



THE GLOBE PROGRAM
 A Worldwide Science and Education Program



Biosphere • Carbon Cycle
 Carbon Cycle Introduction



Carbon Cycle Introduction

Read the module content and take the test that follows to earn the GLOBE Biosphere: Carbon Cycle certificate.


Biosphere • Carbon Cycle
 Introduction





- A. Overview**
- B. Learning Objectives
- C. What is the Biosphere?
- D. What is the Carbon Cycle?
- E. Why Collect Carbon Cycle Data?
- F. Introductory Activities
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Overview

This module...

- teaches why carbon is an important element in ecosystems and how it cycles through ecosystems.
- demonstrates how carbon is stored in and transferred between the biosphere, geosphere, atmosphere, and hydrosphere.
- explains how humans have disrupted the natural carbon cycle, including rates of transfer between spheres.
- explains how increases in atmospheric CO₂ impact climate.
- highlights four introductory Learning Activities.



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Learning Objectives


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Learning Objectives

After completing this module, you will be able to:

- diagram the major pools and fluxes of the carbon cycle at a global scale.
- provide examples of the role of humans in the global carbon cycle.
- explain how carbon is stored in and passed between living & non-living things in terrestrial ecosystems.
- describe two ways in which environmental conditions impact carbon flows through ecosystems.

Estimated time to complete module: 2 hours



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The Biosphere

The Biosphere is comprised of all living things on Earth. GLOBE has several ways to explore and measure components of the biosphere through investigations about one of the most fundamental elements for life on Earth – carbon. Carbon also plays a critical role in regulating the Earth's climate system.


Through the burning of fossil fuels and land use change, humans have disrupted the carbon cycle and are now the dominant cause of global climate change.

The GLOBE Carbon Cycle Project consists of four major categories:

- (1) Introductory Learning Activities
- (2) Classroom experiments (Plant-A-Plant)
- (3) Field Measurements (Protocols)
- (4) Modeling



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Carbon: A building block of life


- The most abundant element in living things
- Accounts for 45-50% of the total mass of the biosphere
- Also present in the Earth's atmosphere, soil, oceans, and crust



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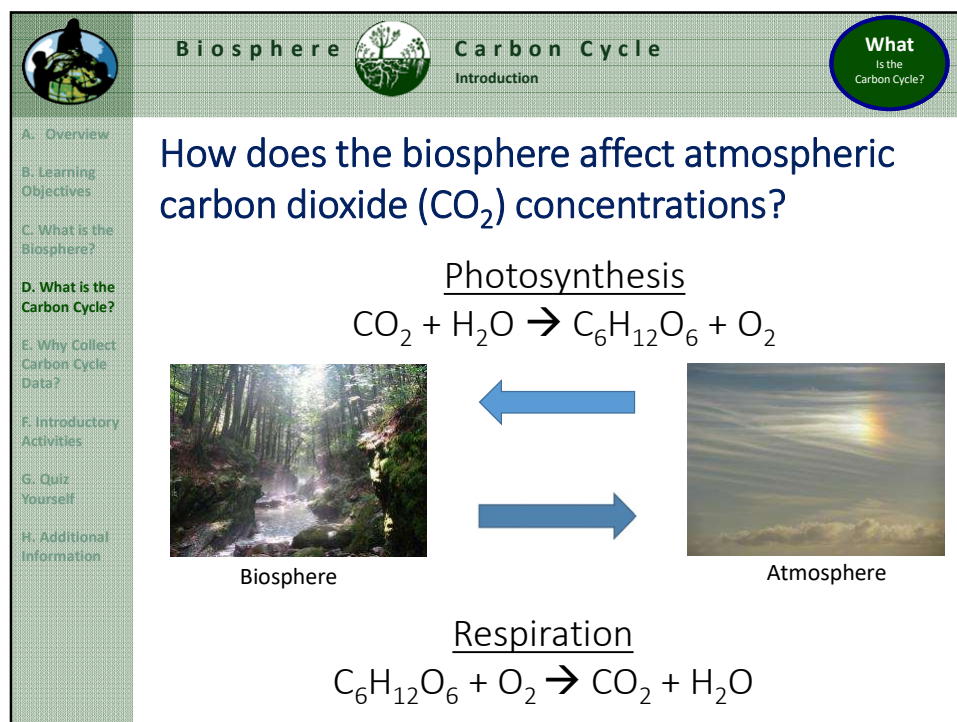
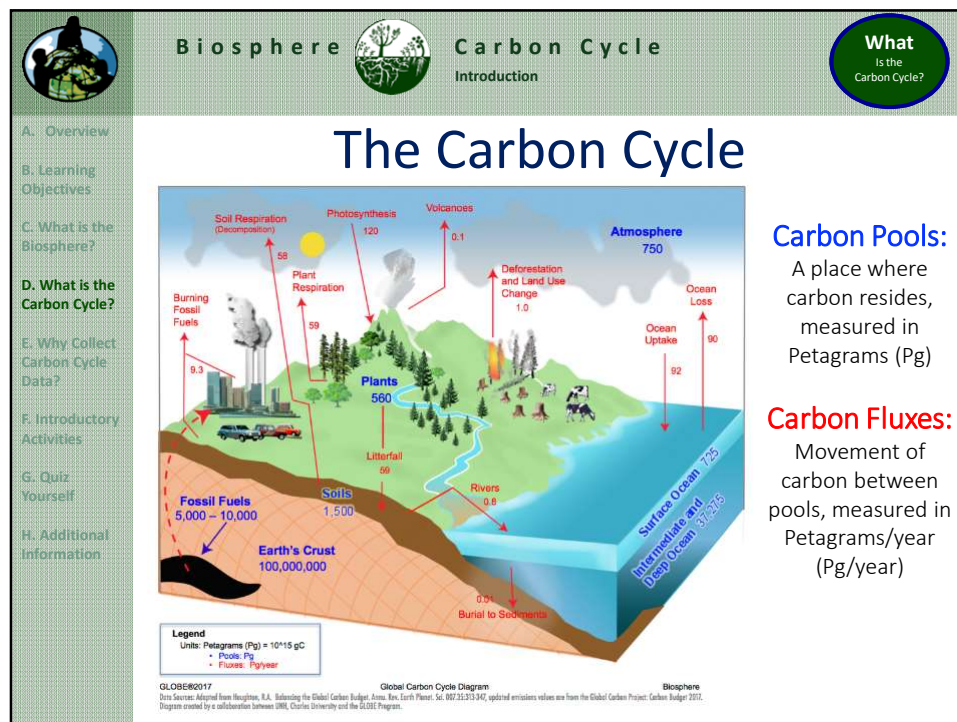
G. Quiz Yourself

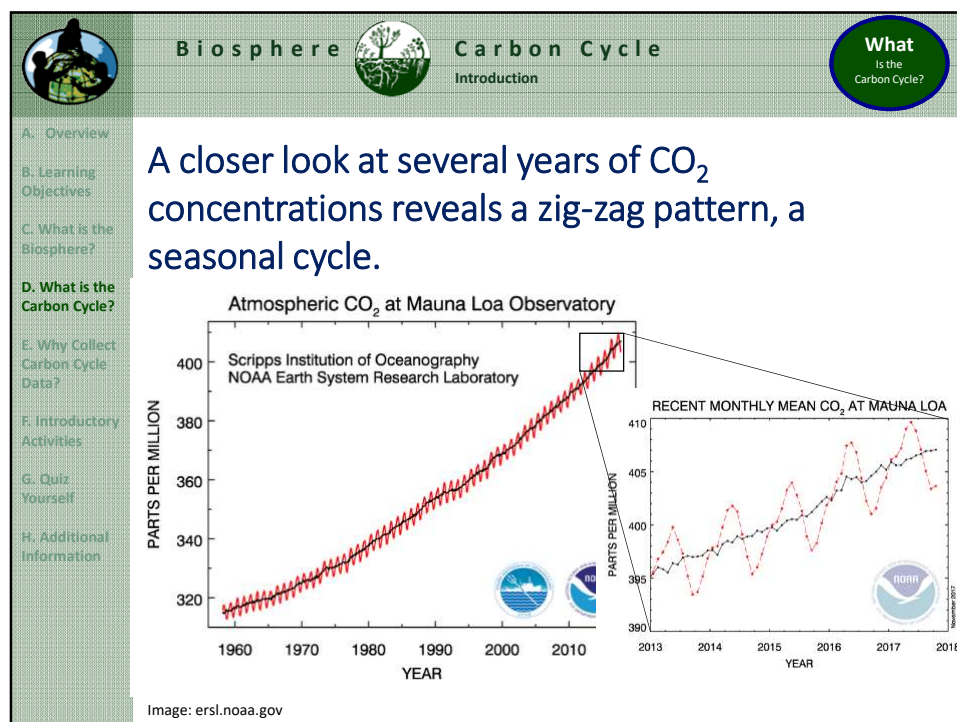
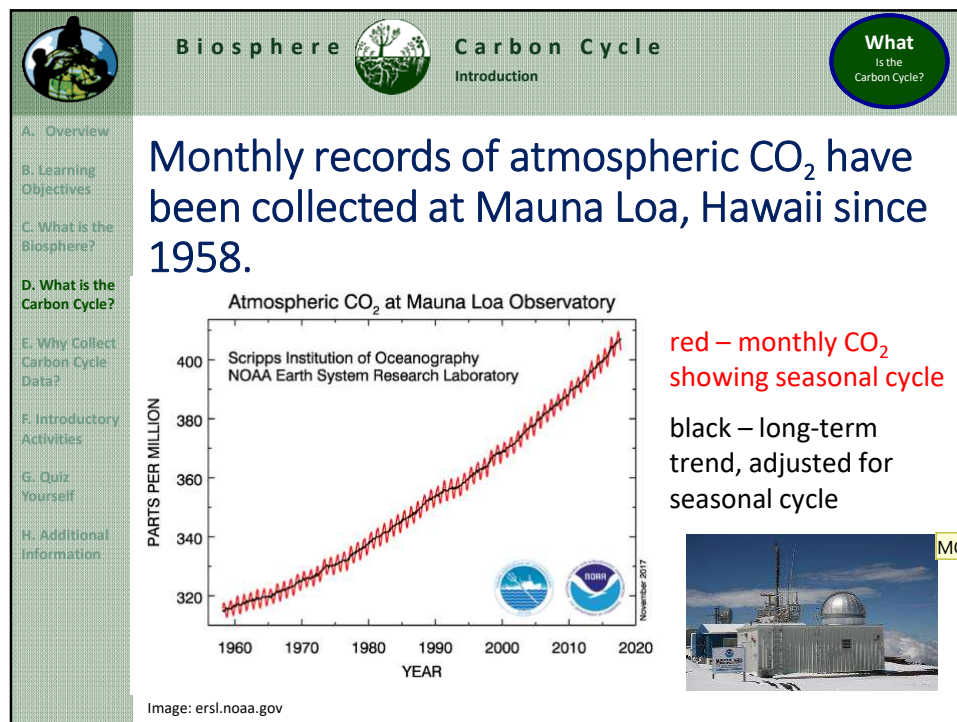
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What is the Carbon Cycle?

The global carbon cycle characterizes the movement of carbon between Earth's spheres. It is a key regulator of Earth's climate system and is central to ecosystem function. Rising CO₂ is the dominant contributor to climate change. Understanding how ecosystems cycle and store carbon is key to understanding solutions to climate change.

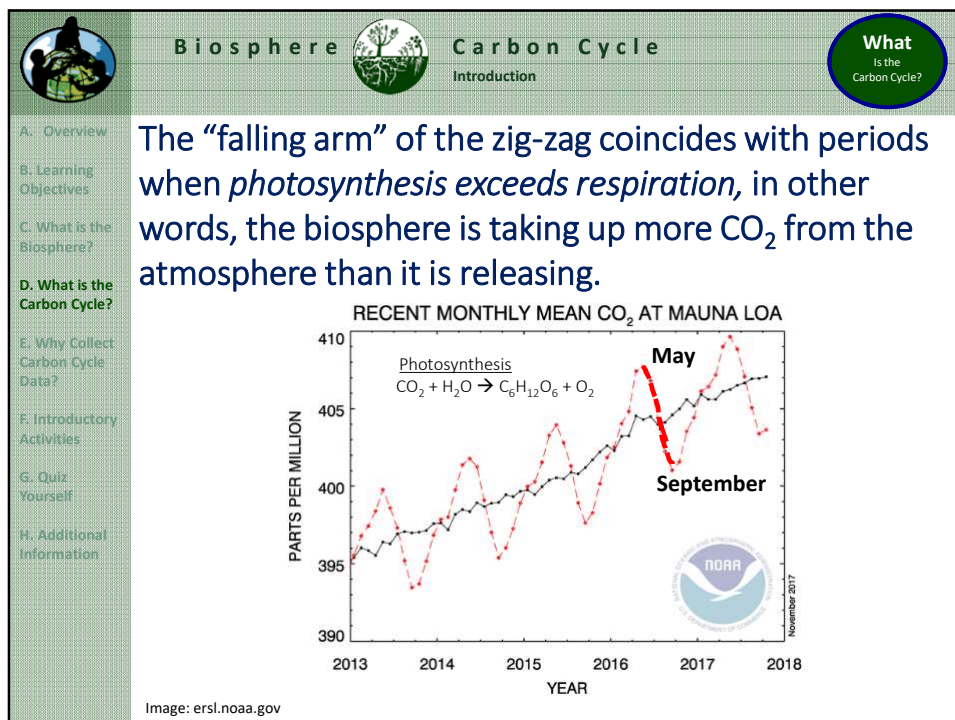
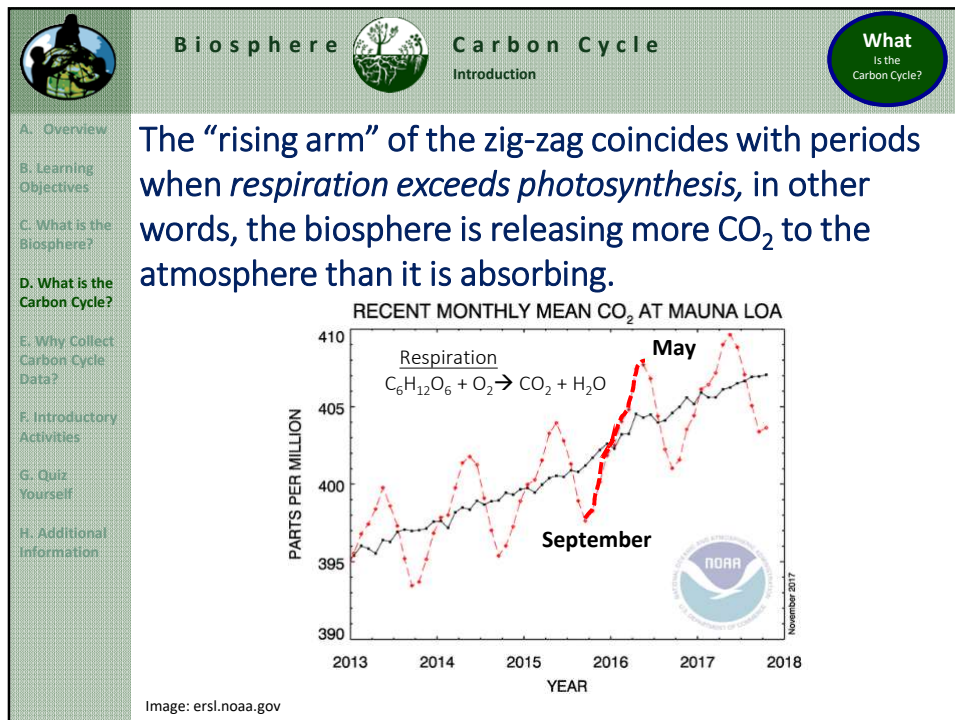




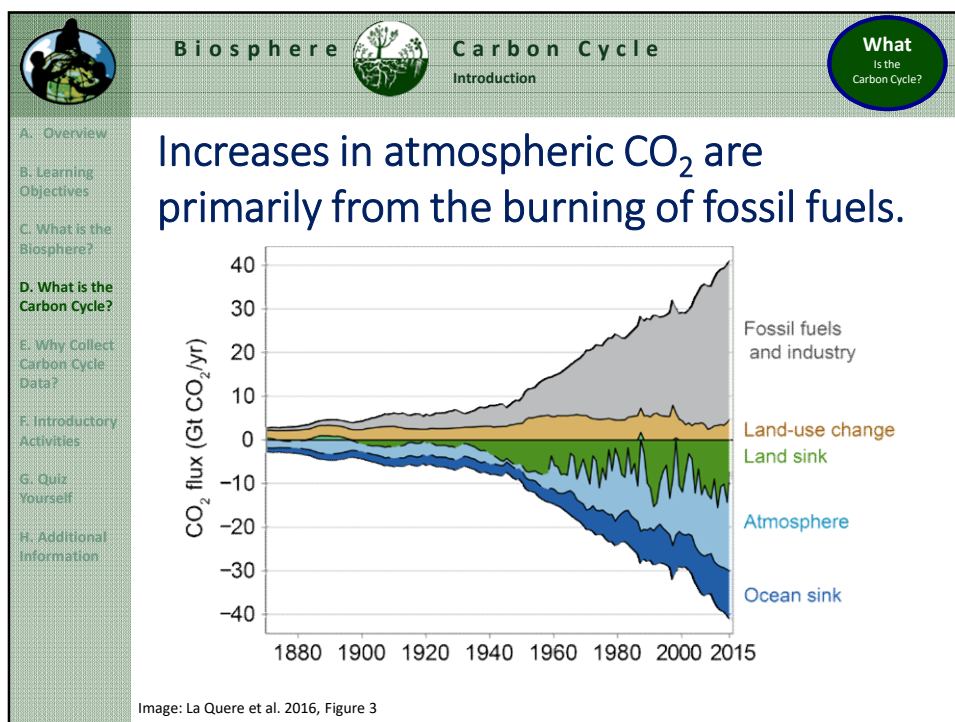
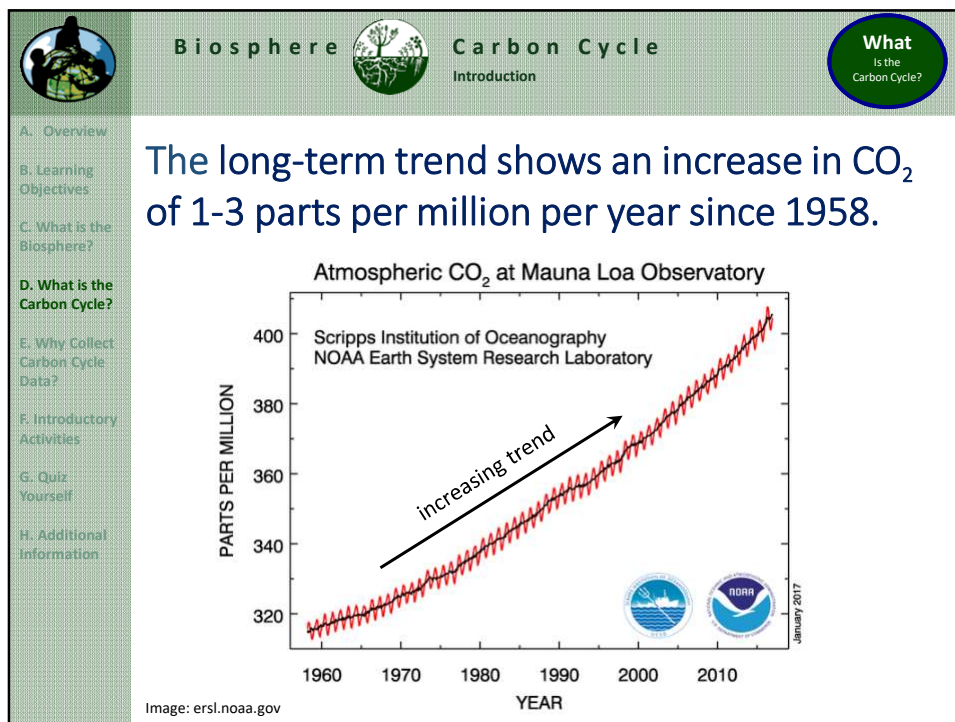




Snímek 9

MOU1 Image from:
<https://research.noaa.gov/News/NewsArchive/LatestNews/TabId/684/ArtMID/1768/ArticleID/10061/Ca>
Microsoft Office User; 21.03.2018







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Fossil fuels come from organic material that was buried and deposited millions of years ago.



Link to video if it does not play in PowerPoint:
<http://earththeoperatorsmanual.com/feature-video/earth-the-operators-manual>



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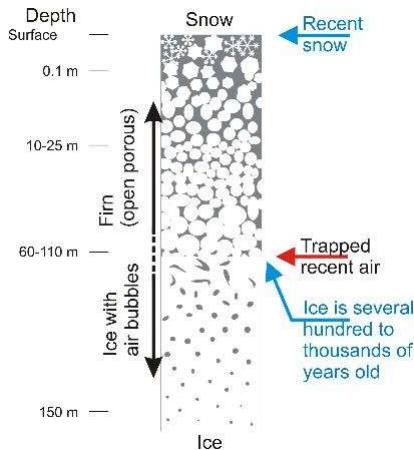
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Ice cores trap ancient atmosphere in tiny bubbles.




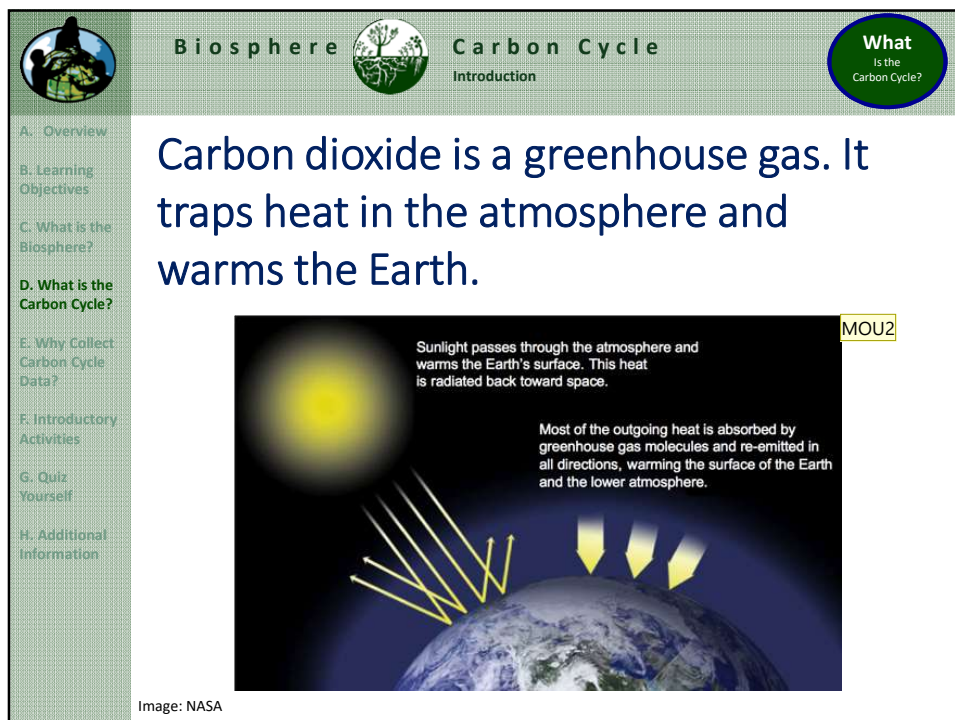
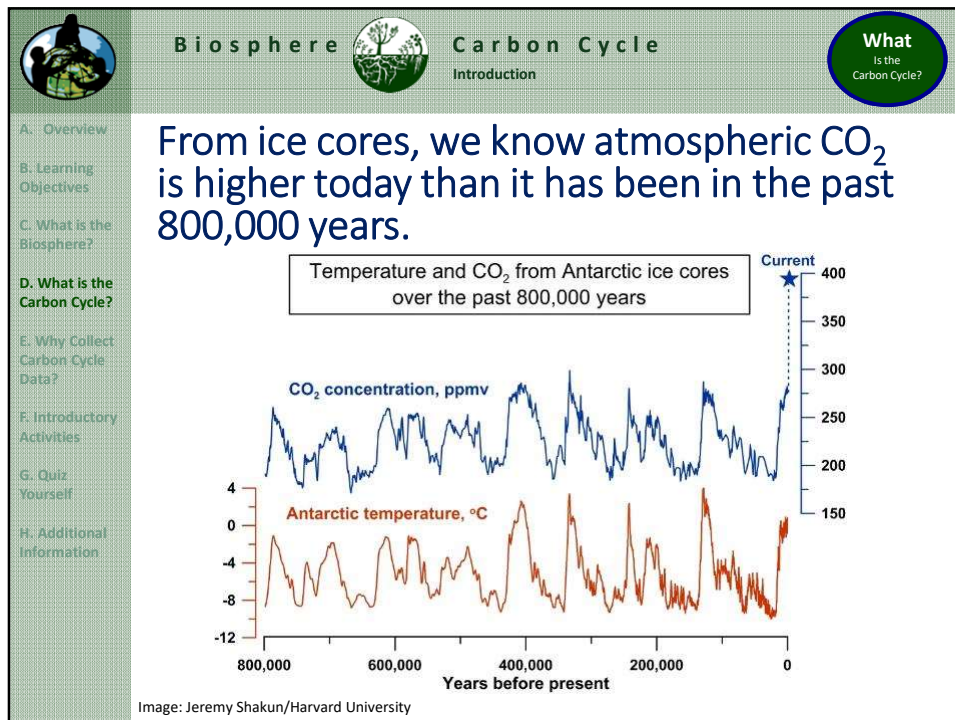


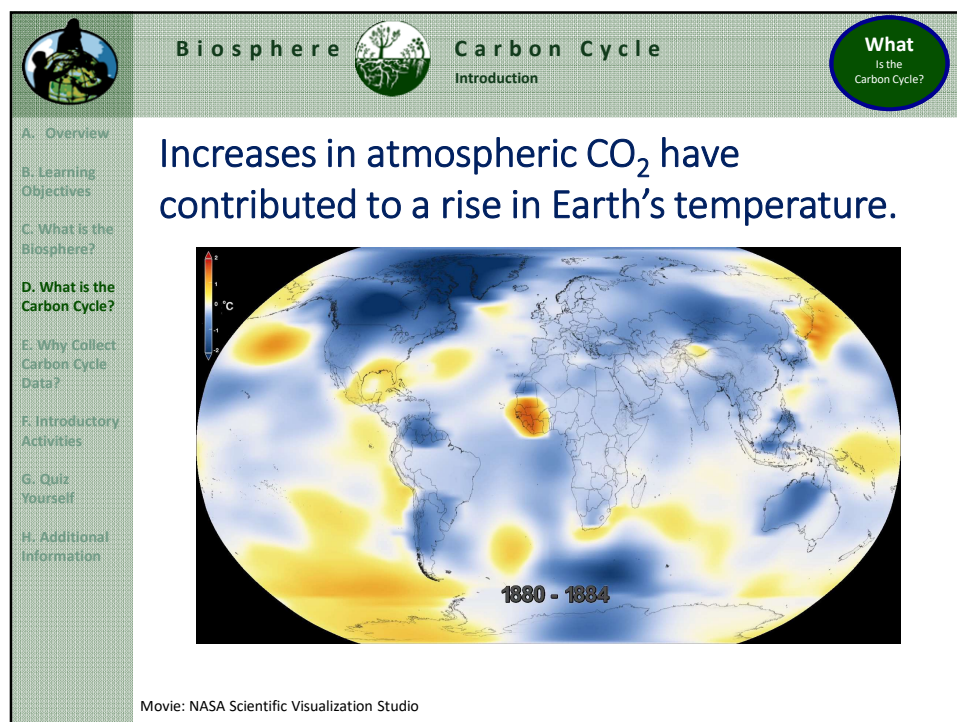
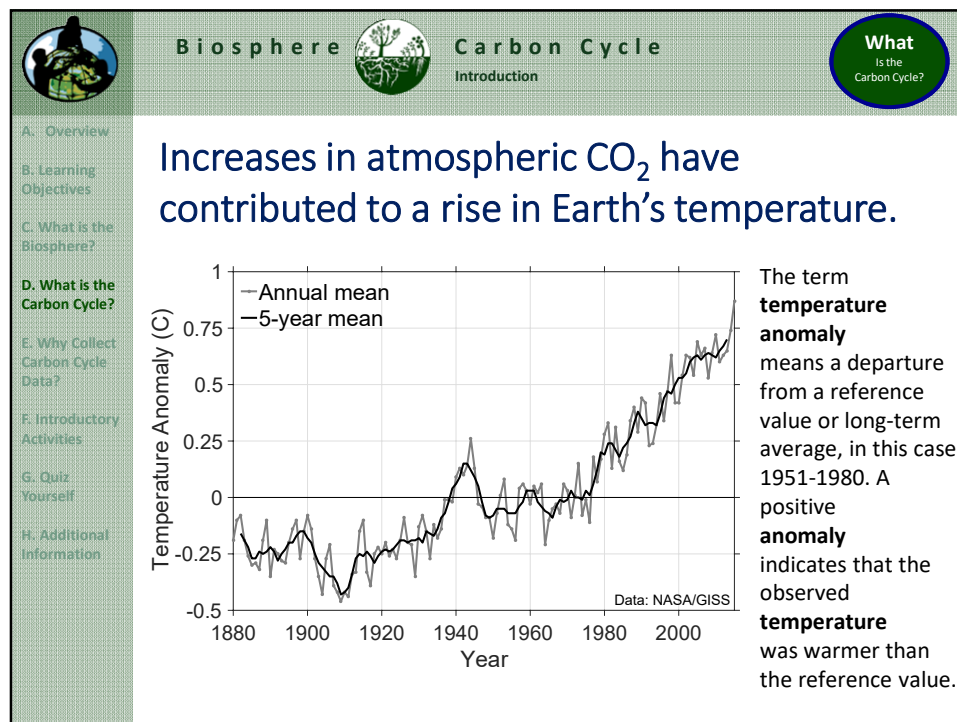
Image: Bernhard Bereiter


Image: Niels Bohr Institute




Snímek 18

MOU2 Microsoft Office User; 21.03.2018





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Why Collect Carbon Cycle Data?

The carbon cycle is no longer in balance due to human activities, specifically burning fossil fuels and land use change. CO₂ concentrations in the atmosphere are over 40% higher than the natural range over the past 800,000 years.





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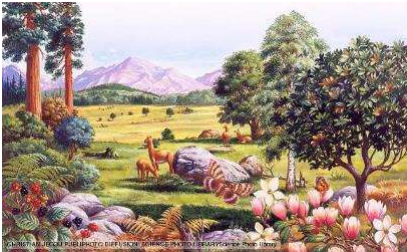
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Why Collect Carbon Cycle Data?

The last time in Earth's history CO₂ levels were this high was over 3 million years ago, during the mid-Pliocene Warm Period. The increase in atmospheric CO₂ occurred over thousands of years. Sea level was 5-20 m higher, global air temperatures were 4°C warmer, and global sea surface temperatures were 2°C warmer. Today, we are increasing atmospheric CO₂ at a rate faster than we've ever seen in the geologic record.





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Why Collect Carbon Cycle Data?

Scientists collect carbon cycle data to understand how terrestrial ecosystems will respond to warmer temperatures and higher CO₂. Carbon cycle data collected with GLOBE will contribute to a better understanding of the relationship between carbon storage in plants and surface climate.








Photo: GLOBE UCAR Team

Photo: Czech Republic Carbon Cycle Team



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Your measurements can help scientists!

They can:

1. help local scientists see how changes in the landscape are affecting carbon storage in their region.
2. help scientists improve on the ground estimates of current carbon storage.
3. be used as a validation method for satellite estimates of carbon storage.



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Introductory Activities


The GLOBE Carbon Cycle materials include learning activities that introduce students to systems thinking, carbon, and the carbon cycle.

If these concepts are new to your students, they are highly recommended prior to conducting field protocols or modeling activities. The activities include:

1. **Paperclip Simulation:** introduction to systems thinking and using the '1-box model'
2. **Carbon Cycle Adventure Story:** follow a carbon atom through the carbon cycle
3. **Carbon Travels Game:** follow a carbon atom as it travels through the Earth's carbon pools
4. **Getting To Know Global Carbon:** learn the basics of the carbon cycle through diagrams



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Introductory Activities




[Paperclip Simulation](#) - Introduction to Systems Thinking (60 minutes + 30 math extension).

Student Outcomes:


- Simulate a basic system
- Collect, record, and analyze data
- Create a 1-box model to learn modeling and system terms
- Manipulate variables to obtain an expected outcome

Materials:

- Simulation materials: paperclips, bell, signs, and roles
- Class Data Table (paper OR .xls) and Projector AND/OR Whiteboard/large paper with markers
- *Student Worksheets & Paper Clip Simulation Data Table*



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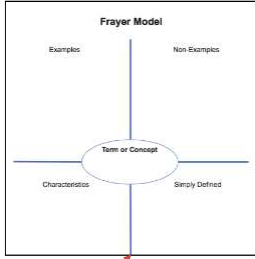
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What is a System?


Definition: A collection of interconnected parts that function as a complex whole, through which matter cycles and energy flows.

Why does GLOBE use a 'systems thinking' approach to understand the Carbon Cycle?


1. Systems are an important unifying concept across the K-12 curriculum.
2. The actual carbon cycle is extremely complicated. Simplifying it as a system that focuses on the most important elements can help us understand why the atmosphere is changing and what it might look like in the future.



**Use the [Freyer Model template](#) to help students define the word 'system'



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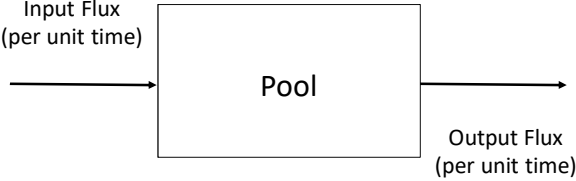
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Modeling Systems with the 1-Box Model

The 1-box model represents an individual component of a system. It introduces concepts like inputs, outputs and residence time and shows how these can produce particular patterns of change over time.


In the GLOBE Carbon Cycle Learning Activities, students use the 1-box model to diagram and manipulate movement of matter through systems.



*A pool can also be referred to as a stock or reservoir, a flux can also be referred to as a flow.



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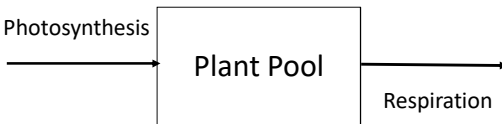
Modeling Systems with the 1-Box Model


The 1-box model can be used to represent many different systems.

In the paperclip factory simulation to understand the components of a system:




Or to model parts of the Global Carbon Cycle:





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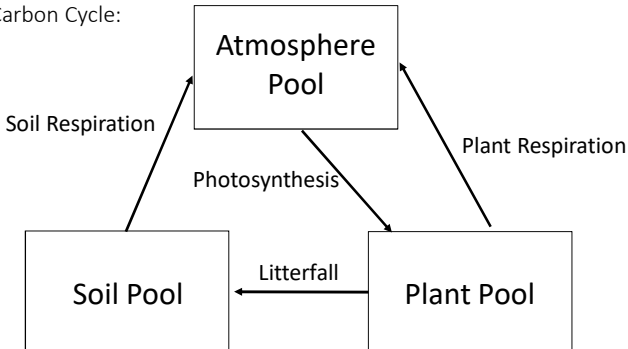
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Putting many '1-Box Models' together makes a box and arrow model that shows how individual components of an entire system are connected.

Putting together many boxes (pools) and arrows (fluxes) allows you to model the movement of matter through more complex systems. For example, the model below shows the movement of carbon through the Atmosphere, Soil and Plant Pools of the Carbon Cycle:





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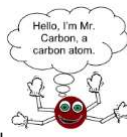
[Carbon Cycle Adventure Story](#) – Follow a carbon atom through the carbon cycle in a self-guided adventure story (60-90 minutes).


Student Outcomes:

- List major pools and fluxes of the carbon cycle
- Diagram the carbon cycle using box and arrow models
- Describe what components of the carbon cycle make it a system


Materials:

- *Carbon Cycle Adventure Story booklets (one per student or pair)*
- *Carbon Story Journey Table (one per student or pair)*
- White board, chalk board, large paper, or overhead projector & markers/chalk





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[Carbon Travels Game](#) – roll the dice to determine the fate of a carbon atom as it travels through Earth's carbon pools (60-120 min)

Student Outcomes:


- Research a specific carbon pool and present to peers
- List all major pools and fluxes in global carbon cycle
- Define residence time
- Compare and contrast the carbon cycle pre- and post-1700

Materials:


- Resources about carbon cycle
- Large sheets of paper
- *Carbon Cycle Station Instructions and Signs*
- *Journey Table (1 per student)*
- 1 six-sided die per student or station



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Getting to Know Global Carbon


– learn the basics of the carbon cycle through diagrams (70-100 min)


Student Outcomes:

- Create diagrams of complex systems
- Conceptualize 1 Pg of carbon
- Describe why the carbon cycle is not in equilibrium


Materials:

- White board, chalk board, large paper or overhead projector & markers/chalk
- Materials for students to draw their own carbon cycle diagram
- Global Carbon Cycle Diagram – student copies or projected image





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Quiz Questions

Challenge yourself to answer these questions and check whether you have achieved the learning objectives of this module.

1. What is the carbon cycle?
2. What is the difference between *pools* and *fluxes*?
3. What are the major *pools* of carbon in the Earth System? Which contain the most carbon? The least?
4. Why is studying the carbon cycle important?
5. When atmospheric carbon dioxide concentrations increase, what happens to Earth's temperature?
6. Does photosynthesis add or remove carbon from the atmosphere? Does respiration add or remove carbon from the atmosphere?
7. What process has caused the most recent (past 150 years) increase in atmospheric carbon dioxide?
8. What activity could you use to introduce students to systems thinking?
9. What is a system?
10. What is a 1-box model? What are two examples of a 1-box model?



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NASA's A Breathing Planet, Off Balance Article and Video:
<https://www.nasa.gov/feature/goddard/carbon-climate>

NASA Global Climate Change Website:
<https://climate.nasa.gov/>

NASA Scientific Visualization Studio
(<https://svs.gsfc.nasa.gov>)

Global Carbon Project
(<http://www.globalcarbonproject.org>)

Global Carbon Atlas
(<http://www.globalcarbonatlas.org>)