

Designing Learning Experiences & Global Carbon Cycling

Session 8

Homework Review: Reflection Prompts

- *OSS 2.3:*
 - Explain how carbon might move from the atmosphere and eventually end up in you.
 - How might cutting down forests affect CO₂ levels in the atmosphere?
 - What do you think might happen to a plant grown where there is less CO₂ in the air?
- *OSS 2.6 and 2.7:*
 - Explain how carbon might move from an organism that dies and eventually ends up in the atmosphere.
 - Explain why we find carbon in rocks, like limestone?
 - How does human activity affect the flow of carbon between reservoirs?

Discuss the reflections with a partner using these prompts ...

- a. After responding to the reflection prompts, what questions do you still have?
- b. Choose two reflection prompts and discuss how middle school students might respond to each. Do students have enough information from the sessions to attempt an answer?
- c. How might using the reflection prompts with students help a teacher to understand where students are in their understanding of the science concepts?
- d. What ah-ha's did you have about the types of questions used in the reflection prompts?
- e. As a teacher, how would you use these questions?

Session Goals

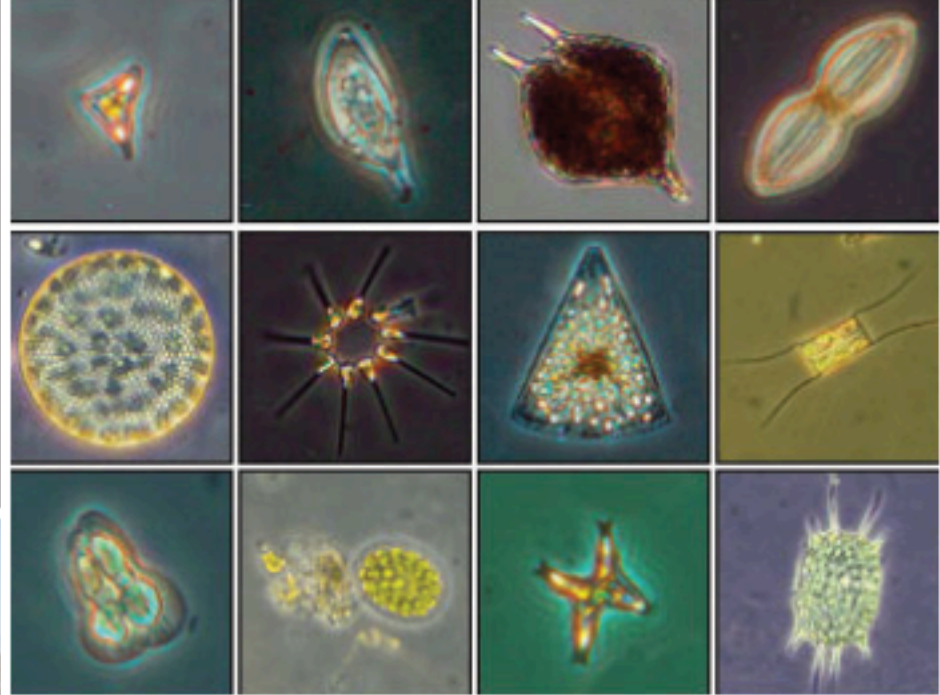
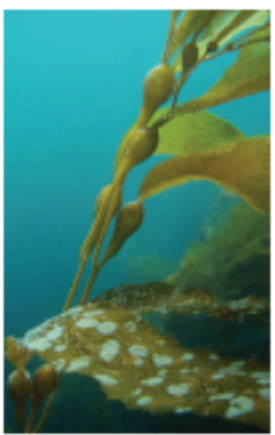
- **Climate science ideas:** Carbon flows between the land, the ocean and atmosphere through many different processes as part of the carbon cycle.
- **Using data:** Use data to make conclusions and relate it to a broader science concept. Use strategies to develop testable questions to explore using authentic data. Introduce the Final Project Guideline used to develop a data-based lesson.
- **Teaching and learning:** Review the Learning Cycle instructional model and examine the possibilities and limitations for learning in the design of different activities.
- **Framework/NGSS:** Learn about the Big Ideas of Systems and System Models and Scale, Proportion and Quantity, and discuss how they support conceptual understanding.

An underwater photograph showing a dense population of translucent jellyfish swimming in the water. In the foreground, there are brown, leafy seaweed plants. The water is a clear, light blue-green color.

Session 2.5

Investigating Carbon in the Ocean

Photosynthetic Ocean Organisms



Ocean Organisms with Shells



Guiding Question:

**How does carbon get
into the ocean?**

Investigating the question— how can CO₂ from the atmosphere get into the ocean?

- Work with your small group to design an investigation, using the materials on the tray, to answer the guiding question.
 - Explore materials on tray, but don't open jars yet
 - Containers of water and air represent the ocean and atmosphere.
 - BTB has been added to the water (serves as a proxy for CO₂)

Planning investigations

- Use the following prompts as you discuss ideas for how to investigate the question:
 - What would happen if we _____?
 - That would tell us that _____ about the real ocean.
- Be ready to share your ideas with the class.

Carry out Investigations

- Do as many of the investigations as you can in 5 minutes.
- Describe what you notice and discuss possible claims using evidence that answers the question:
 - How can CO₂ from the atmosphere get into the ocean?
- Be ready to share your claims and reasoning with the class.

What claim can you make
based on these results?



- **The ocean absorbs huge amounts of CO_2 from the atmosphere.**
- **Many ocean organisms need carbon for photosynthesis or for making shells, and they get it from the CO_2 that was absorbed in seawater.**

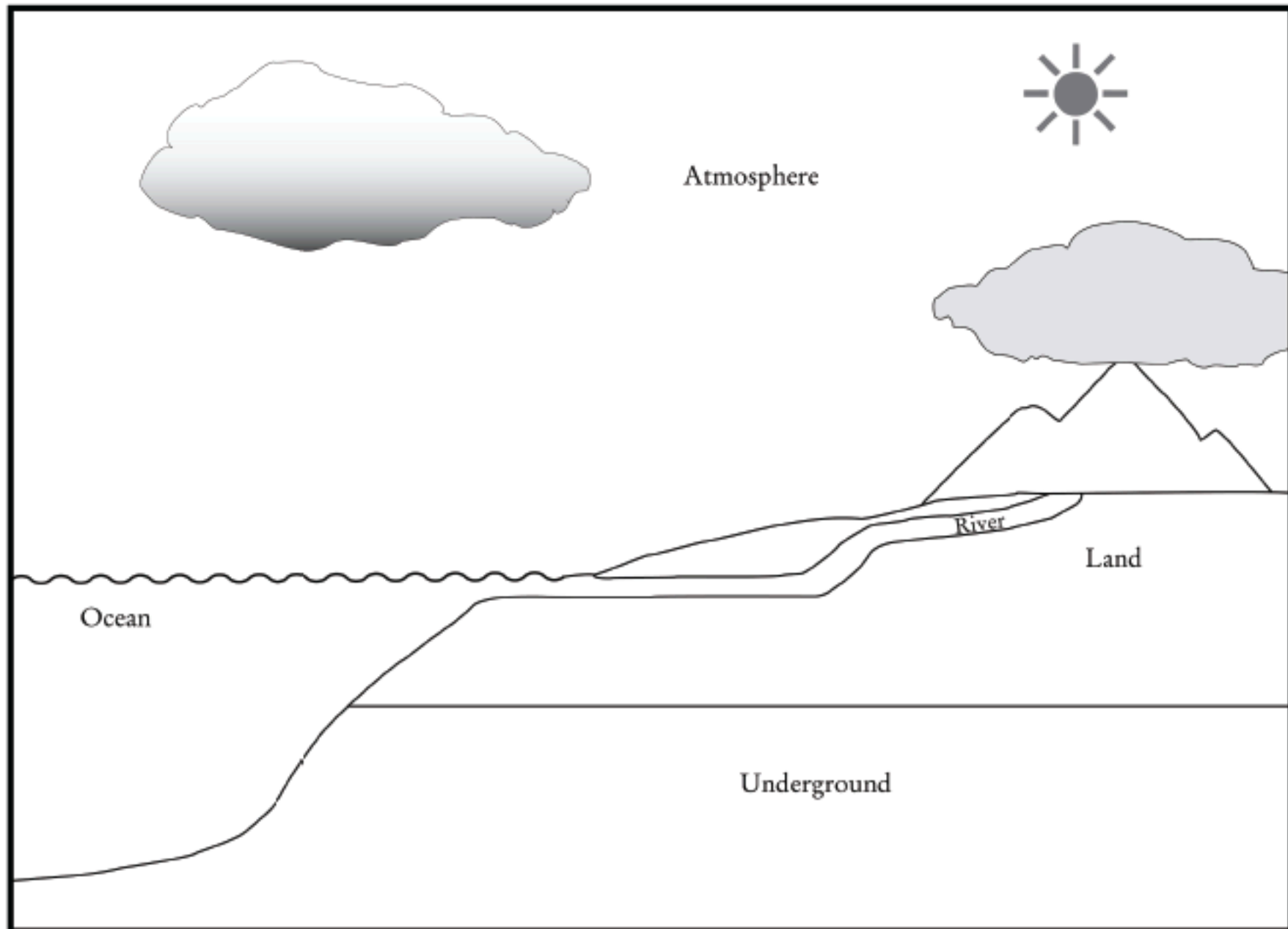
Review Homework Prompts & Notes

- Explain how carbon might move from the atmosphere and eventually end up in you.
- How might cutting down forests affect CO₂ levels in the atmosphere? Describe the carbon cycle processes that are involved in your prediction.
- What do you think might happen to a plant grown where there is less CO₂ in the air? Explain your answer.
- Explain how carbon might move from an organism that dies and eventually ends up in the atmosphere.
- How does human activity affect the flow of carbon between reservoirs?
- Considering how fossil fuels form, why are some people worried about running out of fossil fuels? What do you think about this?

Turn & Talk

- After responding to the reflection prompts for homework,
 - What questions do you still have about photosynthesis, respiration and fossil fuels?
 - How might using the reflection prompts with students help a teacher to understand where they are in their understanding of the science concepts?

Carbon Cycle Diagram



Turn & Talk

- Discuss your diagram with a partner
- Encourage each other to provide details and rationale for your ideas and additions
- Add to your diagram based on the discussion

Session 2.6

Detecting Decaying or Buried Bodies

What happens to the carbon in organisms after they die?
Could the answer be different depending on where the organism dies?

Think individually then be ready to share whole group

- Carbon flows into reservoirs of coal, crude oil, and limestone when organisms die. This process takes a VERY long time.
 - How do you think carbon might come out of these reservoirs?
- Answers:
 - **Fossil fuel reservoirs:** Natural leakage and breakdown of fossil fuels; and human industry - combustion.
 - **Limestone reservoirs:** weathering, volcanic eruptions; and human industry - making cement.

Defining the Carbon Cycle

✓ Simple Definition:

*The whole system of flows of carbon between different parts of Earth is called the **carbon cycle**.*

✓ More Complete Definition:

Living things take in carbon as CO_2 through the process of photosynthesis and return carbon to the environment through the processes of

(a) respiration, (b) _____,

(c) _____, (d) _____,

and (e) _____. *This is the **carbon cycle**.*

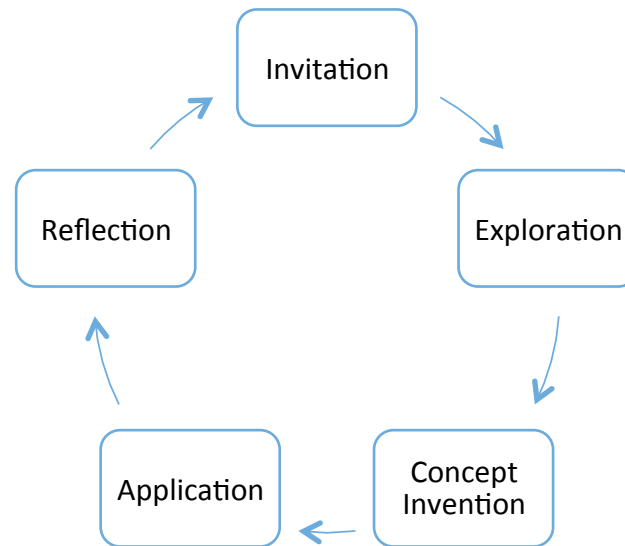
Where is the carbon in the Sydney Harbor ecosystem?

Label any additional reservoirs & carbon flows you learned about.
Record new questions & try to answer your previous questions.



Carbon cycle activity stations

- Goal:
 - to arrive at a deeper understanding of this complex system while also thinking about how you are making sense of the concepts
 - Reflect on how the stations could be sequenced into the learning cycle

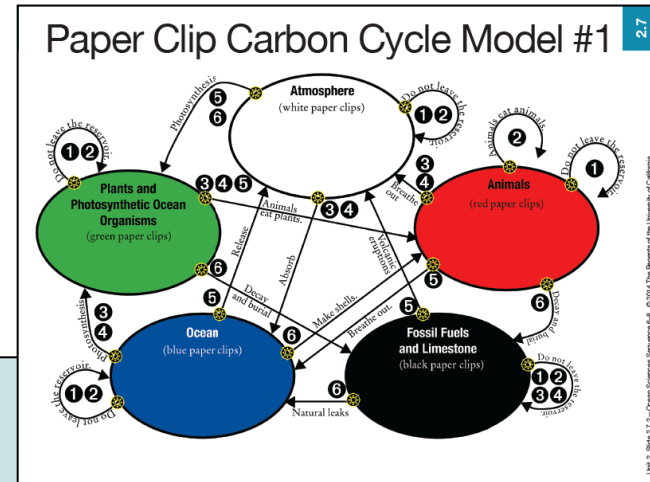


As you engage with the 3 stations, reflect on the learning experience—

- What do you think the specific content learning goals are for each station? (Why was this particular activity included?)
- What is one piece of science content you are taking away? Were you able to answer some of your questions?
- What additional questions about the content arise for you as you engage in the activities? Record your questions.

Carbon Cycle Investigation Stations

- 3 stations; 12 min each
- Work in teams
- Follow the instructions
- Clean up the Station for the next group
- Write down answers to question prompts



Atmosphere (800 gigatons)

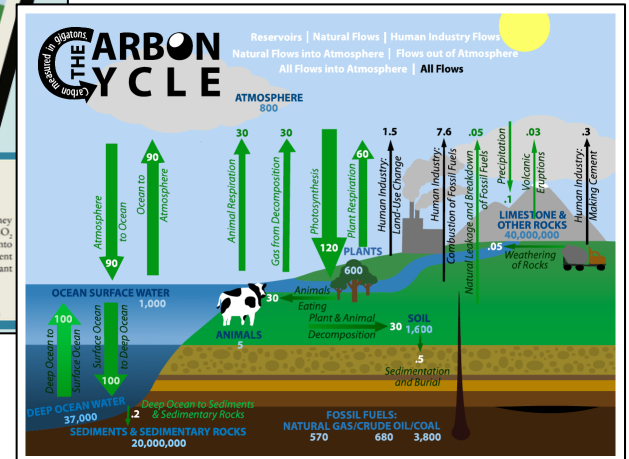
Limestone & Other Rocks (40,000,000 gigatons)

Animals Eating (30 gigatons per year)

Human Industry: Combustion of Fossil Fuels (17.6 gigatons per year)

Flow
Deep Ocean to Surface Ocean
Carbon can remain in the deep ocean for hundreds of years. However, mixing can bring deep water with carbon back to the surface.

Reservoir
Plants
Plants are built of sugars (C₆H₁₂O₆) that they make through photosynthesis, using CO₂ and H₂O. The sugars are then changed into cellulose and other materials to make different plant structures. Every cell of every plant contains carbon.





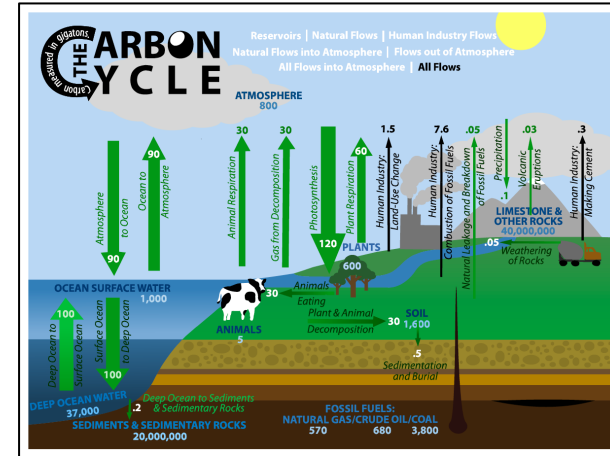
*Key
Concept*

- **Carbon moves between reservoirs, but the total amount of carbon on Earth doesn't change.**
- **Human industry moves carbon out of fossil fuel and limestone reservoirs and into the atmosphere.**

Designing experiences to support learning

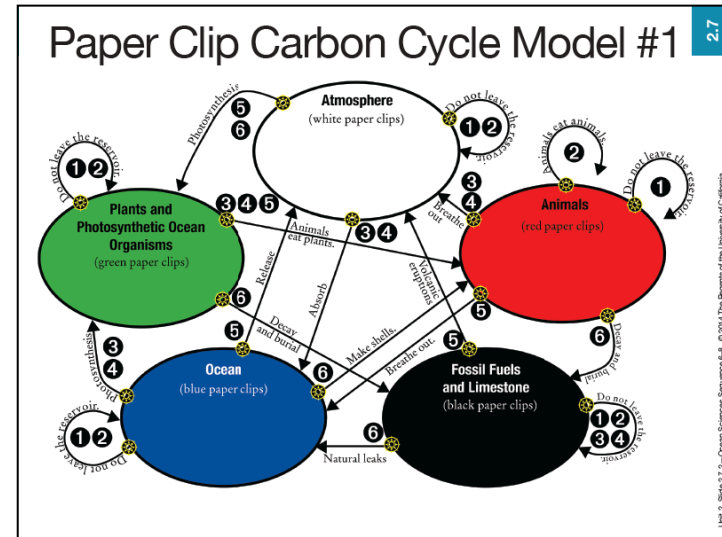
- Learning goals affect what experiences are offered and how they are designed.
 - How were you engaging with the materials and content in the different station activities to learn about the carbon cycle?
 - What do you think the content learning goal or purpose was for each of the individual stations?

Station A: Open-ended exploration



- What was your reaction to the station?
- What were the possibilities & limitations?
 - What were you able to do in the activity?
 - What were you not able to do in the activity?

Station B: Structured activity



- What was your reaction to the station?
- What were the possibilities & limitations?
 - What were you able to do in the activity?
 - What were you not able to do in the activity?

Station C: Guided discovery

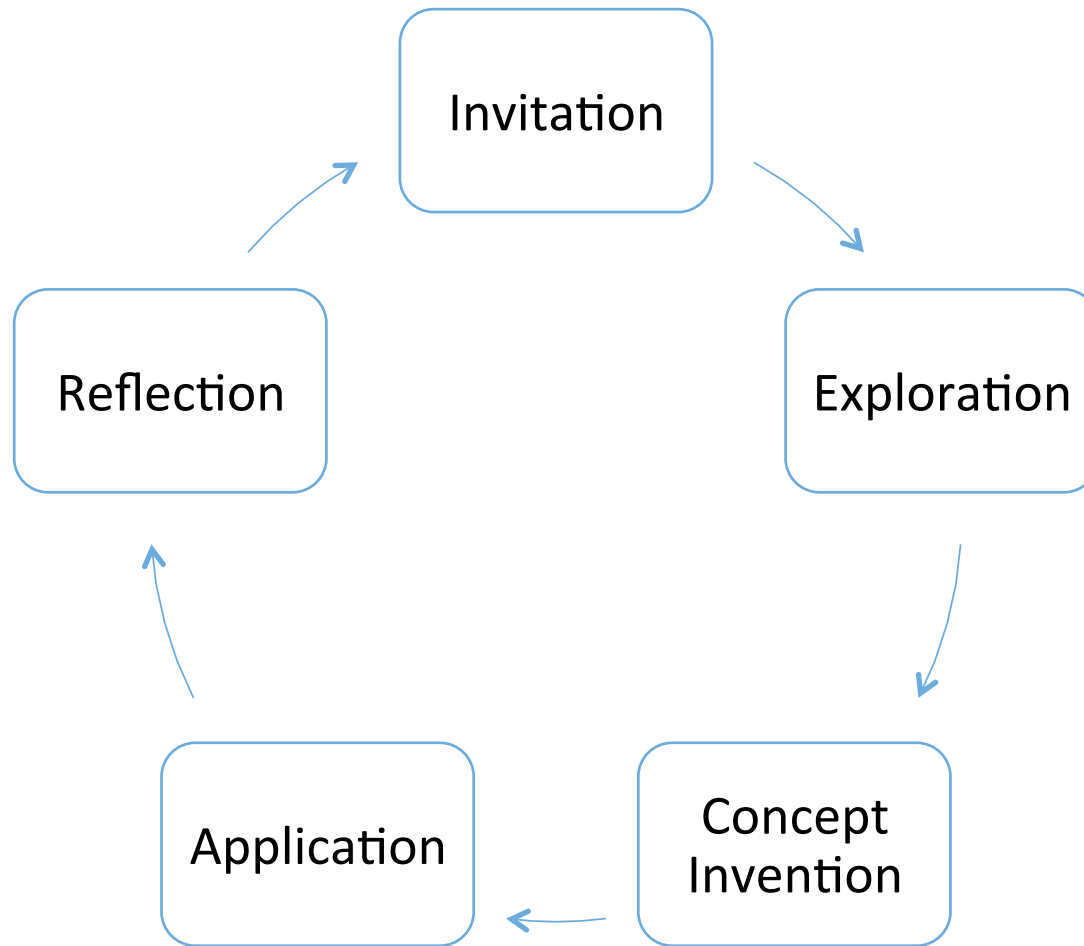


- What was your reaction to the station?
- What were the possibilities & limitations?
 - What were you able to do in the activity?
 - What were you not able to do in the activity?

What science concept learning goals might be addressed by each station?

- Station A
 - see the carbon cycle in a new and yet familiar way since it is designed to be similar to the carbon cycle diagram you've been working on.
 - the interactive diagram provided additional information to answer questions that arise through the small group discussions.
- Station B
 - designed to specifically address the common misconception that Earth is getting more carbon, rather than that essentially no new carbon is entering the system; rather it is cycling more quickly between the reservoirs.
 - human activities have taken carbon which was stored long-term in the fossil fuel reservoirs, and caused it to flow much more rapidly than it naturally would into the atmosphere and ocean reservoirs.
- Station C
 - work together to learn more about the carbon cycle, while also realizing what you know and don't know about the carbon cycle.
 - opportunity to make sense of the content in individual ways as there are many correct ways to make the model.

The Learning Cycle



Phase of Learning Cycle	Carbon Cycle Activity Station
Invitation	Sydney Harbor Sketch and recording questions; interactive computer model
Exploration	The interactive computer model, and the tabletop diagram
Concept Invention	The tabletop diagram, paperclip model, revisiting diagram and discussing questions and concepts.
Application	Introduce the second interactive computer model, “Change the Flow” and describe it as providing scenarios and opportunities to describe and provide evidence and reasoning about what will happen.
Reflection	Quick write about what was learned, how it was learned, and generating new questions; discussion of crosscutting concepts coming up at the end of this session

Five Foundational Ideas

- Learning is ***an active process*** to construct understanding.
- Learning ***builds on prior knowledge***.
- Learning occurs ***in a complex social environment*** and is a social activity.
- Learning should be ***situated in an authentic context***.
- Learning is affected by ***motivation and cognitive engagement***.

Crosscutting Concepts

- Read NRC Framework, pp. 89-94; and in addition
 - One-half will read about *Systems and System Models* and the other half about *Scale, Proportion, and Quantity*. Use the Active Reading strategies.
- When you finish, pair up with someone else who read the same crosscutting concept.
 - Discuss ideas from the reading — what you found interesting, and/or confusing and try to answer each other's questions.

Turn & Talk about your crosscutting concept

- ***Systems and System Models:*** the Carbon Cycle diagrams, the Interactive Carbon Cycle animation, the Carbon Cycle game and the Carbon Flow cards represent what we know about this system - they are models. Discuss the following:
 - What are the parts and sub-systems that make up this system? How do they work together?
 - How can our system models be made more accurate? What predictions can we make using the models?
 - What kind of data could help us understand this system? What would the data tell us about the system?
- ***Scale, Proportion and Quantity:*** In thinking scientifically about any system and processes, it is essential to recognize that there is variability in size and/or time span, and in the relationships between the scales of the different quantities. Consider the role of Scale, Proportion, and Quantity in how we learned about the Carbon Cycle. Discuss the following:
 - What scales or proportions or quantities were included in the Carbon Cycle models?
 - How did including this information affect your understanding of the Carbon Cycle and the predictions you could make?

Think Pair Share

- How does framing what we know about the Carbon Cycle through the lens of ***Matter and Energy*** affect a learner's understanding? What makes you think that?
- Those who read about ***Systems and System Models***: How does framing what we know about the Carbon Cycle as a system affect a learner's understanding? What makes you think that?
- Those who read about ***Scale, Proportion, and Quantity***: How does framing what we know about the Carbon Cycle through the lens of scale, proportion and quantity affect a learner's understanding? What makes you think that?

Introduction to the Final Project

- Opportunity to show what you've learned and includes the following components:
 - Use of real or near-real time data, ideally local data, which helps to develop an explanation of a climate science related concept
 - Incorporation of the learning cycle instructional model into the design of the lesson
 - Demonstration of knowledge of 3-dimensional teaching and learning through specifically addressing crosscutting concepts, science and engineering practices, and disciplinary core ideas (e.g. performance expectations)
 - Demonstration of understanding of a climate science concept(s)

Final Project Guidelines

The final project, which will be centered around development of a data-based lesson plan, will provide the opportunity to show what you've learned, and as such will include the following components:

- Use of near or near-real time data, ideally local data to where you are, which helps to develop an explanation of a climate science related concept
- Incorporation of the learning cycle instructional model into the design of the activity
- Demonstration of knowledge of 3-dimensional teaching and learning through specifically addressing crosscutting concepts, science and engineering practices, and disciplinary core ideas (e.g. performance expectations)
- Demonstration of understanding of a climate science concept(s)

Complete the following table. 100 Points Total

Introduction: Lesson Content Goals and Learning Objectives (5%)	Student Learning Objective (content and data)	
	How is your activity three dimensional? (describe the climate science concepts, science and engineering practices, and crosscutting concepts that students will demonstrate their understanding of)	
	What data skills will students demonstrate upon completion of your lesson?	
	How does this lesson use real or near-real time scientific data, ideally local data, to help students learn to develop an understanding of a climate science-related concept?	

Topic Area Questions

- Narrowing a question about a topic area down to a question that can actually be investigated and answered using data is a huge accomplishment and challenge (for scientists too).
- Questions that are investigated using data can be called testable.

Topic Area Questions for Final Project

1. **Topic Area: Photosynthesis, Respiration and Oxygen**
 - a. *Topic Area Question:* What is the relationship between day/night and oxygen?
 - b. *Topic Area Question:* How does the relationship between day/night and oxygen differ between winter and summer?
2. **Topic Area: Daily Rains**
 - a. *Topic Area Question:* What causes "daily rains" in the southeast during summer months?
 - b. *Topic Area Question:* What do concurrent changes in barometric pressure, wind direction, and PAR reveal about what causes the "daily rains"?
 - c. *Topic Area Question:* Do "daily rains" have an effect on salinity?
3. **Topic Area: Land vs Sea Breezes**
 - a. *Topic Area Question:* What is the relationship between wind speed and direction during different times of the day?
 - b. *Topic Area Question:* How does the relationship between wind speed and direction differ between the summer and winter?
 - c. *Topic Area Question:* Where and when can you observe land and sea breezes?
4. **Topic Area: Upwelling/Density**
 - a. *Topic Area Question:* What causes upwelling? What changes in the ocean occur when upwelling is present?
 - b. *Topic Area Question:* What causes density driven currents? What changes in the ocean occur when density driven currents are present?
 - c. *Topic Area Question:* What is the relationship between water temperature, salinity, and primary productivity in areas of upwelling and/or density driven currents?
5. **Topic Area: Temperatures around the Planet**
 - a. *Topic Area Question:* What is the relationship between ocean water temperature and latitude? And longitude?
 - b. *Topic Area Question:* What is the influence of ocean currents on ocean water temperature?
 - c. *Topic Area Question:* How does ocean water temperature vary among the major ocean currents?
6. **Topic Area: El Nino, Rainfall and Temperature**
 - a. *Topic Area Question:* Does El Nino have an impact on land rainfall?
 - b. *Topic Area Question:* Does La Nina have an impact on land rainfall?
 - c. *Topic Area Question:* How does the impact of El Nino or La Nina on land rainfall vary geographically?
7. **Topic Area: Heat, Air, Currents**
 - a. *Topic Area Question:* What is the relationship between/among wind direction, barometric pressure, precipitation, wind speed, and/or temperature?
 - b. *Topic Area Question:* What does the relationship between/among wind direction, barometric pressure, precipitation, wind speed, and/or temperature mean for air currents?
8. **Topic Area: Variability in Chlorophyll Concentrations**
 - a. *Topic Area Question:* How does chlorophyll concentrations vary over time?
 - b. *Topic Area Question:* Do chlorophyll concentrations vary similarly among different geographic locations?

Choosing a topic area question

- Review the Topic Areas and Topic Area Questions
- Choose one you are interested in and find a partner interested in the same one.
- Homework: get started on the final project **with your partner** by:
 - getting more information about the climate Topic Area that their Topic Area Question is focusing on, and
 - answering a few related questions (see homework assignment).

Quick Write–Testable questions

What criteria do you think would be included in determining whether a question is testable or not?

Characteristics of Testable Questions

“Smart Questions”

- **Specific** (not too broad) – a testable question begins with *How, What, When, Who, or Which*, (not *Why, Is, or Does*).
- **Measureable** (there are datasets available to answer the question) – a testable question can't be answered just by doing reading.
- **Achievable** (the question is able to be investigated with data) – data are available to and accessible by you.
- **Relevant** (who cares and why do they care) – you can explain why you care about asking the question
- **Temporally and Spatially bound** – the question includes when and where the data are coming from

Sample Student Investigation Questions

Sample Student Investigation Questions

1. *Student Question:* Fossil Fuels or Cement: Which is Worse?
 - a. *Revised Question:*
2. *Student Question:* How will changes in how much carbon dioxide there is in the ocean affect humans?
 - a. *Revised Question:*
3. *Student Question:* Will the ocean ever boil over?
 - a. *Revised Question:*
4. *Student Question:* Who needs the sun?
 - a. *Revised Question:*
5. *Student Question:* How do ocean organisms respond to a change in the ocean with more carbon dioxide?
 - a. *Revised Question:*
6. *Student Question:* Does the amount of dissolved oxygen in the ocean affect ocean organisms?
 - a. *Revised Question:*
7. *Student Question:* What carbon dioxide reservoir impacts the most sea life?
 - a. *Revised Question:*

Work with a partner to refine one student question so that it becomes testable

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Characteristics of Testable Questions (a guide for developing data inquiry questions and projects)

“SMART Questions”

- **Specific** (not too broad)
 - question begins with How, What, When, Who, or Which, (not with why or is).
- **Measurable** (there are datasets available to answer the question)
 - question can't be answered just by doing reading.
- **Achievable** (the question is able to be investigated with data)
 - data are available to, or accessible by you.
- **Relevant** (who cares and why do they care)
- **Temporal or Spatially oriented**
 - these types of comparisons are usually more accessible and informative

Checklist for Testable Questions

- Question begins with How, What, When, Who, or Which.
- Question is measurable or able to be investigated with data - available to or accessible by you
- Question includes effects/variables being investigated.
- Question only 1-2 effects/variables are included in question.

Expert groups work together

- Partners share revisions with another pair that worked on the same question.
- Come to a consensus that best aligns with the *Characteristics of testable questions*.

Characteristics of Testable Questions
(a guide for developing data inquiry questions and projects)

“SMART Questions”

- **Specific** (not too broad)
 - question begins with How, What, When, Who, or Which, (not with why or is).
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Student Question Reflection

- Are there any additional supports that might help your students to ask testable questions?
- What challenges did you encounter in refining the student questions?

Homework

- Science Topic Area paper (completed individually).
 - See handout for more details
- Become familiar with the Ocean Literacy Principles and Ocean Literacy Scope & Sequence
 - Available at oceanliteracy.net