

What Does Carbon Have to Do With It?

Teacher Information



.....just add students™

Summary

Students test a water sample to determine if the level of CO₂ in ocean water is causing oysters to die at a local oyster farm. By exploring models of the carbon cycle, students identify sources of carbon to explain how carbon cycles through Earth's spheres. Using the carbon cycle models, students explore how human activities can modify the amounts of carbon in each sphere.

Core Concepts

- The amount of carbon on Earth remains constant.
- Carbon moves through Earth's spheres (atmosphere, hydrosphere, biosphere, geosphere) in a complex cycle.
- Carbon is present in many places called stocks. Carbon fluxes are natural processes that move carbon from one stock to another.
- Human activities modify carbon fluxes, resulting in increased carbon in the atmosphere and ocean stocks.
- Excess carbon in the ocean and the atmosphere can impact processes occurring in these spheres.
- Removing excess carbon from ocean and atmosphere stocks can return carbon stocks to pre-human activity levels.

Time Required

3–4 forty-minute class periods

Kit contains

- Netarts Bay water sample (simulated)
- Water test strip (simulated)
- 20-sided dice
- 25 Black “carbon” disks
- **Water Test Kit Directions**
- **Carbon Cycle Model**
- **Natural Carbon Cycle Model Rules**
- **Human Activity Model Rules**
- **Effects of Shifting Carbon Storage**
- **Evidence Supporting Claims**
- **Carbon Sequestration Processes**

Teacher Provides

- Safety goggles
- Paper towel for clean-up

Warning: Choking Hazard

This Science Take-Out kit contains small parts. Do not allow children under the age of seven to have access to any kit component.

Supplementary Resources

(Note: This kit is based on the first two articles.)

- Grossman, E. (2011). Northwest Oyster Die-offs Show Ocean Acidification Has Arrived. *Yale E360*. https://e360.yale.edu/features/northwest_oyster_die-offs_show_ocean_acidification_has_arrived
- Barton, A., Hales, B., Waldbusser, G. G., Langdon, C., and Feely, R. A. (2012). The Pacific oyster, *Crassostrea gigas*, shows negative correlation to naturally elevated carbon dioxide levels: Implications for near-term ocean acidification effects. *Limnology and Oceanography*, 57(3), 698–710. <https://www.jstor.org/stable/26954033>
- Feely, R., Sabine, C., Takahashi, T., and Wanninkhof, R. (2015). Uptake and Storage of Carbon Dioxide in the Ocean: The Global CO₂ Survey. *Oceanography*, 14(4), 18–32. <https://doi.org/10.5670/oceanog.2001.03>
- Kandasamy, S., & Bejugam Nagender Nath. (2016). Perspectives on the Terrestrial Organic Matter Transport and Burial along the Land–Deep Sea Continuum: Caveats in Our Understanding of Biogeochemical Processes and Future Needs. *Frontiers in Marine Science*, 3. <https://doi.org/10.3389/fmars.2016.00259>
- Ocean Acidification. (2014). *Smithsonian Ocean*. <https://ocean.si.edu/ocean-life/invertebrates/ocean-acidification>
- Shahzar, E. (2023, July 4). 3 nature-based solutions to help us start sequestering carbon now. *World Economic Forum*. <https://www.weforum.org/agenda/2023/07/these-3-nature-based-solutions-can-help-us-sequester-carbon-today/>
- Temple, J. (2020, June 22). How green sand could capture billions of tons of carbon dioxide. *MIT Technology Review*. <https://www.technologyreview.com/2020/06/22/1004218/how-green-sand-could-capture-billions-of-tons-of-carbon-dioxide/>

Reusing the kits

Kits may be refilled and reused. Allow approximately 30 minutes for refilling 10–15 kits. Teachers will need to instruct students on how to handle clean-up and return of the reusable kit materials. For example, teachers might provide the following information for students:

Discard	Return to kit
• Water test strip	• Water sample tube • Water test kit bag • 20-sided dice • Black Carbon Disks • All printed materials

Note: Consider laminating the printed materials of the kits that will be reused.

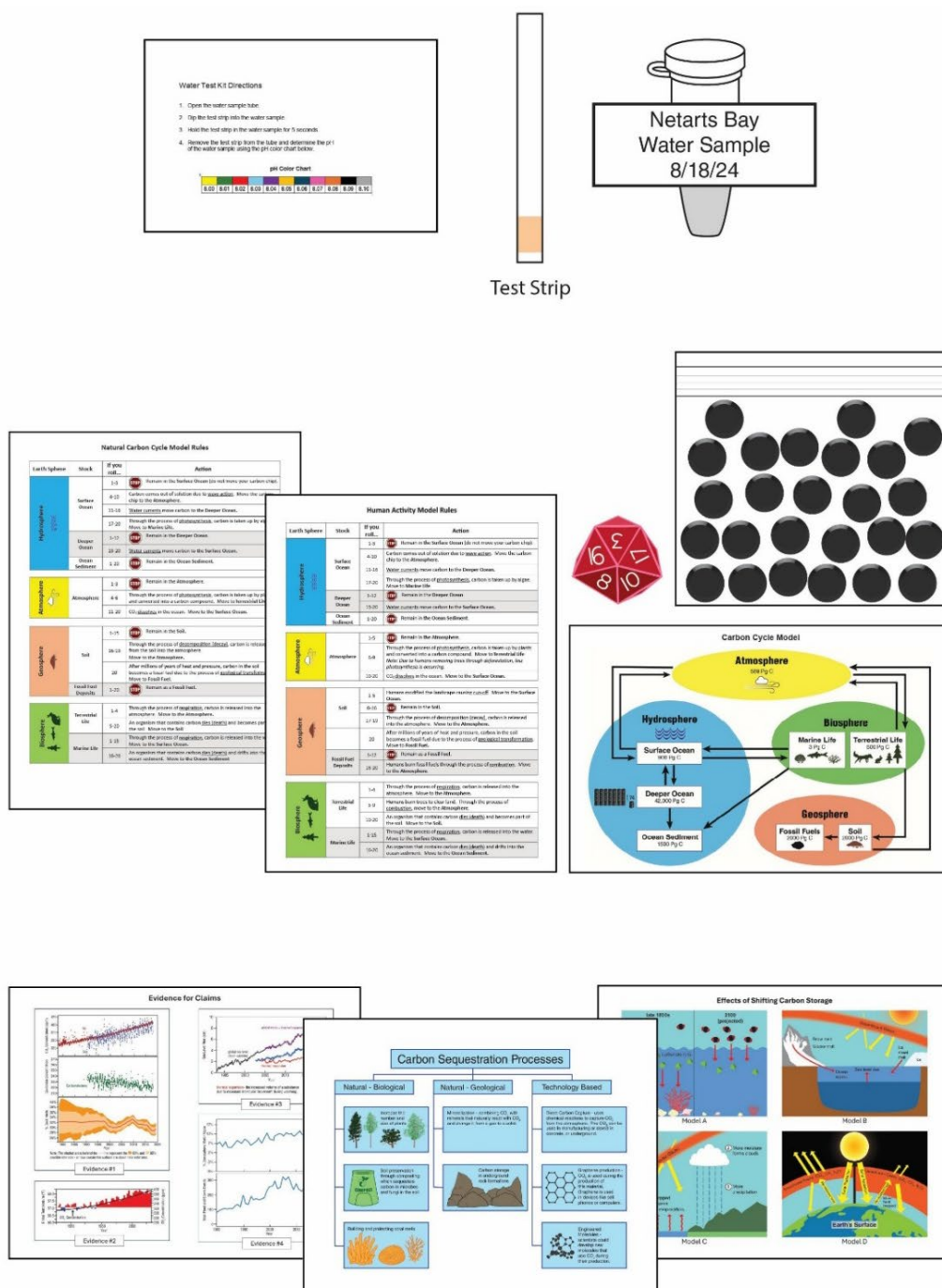
Refills for the *What Does Carbon Have to Do With it?* kits are available at www.sciencetakeout.com. The 10 Kit Refill Pack includes the following materials:

- Water sample (simulated)
- 10 Water test strips (simulated)
- 10 **Carbon Sequestration Process** sheets
- 10 **Carbon Cycle Model** sheets

NGSS Correlation

Working Towards Performance Expectation(s)		
HS-ESS2-6. Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.		
Science and Engineering Practices <i>Developing and Using Models</i> Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system.	Disciplinary Core Ideas <i>ESS2.D: Weather and Climate</i> - Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. - Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate.	Cross Cutting Concepts <i>Energy and Matter</i> The total amount of energy and matter in closed systems is conserved.

Kit Contents Quick Guide



Read these instructions before using Science Take-Out kits

Parental or Adult Supervision Required

This kit should be used only under the supervision of an adult who is committed to ensuring that the safety precautions below, and in the specific laboratory activity, are followed.

Chemicals Used in Science Take-Out Kits

Every effort has been made to reduce the use of hazardous chemicals in Science Take-Out kits. Most kits contain common household chemicals or chemicals that pose little or no risk. Safety Data Sheets (SDS) provide specific safety information regarding the chemical contents of the kits. SDS information for each kit is provided in the accompanying teacher instructions. We encourage students to adopt safe lab practices when performing laboratory activities involving chemicals.

Warning: Choking and Chemical Hazard

Science Take-Out kits contain small parts that could pose a choking hazard and chemicals that could be hazardous if ingested. Do not allow children under the age of seven to have access to any kit components.

No blood or body fluids from humans or animals are used in Science Take-Out kits. Chemical mixtures are substituted as simulations of these substances.

General Safety Precautions

1. Never taste, smell, or ingest any chemicals provided in the kit – they may be hazardous.
2. Chemicals used in Science Take-Out experiments may stain or damage skin, clothing or work surfaces. If spills occur, wash the area immediately and thoroughly.
3. Report any chemical spills or contact with chemicals to your teacher.
4. Work in a clean, uncluttered area. Cover the work area to protect the work surface.
5. Read and follow all instructions carefully.
6. Pay particular attention to following the specific safety precautions provided by your teacher or included in the kit activity instructions.
7. Do not use the contents of this kit for any other purpose beyond those described in the kit instructions.
8. Do not leave experiment parts or kits where they could be used inappropriately by others.
9. Do not eat, drink, or apply make-up or contact lenses while performing experiments.
10. Wash your hands before and after performing experiments.



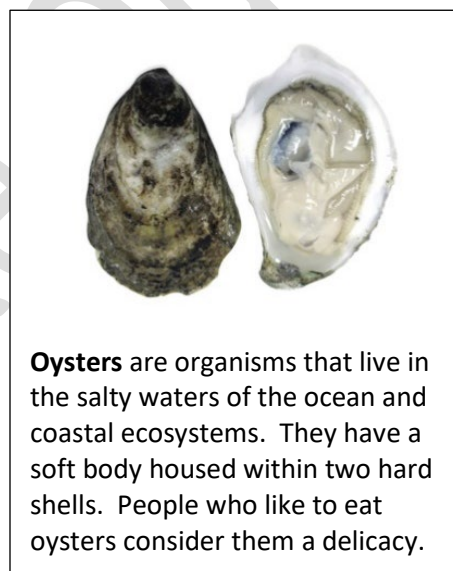
What Does Carbon Have to Do With It?

..... just add students™

Part 1: Testing the waters

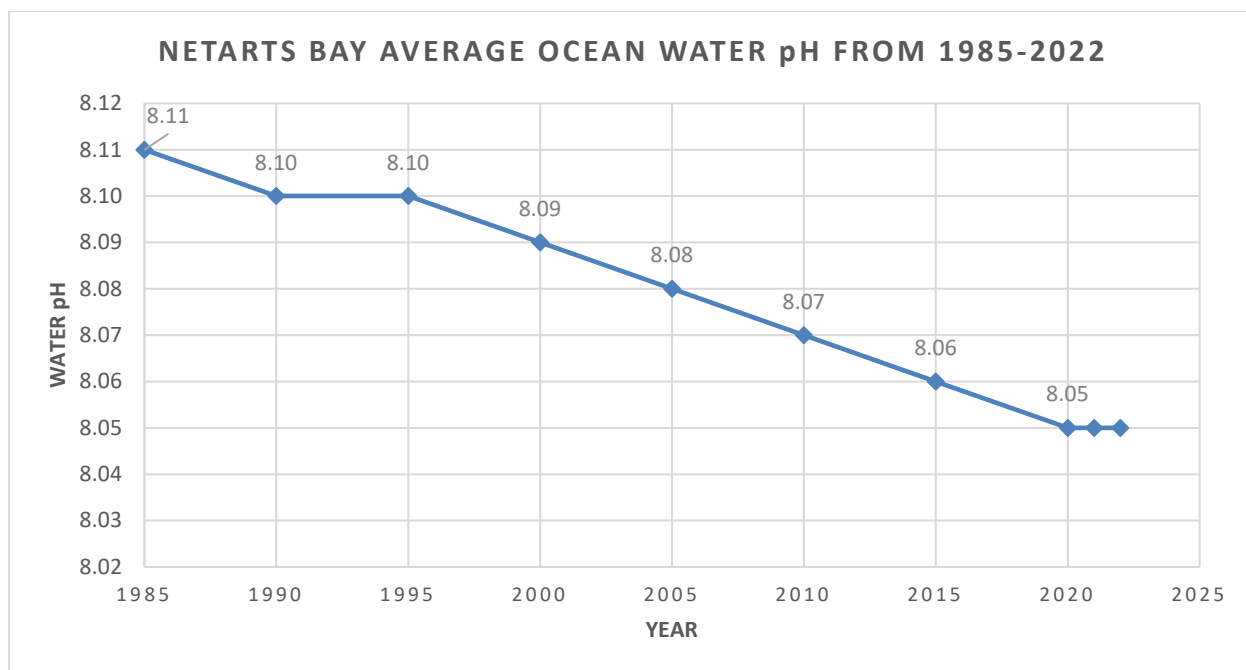
Mark and Sue have raised oysters in Netarts Bay, Oregon for the past 40 years. An oyster farm is much like any other farm. Mark and Sue care for their oysters in the ocean until the adult oysters are collected and sold as food. Oyster farmers like Mark and Sue rely on adult oysters to reproduce baby oysters (called larvae) to keep their farm going from year to year.

Mark and Sue were concerned about their farm because 75% of their oyster larvae (baby oysters) died last year. The normal procedures that Mark and Sue use to prevent larvae die-off were not working. To help them figure out why their oysters were dying, they sent ocean water samples to Dr. Burke Hales, a water chemistry specialist at Oregon State University.



Oysters are organisms that live in the salty waters of the ocean and coastal ecosystems. They have a soft body housed within two hard shells. People who like to eat oysters consider them a delicacy.

Dr. Hales has monitored the pH of the ocean water in Netarts Bay since 1985! The graph on the next page shows his data for ocean water pH at Netarts Bay since 1985.



1. What trend is observed in the data collected by Dr. Hales?

2. What is the overall change in the pH between 1985 and 2020?

This small change in pH may not seem important. However, Dr. Hales explained that even a slight decrease in pH is concerning because it indicates that more carbon dioxide is dissolved in the ocean water.

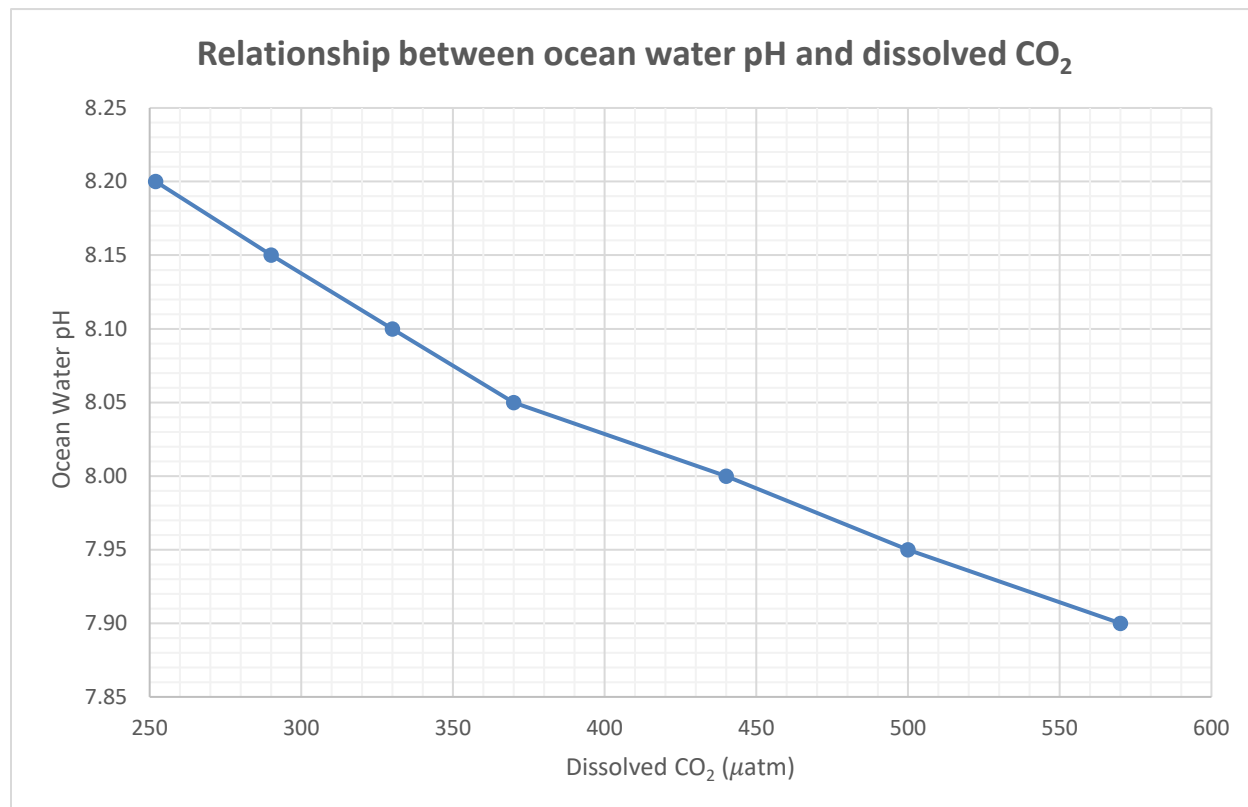
3. Use the materials in your **Water Test Kit** and the **Water Test Kit Directions** sheet to determine the pH of the water sample from Mark and Sue's oyster farm.

- Date of the water sample _____
- pH of the water sample _____

4. Are the results of the water sample test from Mark and Sue's oyster farm consistent with the trend in Dr. Hales' data? Support your answer.

The graph below shows the relationship between ocean water pH and the amount of carbon dioxide (CO₂) dissolved in the water.

NOTE: μatm (microatmospheres) is a unit of measure of the amount of dissolved carbon dioxide (CO₂) in water.



5. Based on the information in the graph, describe the relationship between ocean water pH and dissolved CO₂.

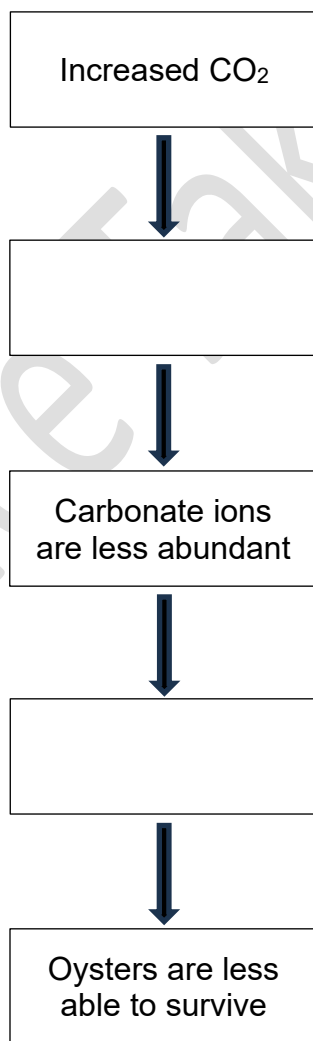
6. In 1985, Dr. Hales measured the pH of ocean water in Netarts Bay as 8.11. Use the graph above to determine the amount of dissolved CO₂ at this pH.

7. Use the graph to identify how much CO₂ is dissolved in the water sample from Mark and Sue's oyster farm.

Mark and Sue wondered how the increased CO₂ caused their oyster larvae to die. Dr. Hales explained that high CO₂ levels in the ocean cause a complex series of chemical reactions. These chemical reactions cause the ocean water to become more acidic through a process called **ocean acidification**.

A consequence of ocean acidification is that the amount of carbonate ions decreases. Oysters rely on carbonate ions to build their shells and skeletons. A lack of carbonate ions weakens the shells of oysters, decreasing their ability to survive.

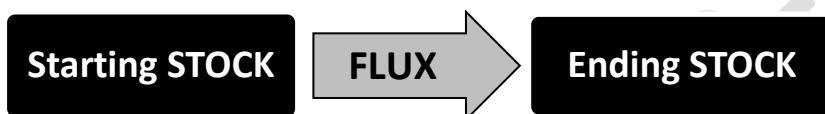
8. Complete the model below to explain how increased CO₂ levels in the water caused the oyster larvae to die off in Netarts Bay, Oregon.



Part 2: Where does the CO₂ in the ocean come from?

What could cause the CO₂ levels in the ocean to change over time? Dr. Hales explained that the amount of carbon atoms on our planet remains constant. The amount of carbon atoms on Earth does not increase or decrease over time. However, CO₂ circulates between the biosphere (living things), the atmosphere (air), the hydrosphere (water), and the geosphere (land). This circulation is part of a complex **biogeochemical cycle** that moves carbon atoms (from CO₂) throughout Earth's different spheres.

Carbon is stored in different locations within Earth's spheres. The locations of carbon storage are called **stocks**. Different processes move carbon atoms between stocks. The processes that move carbon atoms are called **fluxes**. The complex interactions of stocks and fluxes that move carbon atoms are part of the biogeochemical cycle called the **carbon cycle**.



1. Based on the reading above, what is a carbon stock?

2. In the carbon cycle, what is a flux?

Observe the **Carbon Cycle Model** sheet. Important carbon stocks are identified as boxes on the model. The numbers in each box indicate the amount of carbon stored in that stock in units called peta-grams (PgC).

Note: 1 PgC = 1,000,000,000,000,000 grams of carbon or 1×10^{15} g of carbon

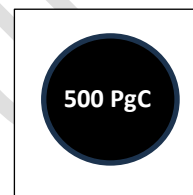
3. What carbon stocks are found in the geosphere?

4. Which of Earth's spheres stores the most carbon?

5. Which single carbon stock stores the most carbon? Support your answer.

6. What do the arrows on the **Carbon Cycle Model** represent?

To model carbon stocks, you will use small black disks. Each black disk represents approximately 500 peta-grams of carbon (500 PgC). For example, the atmosphere stores 589 PgC. One black disk would be used to represent the amount of carbon in the atmosphere stock on the **Carbon Cycle Model**.



7. Complete the following table to identify how many black disks should be added to each carbon stock on the model. (HINT: Use rounding rules so that you only use whole numbers of black disks.)

Carbon Stock	Amount of carbon (PgC)	Number of black disks to add to each carbon stock
Atmosphere	589	1
Terrestrial Life	500	
Soil	2000	
Fossil Fuels	2000	
Surface Ocean	900	
Deeper Ocean	42,000	
Ocean Sediment	1500	
Marine Life	3	0 – the amount is too small

Use the **Carbon Cycle Model** to show how the natural (without any human activities) biogeochemical cycle works. Place the appropriate number of black disks into each stock on the Carbon Cycle Model.



Note: 84 black disks are too many disks to add to the ocean in the **Carbon Cycle Model**. To make it easier, 74 disks have already been drawn in the deeper ocean stock. You only need to add 10 actual disks to the model make up the difference.

Let's learn the rules of the simulation *before* we start changing our model. The **Natural Carbon Cycle Model Rules** sheet identifies the "rules" you will use to move carbon through the cycle. Your move is determined by the number you roll on a 20-sided dice. Each rule identifies the new carbon stock you should move to and describes the process that moves the carbon into that stock. Once the carbon moves into a new stock, you should follow the "rules" for the new stock.

8. Let's follow 500 peta-grams of carbon (500 PgC = 1 black disk) starting in the atmosphere. Find the "rules" for the atmosphere. Imagine you rolled a 5 on the dice, what new carbon stock would you move the black disk to?

9. What process moves the carbon out of the atmosphere into a new stock?

10. Imagine you roll a 5 again, use the rules for this new stock to identify where your carbon moves, and what process moved the carbon into that stock.

11. Let's follow a new 500 peta-grams of carbon (500 PgC = 1 black disk) starting in the fossil fuels stock. Explain why you would not move any carbon out of this stock.

12. Now that you understand some of the “rules,” you can develop the model a little more.

- a. Start with one carbon disk in the **atmosphere** stock.
- b. Roll your dice. If you roll a number that has you remain in that stock, continue to roll until you can move. Count and record how many rolls it took to leave the starting stock and record this number in the 2nd column of the **atmosphere row** in the data table below.
- c. When you roll a number that allows the carbon to leave, move one black disk out of the **atmosphere**. Place it in the new stock identified by your roll. Record the name of the process that moved the carbon in the 3rd column of the **atmosphere row** in the data table.
- d. Continue to roll, moving the carbon disk from stock to stock. Each time you move, record the name of the process that moved the carbon in the 3rd column of the **atmosphere row** in the data table. (Note: you may have multiple processes in one box.)
- e. Continue to roll the dice until the rules tell you to **remain** in one of the carbon stocks.
- f. Record this carbon stock as your ending stock for the carbon disk in the 4th column of the **atmosphere row** in the data table to document your turn.
- g. You just completed one turn! The only row that should be completed in your data table at this point is the **atmosphere row**.

Natural Carbon Cycle Model			
Starting Carbon Stock	Number of dice rolls it took to leave the starting stock	Processes used to move carbon through stocks (FLUXES)	Ending Carbon Stock
Atmosphere			
Soil			
Fossil Fuels			
Terrestrial Life			
Marine Life			
Surface Ocean			
Deeper Ocean			
Ocean Sediment			

13. Your task is to follow the rules for moving carbon out of **each** of the remaining starting stocks in the data table. (*Your teacher may assign only some of the stocks.*)

- Remember to move your black disks between stocks based on your rolls.
- Complete the data table to document your turns.

14. Identify a carbon stock where it took three or more dice rolls to leave the carbon stock.

15. Identify a stock that could be considered a location of long-term carbon storage.

16. Use your **Carbon Cycle Model** to compare the amount of carbon in each stock before and after natural fluxes by completing the data table below.

Carbon Stock	Amount of carbon in stock before natural fluxes (number of black disks)	Amount of carbon in stock after natural fluxes (number of black disks)
Atmosphere	1	
Terrestrial Life	1	
Soil	4	
Fossil Fuels	4	
Surface Ocean	2	
Deep Ocean	84	
Ocean Sediment	3	

17. Did the amount of carbon in each stock change a lot? Explain your answer.

18. Your **Carbon Cycle Model** is not complete. The processes that move carbon between stocks have not been labeled. Use your **Natural Carbon Cycle Model Rules** to help label each arrow on your **Carbon Cycle Model**.

19. Identify two carbon cycle processes that would be immediately affected if marine life was eliminated.

20. What effect would removing terrestrial life have on the overall movement of carbon through the carbon cycle?

21. Explain how your model represents the carbon cycle – a complex **biogeochemical cycle**.

22. Dr. Hales identified the cause of the oysters dying off as increased CO₂ in the surface ocean waters. Use your model to identify at least two processes that could increase surface ocean CO₂.

Part 3: How have humans altered this cycle?

Your original model was used to explain how carbon atoms **naturally** move through Earth's spheres. Human activities modify this cycle. Use the **Human Activities Model Rules** to develop a model that explains the effects that human activities have on carbon stocks and fluxes.

To begin, reset the **Carbon Cycle Model** so that the number of black disks in each box matches the approximate amount carbon stored in each stock. *HINT: Use your numbers from the data table in Part 2, Question 7.*

1. Use the **Human Activity Model Rules** sheet to identify what happens to carbon:
 - a. Start with one of the carbon disks in the **soil** stock.
 - b. Roll your dice. If you roll a number that has you remain in the **soil**, continue to roll until you can move. Count and record how many rolls it took to leave the starting stock and record this number in the 2nd column of the **soil** row in the data table on the next page.
 - c. When you roll a number that allows the carbon to leave, move one black disk out of the **soil**. Place it in the new stock identified by your roll. Record the name of the process that moved the carbon in the 3rd column of the **soil** row in the data table on the next page.
 - d. Continue to roll the dice, moving the carbon disk from stock to stock. Each time you move, record the name of the process that moved the carbon in the 3rd column of the **soil** row in the data table on the next page. (Note: you may have multiple processes in one box.)
 - e. Continue to roll the dice until the rules tell you to **remain** in one of the carbon stocks.
 - f. Record this carbon stock as your ending stock for the carbon disk in the **soil** row of the data table on the next page to document your turn.
 - g. You just completed one turn! The only row that should be completed in the data table at this point is the **soil** row.
2. Your task is to follow the rules for moving carbon out of each of the remaining starting stocks in the data table on the next page. (*Your teacher may assign only some of the starting stocks.*)
 - Remember to move your black disks between stocks based on your rolls.
 - Complete the table to document your turns.

Human Activity Model			
Starting Carbon Stock	Number of dice rolls it took to leave the starting stock	Processes used to move carbon through stocks (FLUXES)	Ending Carbon Stock
Soil			
Atmosphere			
Fossil Fuels			
Terrestrial Life			
Marine Life			
Surface Ocean			
Deeper Ocean			
Ocean Sediment			

3. Identify at least two ways that human activity has modified the natural carbon cycle model.

4. Use your model to compare the amount of carbon in each stock before and after human activities by completing the data table below.

Carbon Stock	Amount of carbon in stock before human activities (number of black disks)	Amount of carbon in stock after human activities (number of black disks)
Atmosphere	1	
Terrestrial Life	1	
Soils	4	
Fossil Fuels	4	
Surface Ocean	2	
Deep Ocean	84	
Ocean Sediment	3	

5. Construct an argument to explain how a carbon stock was changed because of human-modified fluxes. In your answer, identify at least one carbon stock that changed because of the human-modified fluxes, make a claim about the cause of that change, and support your choice(s) with evidence from the carbon cycle model.

Carbon Stock: _____

Claim: _____

Evidence supporting my claim: _____

6. Your **Carbon Cycle Model** is not complete. The processes that move carbon between stocks due to human activity have not been included. Use your **Human Activity Model Rules** to add arrows and labels on your **Carbon Cycle Model to indicate** processes caused by human activity.
7. Dr. Hales identified increased CO₂ in the surface ocean as the cause for the oyster die-off. Use your model to support the idea that human actions have led to this increase in CO₂ in the surface ocean.

Part 4: How do shifts in carbon stocks cause problems?

You may have noticed that human activities have increased the amount of carbon (number of black disks) in the atmosphere and ocean stocks. This shift in carbon stocks led to the die-off at the oyster farm. How has the change in carbon storage affected how other living and non-living systems function on Earth?

We can describe the effects of shifting carbon stocks using both words and pictures to help understand how parts of Earth's systems work together. Pictures that describe processes are called **models**. Scientists use models and data as evidence to support their claims. Let's explore some claims related to changes in the carbon cycle and how this affects other systems.

- Read each claim below.
- Use the **Effects of Shifting Carbon Storage** images to select the model that best fits each claim.
- Use the **Evidence for Claims** sheet to select the data that supports each claim.

Claim #1: A student claims that as more greenhouse gases like CO₂ are stored in the atmosphere, more heat is trapped. The increase in trapped heat causes global temperatures to rise resulting in climate change.

1. The model that best matches claim #1 is _____.
2. The evidence that best supports claim #1 is _____.

Claim #2: A student claims that as more CO₂ dissolves in the ocean, corals will be less likely to build shells. Without their shells, corals will not build coral reefs. The increase in CO₂ in the ocean causes a decline in the number and size of coral reefs in the ocean.

3. The model that best matches claim #2 is _____.
4. The evidence that best supports claim #2 is _____.

Claim #3: A student claims that more CO₂ in the atmosphere will cause increased evaporation that will lead to more extreme weather events like flooding and larger hurricanes.

5. The model that best matches claim #3 is _____.
6. The evidence that best supports claim #3 is _____.

7. Increasing carbon stocks (black disks) in the atmosphere and ocean have caused problems with global temperature, ocean health, and extreme weather. Use the **Carbon Cycle Model** to identify actions humans could take to balance the carbon stocks (black disks).

Part 5: Getting the carbon in balance

To prevent problems associated with increased CO₂ in the atmosphere and ocean stocks, scientists suggest returning the carbon stocks closer to the levels seen in the natural model. Success in fixing the cycle requires two main things:

- Adding less CO₂ to the atmosphere and ocean stocks to prevent problems from getting worse in the future.
- Removing some CO₂ from the atmosphere and ocean stocks to reduce existing problems.

1. Using your **Carbon Cycle Model** as a guide, identify at least one solution to prevent additional CO₂ from entering the atmosphere and the ocean due to human activities.

2. Using your **Carbon Cycle Model** as a guide, identify at least one natural process that can remove CO₂ from the atmosphere and the ocean.

3. Explain why removing CO₂ currently stored in the atmosphere or ocean must be one of the requirements of a successful strategy to return the carbon stocks to normal levels to prevent worsening future problems including climate change and ocean acidification.

The process of removing carbon from the atmosphere and ocean stocks is called **carbon capture and sequestration**. Sequestration stores carbon in stocks that do not influence climate change or ocean health. Processes that sequester (store) carbon can be natural or technology based. Natural methods can take many years for large amounts of carbon to be removed from the atmosphere and stored in another stock. While the technology-based processes may take only days to capture the same amount of carbon, they require the use of large amounts of energy which make them costly.

4. Based on your **Carbon Cycle Model** and what you have learned so far, identify at least two carbon stocks that would be good places to sequester (store) carbon because they do not affect climate change or ocean health.

The **Carbon Sequestration Processes** graphic describes several methods for carbon sequestration. Researchers from an organization in California called Project Vesta developed a carbon capture and sequestration process that involves distributing naturally occurring igneous rocks along beaches. These igneous rocks contain olivine, a green colored mineral. Incoming waves grind down the olivine, creating green colored sand. The olivine sand acts as a carbon dioxide absorber. Through a series of natural chemical reactions, CO₂ gas is essentially locked up in carbonate minerals in the sand.

Project Vesta estimates this process could potentially store hundreds of trillions of tons of carbon dioxide. That's far more carbon dioxide than humans have released since the start of the Industrial Revolution in the mid-18th century! Project Vesta estimates the cost to be \$10 per ton of stored carbon dioxide.

5. Which carbon capture and sequestration process is used by Project Vesta? Use the **Carbon Sequestration Process** graphic to *circle* the carbon capture and sequestration processes used by Project Vesta.

6. Identify at least two advantages of using the Project Vesta process as a method for getting the carbon in balance.

7. Identify at least one reason why people may have concerns about using the Project Vesta process as a solution for the complex problem of changing carbon storage due to human activity.

The Shunli factory in China has the world's first large-scale factory designed to convert atmospheric CO₂ to methanol. The factory captures 160,000 tons of CO₂ annually to produce 110,000 tons of methanol. This low-carbon methanol is used in another factory to create various chemical products, reducing reliance on fossil-based methanol and lowering carbon release. This process effectively recycles carbon dioxide into useful products. However, it consumes large amounts of energy to run the reaction. The Shunli factory uses wind and solar power as the energy source. Few other companies recycle CO₂ into methanol because of the high energy demands.

8. Which carbon capture and sequestration process is used in the Shunli factory? Use the **Carbon Sequestration Process** graphic to draw a *square* around the carbon capture and sequestration processes used by the Shunli factory.

9. Identify at least two advantages of using the Shunli process as a solution for getting the carbon in balance.

10. Identify at least one reason why people may have concerns about using the Shunli process as a solution for long term carbon capture and storage.

11. Even though large-scale projects are needed to get the carbon cycle in balance, personal decisions made by individuals and families can help solve the problem. From the list of carbon sequestration processes, identify at least one way that you and your family could contribute to the solution at home.

Oyster die-off in Netarts Bay is a local problem caused by the complex real-world problem of changing carbon stocks caused by human activity. Use the following questions to help design a possible solution to this local problem.

Criterion: A specific, measurable goal that a solution must meet to be considered successful.

Constraint: A limitation or restriction for a solution.

12. Identify one specific **criterion** that must be met for a proposed solution to the oyster die-off in Netarts Bay to be considered a success.

13. Identify one **constraint** that must be considered when evaluating a solution to the oyster-die-off.

14. Using the **Carbon Sequestration Process** graphic, choose a possible solution to the oyster-die off problem.

- Describe your solution.
- Explain how this solution meets both your criterion and your constraint.

Section 1 Chemical Product and Company Information

Science Take-Out
150 Office Park Way
Pittsford, NY 14534
(585)764-5400

CHEMTREC 24 Hour Emergency
Phone Number (800) 424-9300
For laboratory use only. Not for drug, food or household use

Product	Buffer Solution pH7
Synonyms	"Netarts Bay water sample 8/18/24"

Section 2 Hazards Identification

This substance or mixture has not been classified at this time according to the Globally Harmonized System (GHS) of Classification and Labeling of Chemicals.

Signal word: WARNING
Pictograms: None required
Target organs: None known

GHS Classification:
Skin Irritation (Category 3)
Eye irritation (Category 2B)

GHS Label information: Hazard statement(s):
H316: Causes minor skin irritation.
H320: Causes eye irritation.

Precautionary statement(s):

P264: Wash hands thoroughly after handling.

P305+P351+P338: IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.

P332+P313: If skin irritation occurs: Get medical attention.

P337+P313: If eye irritation persists: Get medical attention.

Ca Prop 65 - This product does not contain any chemicals known to the State of California to cause cancer, birth defects, or any other reproductive harm.

Section 3 Composition / Information on Ingredients

Chemical Name	CAS #	%	EINECS
Water	7732-18-5	99.15%	231-791-2
Potassium phosphate, monobasic	7778-77-0	0.72%	231-913-4
Sodium hydroxide	1310-73-2	0.13%	215-185-5

Section 4 First Aid Measures

INGESTION: Call physician or Poison Control Center immediately. Induce vomiting only if advised by appropriate medical personnel. Never give anything by mouth to an unconscious person.

INHALATION: Remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention.

EYE CONTACT: Check for and remove contact lenses. Flush thoroughly with water for at least 15 minutes, lifting upper and lower eyelids occasionally. Get immediate medical attention.

SKIN ABSORPTION: Remove contaminated clothing. Flush thoroughly with mild soap and water. If irritation occurs, get medical attention.

Section 5 Fire Fighting Measures

Suitable Extinguishing Media: Use any media suitable for extinguishing supporting fire.

Protective Actions for Fire-fighters: In fire conditions, wear a NIOSH/MSHA-approved self-contained breathing apparatus and full protective gear. Use water spray to keep fire-exposed containers cool.

Specific Hazards: During a fire, irritating and highly toxic gases may be generated by thermal decomposition or combustion.

Section 6 Accidental Release Measures

Personal Precautions: Evacuate personnel to safe area. Use proper personal protective equipment as indicated in Section 8. Provide adequate ventilation.

Environmental Precautions: Avoid runoff into storm sewers and ditches which lead to waterways.

Containment and Cleanup: Absorb with inert dry material, sweep or vacuum up and place in a suitable container for proper disposal. Wash spill area with soap and water.

Section 7 Handling and Storage

Precautions for Safe Handling: Read label on container before using. Do not wear contact lenses when working with chemicals. Keep out of reach of children. Avoid contact with eyes, skin and clothing. Do not inhale vapors, spray or mist. Use with adequate ventilation. Avoid ingestion. Wash thoroughly after handling. Remove and wash clothing before reuse.

Conditions for Safe Storage: Store in a cool, well-ventilated area away from incompatible substances.

Section 8 Exposure controls / Personal Protection

Exposure Limits:	Chemical Name	ACGIH (TLV)	OSHA (PEL)	NIOSH (REL)
	Potassium phosphate	None established	None established	None established

Engineering controls: Facilities storing or utilizing this material should be equipped with an eyewash facility and a safety shower and fire extinguishing material. Personnel should wear safety glasses, goggles, or faceshield, lab coat or apron, appropriate protective gloves. Use adequate ventilation to keep airborne concentrations low.

Respiratory protection: None should be needed in normal laboratory handling at room temperatures. If misty conditions prevail, work in fume hood or wear a NIOSH/MSHA approved respirator.

Section 9 Physical and Chemical Properties

Appearance: Clear, colorless liquid. Odor: No odor. Odor threshold: Data not available. pH: 7.0 Melting/Freezing point: Approx. 0°C (32°F) (water) Boiling point: Approx. 100°C (212°F) (water) Flash point: Data not available	Evaporation rate (Water = 1): <1 Flammability (solid/gas): Data not available. Explosion limits: Lower/Upper: Data not available Vapor pressure (mm Hg): 14 (water) Vapor density (Air = 1): 0.7 (water) Relative density (Specific gravity): Approx. 1.0 (water) Solubility(ies): Complete in water.	Partition coefficient: Data not available Auto-ignition temp.: Data not available Decomposition temp.: Data not available Viscosity: Data not available. Molecular formula: Mixture Molecular weight: Mixture
--	--	--

Section 10 Stability and Reactivity

Chemical stability: Stable

Hazardous polymerization: Will not occur.

Conditions to avoid: Excessive temperatures which cause evaporation.

Incompatibilities with other materials: Acids, alkalies, and air will change the buffer's ability.

Hazardous decomposition products: Thermal decomposition will yield phosphates and sodium oxide and/or hydroxides.

Section 11 Toxicological Information

Acute toxicity: Oral-rat LD50: 3,200 mg/kg [Potassium phosphate]

Serious eye damage/irritation: Data not available

Germ cell mutagenicity: Data not available

Skin corrosion/irritation: Data not available

Respiratory or skin sensitization: Data not available

Carcinogenicity: Data not available

NTP: No component of this product present at levels greater than or equal to 0.1% is identified as a known or anticipated carcinogen by NTP.

IARC: No component of this product present at levels greater than or equal to 0.1% is identified as probable, possible or confirmed human carcinogen by IARC.

OSHA: No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by OSHA.

Reproductive toxicity: Data not available

STOT-single exposure: Data not available

Aspiration hazard: Data not available

STOT-repeated exposure: Data not available

Potential health effects:

Inhalation: May be harmful if inhaled.

Ingestion: May be harmful if swallowed.

Skin: May cause mild irritation.

Eyes: May cause mild irritation.

Signs and symptoms of exposure: To the best of our knowledge the chemical, physical and toxicological properties have not been thoroughly investigated. Specific data is not available. Exercise appropriate procedures to minimize potential hazards.

Additional information: RTECS #: TC661500 [Potassium phosphate]

Section 12 Ecological Information

Toxicity to fish: No data available

Toxicity to daphnia and other aquatic invertebrates: No data available

Toxicity to algae: No data available

Persistence and degradability: No data available

Bioaccumulative potential: No data available

Mobility in soil: No data available

PBT and vPvB assessment: No data available

Other adverse effects: An environmental hazard cannot be excluded in the event of unprofessional handling or disposal.

Section 13 Disposal Considerations

These disposal guidelines are intended for the disposal of catalog-size quantities only. Federal regulations may apply to empty container. State and/or local regulations may be different. Dispose of in accordance with all local, state and federal regulations or contract with a licensed chemical disposal agency.

Section 14 Transport Information

UN/NA number: Not applicable

Shipping name: Not Regulated

Hazard class: Not applicable

Packing group: Not applicable

Reportable Quantity: No

Marine pollutant: No

Exceptions: Not applicable

2012 ERG Guide # Not applicable

Section 15 Regulatory Information

A chemical is considered to be listed if the CAS number for the anhydrous form is on the Inventory list.

Component	TSCA	CERLCA (RQ)	RCRA code	DSL	NDSL	WHMIS Classification
Potassium phosphate	Listed	Not Listed	Not Listed	Listed	Not Listed	Uncontrolled Product
Sodium hydroxide	Listed	1,000 lbs (454 kg)	D002	Listed	Not Listed	E

Section 16 Additional Information

The information contained herein is furnished without warranty of any kind. Employers should use this information only as a supplement to other information gathered by them and must make independent determinations of suitability and completeness of information from all sources to assure proper use of these materials and the safety and health of employees.

NTP: National Toxicology Program, IARC: International Agency for Research on Cancer, OSHA: Occupational Safety and Health Administration, STOT: Specific Target Organ Toxicity, SE: Single Exposure, RE: Repeated Exposure, ERG: Emergency Response Guidebook.