of these changes in this ecosystem.

Lesson Summary:

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	Time	Guiding Question / Learning Objective	How are students answering the guiding question or meeting the learning objective?
Engage	10-15 min	Phenomenon  The Great Barrier Reef is experiencing significant amounts of bleaching. VIDEO of GBR	**SEP** – Students will use the before vs. after image and video to make some observations and initial questions that will be revisited later for analysis. **DCI** – Biogeochemical cycles of greenhouse gases/carbon cycle: The abundance of greenhouse gases in the atmosphere is controlled by biogeochemical cycles that continually move these components between the ocean, land, life, and atmospheric reservoirs. The abundance of carbon in the atmosphere is reduced through the seafloor accumulation of marine sediments and plant biomass. It is increased through deforestation, the burning of fossil fuels, and other processes. **CCC** – Students will make an initial claim for the cause and effect of GBR bleaching.
Explore	25-30 min per round (50-60 min)	Students will play two rounds of a Carbon Cycle game to determine the effects of the carbon cycle postindustrial. Carbon Cycle Student Handout Carbon Cycle Game Reservoir Stations	**SEP** – Students will analyze data that they collect during the game. They will compare round 1 (pre-industrial) to round 2 (industrial). **DCI** – Biogeochemical cycles of greenhouse gases/carbon cycle **CCC** – By comparing Round 1 (pre-industrial) to Round 2 (industrial), students will identify the cause and effect of the changes in these rounds on the overall carbon cycle.
Explain	20-25	Graph Analysis images and questions	**SEP- Students will analyze various graphs that represent changes in carbon dioxide emissions, temperature, and pH over time.** **DCI** – Biogeochemical cycles of greenhouse gases/carbon cycle **CCC** – Students will evaluate the variables involved in the ecosystem changes at the GBR. (Cause and effect)
Elaborate	15-20	Classroom discussion with a video afterward.	**SEP** – Students will revisit key concepts and evaluate evidence to make inferences based on new information learned. **DCI** – Biogeochemical cycles of greenhouse gases/carbon cycle **CCC** – Students will evaluate the variables involved in the ecosystem changes at the GBR. (Cause and effect)

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Evaluate	10-15	Students write a CER based on the driving question: “What is the connection of change in carbon dioxide, oceanic temperature, and pH of the ocean to the bleaching of coral?”	

Three Dimensions Focused on in This Lesson		
Disciplinary Core Idea: **NGSS Appendix E** • Photosynthesis and cellular respiration are key components of the global carbon cycle. • The abundance of greenhouse gases in the atmosphere is controlled by biogeochemical cycles that continually move these components between the ocean, land, life and atmospheric reservoirs. The abundance of carbon in the atmosphere is reduced through seafloor accumulation of marine sediments and accumulation of plant biomass and is increased through deforestation and the burning of fossil fuels as well as through other processes.	**Science and Engineering Practices:** **NGSS Appendix F** Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. Analyze data to identify design features or characteristics of the components of a proposed process or system to optimize it relative to criteria for success.	**Crosscutting Concept:** **NGSS Appendix G** **Cause and Effect** students understand that empirical evidence is required to differentiate between cause and correlation and to make claims about specific causes and effects. They suggest cause and effect relationships to explain and predict behaviors in complex natural and designed systems. They also propose causal relationships by examining what is known about smaller scale mechanisms within the system. They recognize changes in systems may have various causes that may not have equal effects.
Related Knowledge and Skills from Prior Grades		
Disciplinary Core Idea: **NGSS Appendix E** Plants use the energy from light to make sugars through photosynthesis. Within individual organisms, food is broken down through a series of chemical reactions that rearrange molecules and release energy.	**Science and Engineering Practices:** **NGSS Appendix F** □ Construct, analyze, and/or interpret graphical displays of data and/or large data sets to identify linear and nonlinear relationships. □ Use graphical displays (e.g., maps, charts, graphs, and/or tables) of large data sets to identify temporal and spatial relationships.	**Crosscutting Concept:** **NGSS Appendix G** In grades 6-8, students classify relationships as causal or correlational, and recognize that correlation does not necessarily imply causation. They use cause and effect relationships to predict phenomena in natural or designed systems. They also understand that phenomena may have more

Sunlight is captured by plants and used in a reaction to produce sugar molecules, which can be reversed by burning those molecules to release energy.	□ Distinguish between causal and correlational relationships in data. □ Analyze and interpret data to provide evidence for phenomena. □ Apply concepts of statistics and probability (including mean, median, mode, and variability) to analyze and characterize data, using digital tools when feasible. □ Consider limitations of data analysis (e.g., measurement error), and/or seek to improve precision and accuracy of data with better technological tools and methods (e.g., multiple trials). □ Analyze and interpret data to determine similarities and differences in findings. □ Analyze data to define an optimal operational range for a proposed object, tool, process or system	than one cause, and some cause and effect relationships in systems can only be described using probability.

Connections to Mathematics and ELA/Literacy Standards

ELA/Literacy Standards: Students will use various technology and media in order to build their skills in research and information gathering. (Standard 4.1: Analyze & evaluate photography, videography, and audio in journalism (e.g., emotional connection, how multimedia elements enhance text, reader response, storytelling quality of the photo).	**Mathematics Standards: Students will analyze chemical formulae, graphs, charts, and quantitative/qualitative data in order to make inferences about causes and effects of the changes happening in the GBR ecosystem.** (Standard SI.MP.4 Model with mathematics. Apply mathematics to solve problems arising in everyday life, society, and the workplace. Make assumptions and approximations, identifying important quantities to construct a mathematical model. Routinely interpret mathematical results in the context of the situation and reflect on whether the results make sense, possibly improving the model if it has not served its purpose.)

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Materials

Handouts	Lab Supplies	Other Resources
Carbon Cycle Game: Data Sheet Carbon Cycle Game: Station cards (.docx) Carbon Cycle Game: Station cards (gdoc) CER chart	8 six-sided dice	Teacher notes & game directions Carbon Cycle Teacher Slides GBR Video Ocean acidification video

ENGAGE

Based on observations of the GBR, what is happening to it and why/how?
What is the bleaching of coral?
How might these changes (bleaching) affect other living things in this ecosystem? How might these changes affect you?

Students will answer and meet the learning objective by:

a. Looking at a Before vs. After picture of a part of the coral reef
b. Watching a video on the Great Barrier Reef

Great Barrier Reef

1) Students Do: See/Think/Wonder
2) **Slide 2**: Based on the picture, students will write down what they see, think, and wonder.
3) Teachers will guide students in discussing their observations and questions, which may be documented on post-it notes and/or class board/jam board-related technology.
4) **Slide 3**: Students will watch a short video and record their observations. *They should be advised to listen to*

Teacher Tips

ELL and literacy strategies – support students who struggle with the writing component through individual discussions (as needed).

Possible guiding questions:

- What do you notice about the difference between the coral "before" and "after?"
- What are the benefits of the Great Barrier Reef?
- What is happening to the Great Barrier Reef?
- Why and How is the Great Barrier Reef changing?
- What is the possible prognosis of the Great Barrier Reef?

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what the reef is like, what is found there, who benefits, whether there are any changes, etc. *a) GBR Video* 5) Teachers will guide students in discussing their observations and questions, which may be documented on post-it notes and/or class board/jam board-related technology. TEACHER SAY: a) On your own, write down what you see, think, and wonder b) Write down the S/T/W about the "Before vs After" picture. c) Write down at least 1-2 Wonders you have about this picture. d) Be prepared to share and discuss with your group/class i) Observations ii) Questions- what do you want to know about these pictures?	• How do these changes affect the organisms that live in the Great Barrier Reef? • How might these changes affect us? Ensure the video is up and ready to start before the lesson starts to skip the commercials and avoid tech issues.

EXPLORE

Based on observations of the GBR, what is happening to it? Why? How?
What is the bleaching of coral?
How might these changes (bleaching) affect other living things in this ecosystem? How might these changes affect you?
Students will compare round 1 (pre-industrial) to round 2 (industrial) and the effects on the carbon cycle. They should be able to identify significant changes; for example, burning fossil fuels results in more carbon in the atmosphere and, subsequently, more that is absorbed into the oceans.

Carbon Cycle Game Data Sheet Carbon Cycle Game Reservoir Stations 1. When students come into class, hand out the student recording sheets. Have them read through the introduction and instructions. 2. Assign students to the different reservoirs using the table in the teacher's notes. Have students move to those stations. 3. Explain that they will be modeling the motion of carbon atoms through the Carbon Cycle but that they will not be initially assigned to "Marine Sediments and Rocks" or "Deep Ocean." Explain that >99% of the Earth's carbon is in rocks and sediments. To play this game, we focus only on the mobile carbon in the carbon cycle. 4. Guiding Students through Activity: 5. Ensure students record every role, including when they remain in a reservoir. 6. Students will get "stuck" in certain reservoirs and may think they have done something wrong. Encourage them to follow the instructions. 7. When students have filled their recording sheets, have them return to their seats to draw their concept maps indicating flux mechanisms as arrows and reservoirs as bubbles.	**Teacher Tips** **Teacher notes** ELL and literacy strategies: Word wall vocabulary: • Carbon • Reservoir • Sink • Flux mechanism • Terrestrial vegetation • Soil • Atmosphere • Surface ocean • Marine biosphere • Fossil fuels • Deep ocean • Rocks

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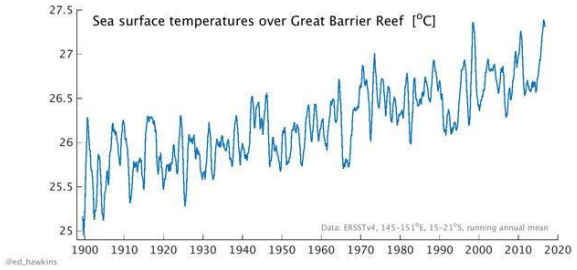
8. When students have completed their concept maps, change the Reservoir cards to the Round 2 set. Assign students to the reservoirs using the table in the teacher's notes and have them repeat the process. 9. When students have completed Round 2, make sure they make a new concept map and write a paragraph or sketch a Venn Diagram comparing the two concept maps. 10. Discuss students' observations with the whole class. Assessment: 11. Students' concept maps should reflect their record sheet. 12. Their comparative paragraphs or Venn Diagrams should clearly show how the pathways differed in the two rounds.	

EXPLAIN

Gallery Walk activity: During this activity, separate students into groups of 6 (1:4, 2:5, 3:6) Have students from each group become "experts" on one of the graphs provided in the student worksheet by answering the guiding questions provided with each set. Students will be given large poster boards or butcher paper to design a model of what they have learned in their group. Have students "gallery walk," looking at each group's work and discussing what they see with their groups, allowing them to connect the three groups and bring understanding to how these things all work together. Ocean/Sea Temperature Change  Ocean Ph Value	**Teacher Tips** Differentiated instructions – Group students based on their proficiency levels and provide appropriate challenges and support for each group. For struggling students, offer additional guidance and scaffolding to help them interpret the data and draw conclusions. Allow flexible grouping where students can move to different groups or stations based on their physical or comprehension levels or interests. Offer optional extension activities for students who finish early or excel in data analysis. These could include creating their own charts, conducting further research, or presenting their findings to the class.

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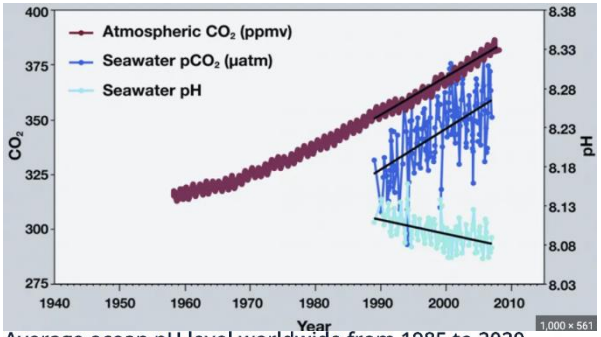
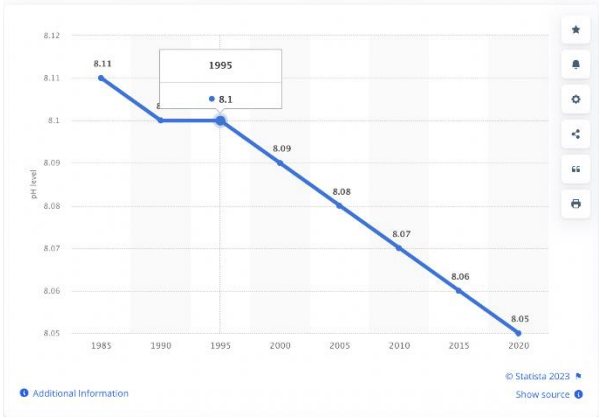


Average ocean pH level worldwide from 1985 to 2020



ELABORATE

- How does the burning of fossil fuels affect bleaching in the population of the Great Barrier Reef?
- How can we build a connection to the Co2, oceanic temperature, and the pH balance of the ocean?
- How does bleaching affect the Great Barrier Reef ecosystem?
- How can a small change to the burning of fossil fuels significantly affect the carbon cycle and, ultimately, the Great Barrier Reef?
- In this video, you will be able to determine how these are all connected and why these are important elements to understanding the cause of bleaching in the Great Barrier Reef.

Teacher Tips

Show the video after allowing students to make the connections between concepts and giving a chance for classroom discussion, staying on task within the time limit.

Ocean acidification video

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EVALUATE

Students will complete the following: 1. Identify the question regarding the phenomenon 2. State your claim that answers the question 3. Provide evidence that supports your claim 4. Justify how or why your evidence supports the claim 5. Include any diagrams or images that help you explain or support your claim Use CER chart to fill out the above information.	**Teacher Tips**

POSSIBLE EXTENSION / ALTERNATIVE ADAPTATIONS

For further exploration of the carbon cycle, see this carbon cycle activity from the Global Learning and Observations to Benefit the Environment (GLOBE) program.

This lesson was created by Bryan Holder, Mikell Sanderson, & Mary Lamoreaux

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