



Matter and Energy in Ecosystems:

Biodome Collapse

Lawrence Hall of Science

Program Directors: Jacqueline Barber and P. David Pearson

Curriculum Director, Grades K–1: Alison K. Billman

Curriculum Director, Grades 2–5: Jennifer Tilson

Curriculum Director, Grades 6–8: Suzanna Loper

Assessment and Analytics Director: Eric Greenwald

Learning Progressions and Coherence Lead: Lauren Mayumi Brodsky

Operations and Project Director: Cameron Kate Yahr

Student Apps Director: Ari Krakowski

Student Content Director: Ashley Chase

Leadership Team: Jonathan Curley, Ania Driscoll-Lind, Andrew Falk, Megan Goss, Ryan Montgomery, Padraig Nash, Kathryn Chong Quigley, Carissa Romano, Elizabeth Shafer, Traci K. Shields, Jane Strohm

Matter and Energy in Ecosystems Unit Team: Stacy Au-yang, Elizabeth Ball, Whitney Barlow, Candice Bradley, Benton Cheung, Barbara Clinton, Kristina M. Duncan, Jennifer B. Garfield, Brandon Hutchens, Nadja Lazansky, M. Lisette Lopez, Deirdre MacMillan, Amybeth O'Brien, Patrice Scinta, Claire Spafford, Lauren Wielgus, Joshua A. Willis

Amplify Irene Chan, Samuel Crane, Shira Kronzon, Charvi Magdaong, Thomas Maher, Rick Martin, Matt Reed, Eve Silberman, Steven Zavari

© 2018 by The Regents of the University of California. All rights reserved. No part of this publication may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopy, recording, or any information storage or retrieval system, without permission in writing from the publisher.

These materials are based upon work partially supported by the National Science Foundation under grant numbers DRL-1119584, DRL-1417939, ESI-0242733, ESI-0628272, ESI-0822119. The Federal Government has certain rights in this material. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

These materials are based upon work partially supported by the Institute of Education Sciences, U.S. Department of Education, through Grant R305A130610 to The Regents of the University of California. The opinions expressed are those of the authors and do not represent views of the Institute or the U.S. Department of Education.

Developed by the Learning Design Group at the University of California, Berkeley's Lawrence Hall of Science.

Matter and Energy in Ecosystems: Biodome Collapse

ISBN: 978-1-942010-95-1

Amplify.



Table of Contents

 LESSON GUIDES 0

CHAPTER 1 1

Lesson 1.1 5

Lesson 1.2 19

Lesson 1.3 37

Lesson 1.4 49

Lesson 1.5 65

Lesson 1.6 81

CHAPTER 2 101

Lesson 2.1 105

Lesson 2.2 121

Lesson 2.3 135

Lesson 2.4 149

Lesson 2.5 163

CHAPTER 3 183

Lesson 3.1 187

Lesson 3.2 201

Lesson 3.3 215

Lesson 3.4 229

CHAPTER 4 249

Lesson 4.1 253

Lesson 4.2 267

Lesson 4.3 281

Lesson 4.4 297



Chapter 1

Photosynthesis



Chapter Overview

Chapter Question

Why didn't the plants and animals in the biodome have enough energy storage molecules?

Investigation Questions

- Where do the energy storage molecules in an ecosystem come from? (1.2, 1.3, 1.4)
- What factors affect how many energy storage molecules producers are able to make? (1.5, 1.6)

Key Concepts

- Carbon is part of carbon dioxide, which is abiotic matter. Carbon is also part of energy storage molecules, which are biotic matter. (1.4, 1.5) ?
- During the process of photosynthesis, producers make energy storage molecules, using carbon from carbon dioxide and energy from sunlight. This moves carbon from abiotic to biotic matter. (1.4) ?
- If one part of a system changes, this affects the rest of the system. (1.5) ?
- When there is more carbon (in the form of carbon dioxide) in abiotic matter, more carbon is available to producers for making energy storage molecules. (1.6) ?
- When there is less carbon (in the form of carbon dioxide) in abiotic matter, less carbon is available to producers for making energy storage molecules. (1.6)
- When there is more sunlight, producers can make more energy storage molecules from the carbon in carbon dioxide. (1.6) ?
- When there is less sunlight, producers cannot make as many energy storage molecules from the carbon in carbon dioxide. (1.6)



Chapter 1 Activities

Lesson 1.1: Pre-Unit Assessment

1	Multiple-Choice Questions	CLASS	
2	Written-Response Question #1	CLASS	
3	Written-Response Question #2	CLASS	

Lesson 1.2: Investigating a Biodome

T	Introducing Biosphere 2	TEACHER	
1	Warm-Up	WARM-UP	
T	Introducing the Biodome	TEACHER	
2	Examining the Biodome Files	READING	
3	Introducing the Simulation	SIM	

Lesson 1.3: Sunlight and Life

1	Warm-Up	WARM-UP	
2	Active Reading: Sunlight and Life	READING	
3	Discussing Annotations	STUDENT-TO-STUDENT DISCUSSION	
4	Homework	HOMEWORK	

Lesson 1.4: How Energy Storage Molecules Are Made

1	Warm-Up	WARM-UP	
2	Revisiting Sunlight and Life	READING	
3	Observing Photosynthesis Close Up	SIM	
4	Homework	HOMEWORK	

Lesson 1.5: Photosynthesis in Ecosystems

1	Warm-Up	WARM-UP	
2	Modeling Energy Storage Molecules	MODELING TOOL	
3	Decreasing Energy Storage Molecules	SIM	
4	Homework	HOMEWORK	

Lesson 1.6: Examining Data from the Biodome

- 1

Warm-Up
- T

A New Message from Dr. Corry
- 2

Examining Data from the Biodome
- 3

Reasoning About Data from the Biodome
- 4

A Model for the Econauts
- 5

Homework
- 6

Self-Assessment (Optional)

- WARM-UP


- TEACHER


- STUDENT-TO-STUDENT DISCUSSION

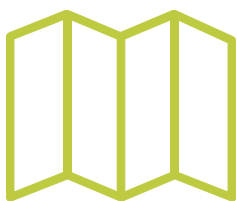

- WRITING


- MODELING TOOL


- HOMEWORK


- HOMEWORK





Lesson 1.1

Pre-Unit Assessment



Lesson at a Glance

ACTIVITY

1

Multiple-Choice Questions (25 min)

These multiple-choice questions provide an auto-scored measure of students' placements on the Progress Build.

CLASS

2

Written-Response Question #1 (10 min)

This written-response question provides additional information about students' placements on the Progress Build including both unit-specific science concepts and crosscutting concepts. This item can be scored by referencing the provided rubrics in the *Matter and Energy in Ecosystems* Pre-Unit Assessment Answer Key and Scoring Guide (in Digital Resources).

CLASS

3

Written-Response Question #2 (10 min)

This written-response question provides additional information about students' placements on the Progress Build including both unit-specific science concepts and crosscutting concepts. This item can be scored by referencing the provided rubrics in the *Matter and Energy in Ecosystems* Pre-Unit Assessment Answer Key and Scoring Guide (in Digital Resources).



CLASS



DIGITAL RESOURCES

Matter and Energy in Ecosystems
Pre-Unit Assessment copymaster

Matter and Energy in Ecosystems
Pre-Unit Assessment Answer Key
and Scoring Guide

Questioning Strategies for Grades
6-8

Matter and Energy in Ecosystems
Glossary

Matter and Energy in Ecosystems
Multi-Language Glossary



1

CLASS

Multiple-Choice Questions



Multiple-Choice Questions



Students complete 18 multiple-choice questions to show their current understanding of the content before beginning this unit.

Instructional Guide

1. Students complete multiple-choice questions. Circulate and assist students with clarifying instructions, as needed.

Teacher Support

Assessment

Pedagogical Goals: Assessing Complex Ideas

The Pre-Unit, Critical Juncture, and End-of-Unit assessments are different from traditional multiple-choice tests. Rather than testing recall of isolated facts, the questions are designed to assess the deep, explanatory understanding called for in NGSS and the Progress Build. Students are required to figure out and explain or make predictions about phenomena and as a result, students should expect to spend more time with each question as they think through the scenarios and work out their answers.

Rationale

Pedagogical Goals: Why Use a Pre-Unit Assessment?

Having students complete an assessment before the unit begins and then again at the end of the unit provides a baseline from which to measure growth of understanding over the course of the unit. Further, it offers the opportunity to understand students' early ideas and initial understanding of the unit's core content, something that can help you adjust instruction to meet the needs of students in your class. In addition, you can also use students' final written arguments from the previous unit as a pre-assessment of their facility with the Science Practice of Engaging in Argument with Evidence.



Possible Responses

1. The sun has been up for several hours, and it has been shining on these trees. What can the trees do because they are in sunlight? What does this mean for the number of energy storage molecules in the trees?

The trees can . . .

c. **take in** carbon from the air. The carbon is used to make energy storage molecules.

2. These goats are eating grass on a sunny day. What is happening to the carbon in the air around the living things on the mountain? Is carbon moving into the air, moving out of the air, or both?

b. Carbon is moving into the air **and** out of the air at the same time.

3. Will has an aquarium with water, plants, and fish that eat the plants. It is sealed so no material can get in or out, and has glass sides that allow sunlight to come in. The aquarium can also be covered to prevent light from entering.

The amount of carbon in the aquarium's water started out high. Now, the amount of carbon in the water is decreasing. Is the aquarium now in sunlight or is it covered? What is happening to the number of energy storage molecules in the plants and fish as a result?

a. The aquarium is now in sunlight, and there are **more** energy storage molecules in the plants and fish.

4. Scientists are studying photosynthesis in a forest ecosystem that has plants, animals, and decomposers (which consume dead things). Which group or groups of organisms in the forest carry out photosynthesis?

d. plants

5. A herd of deer lives in a forest where they eat the leaves of trees. The number of energy storage molecules in the trees and in the deer has increased. What has happened to the amount of carbon in the trees and in the deer?

The amount of carbon in the trees and in the deer . . .

a. has increased.

6. This sea grass has had the sun shining on it for most of the day. What can the sea grass do because it is in sunlight? What does this mean for the number of energy storage molecules in the sea grass?



The sea grass can...

b. **take in carbon from the air.** The carbon is used to break down energy storage molecules.

7. This tortoise is eating cactus on a sunny day. Is carbon moving into the air, moving out of the air, or both?

d. Carbon is moving into the air **and** out of the air at the same time.

8. Lily has an aquarium with water, plants, and fish that eat the plants. The aquarium is sealed so no material can get in or out, and has glass sides that allow light to come in. The aquarium can also be covered to prevent light from entering.

The number of energy storage molecules in the plants and fish started out low, but that number has been increasing over time. Has the aquarium been in sunlight or has it been covered during this time? What has happened to the carbon in the water?

d. The aquarium has been in sunlight, and there is **less** carbon in the water.

9. Scientists are studying cellular respiration in a jungle ecosystem that has plants, animals, and decomposers (which consume dead things). Which group or groups of organisms in the jungle carry out cellular respiration?

c. all organisms in the jungle

10. Giant pandas eat bamboo plants in the mountains of China. The number of energy storage molecules has decreased in both the bamboo and the pandas. What has happened to the amount of carbon in the bamboo and the pandas?

The amount of carbon in the bamboo and pandas . . .

d. has decreased.

11. Giant kelp are plantlike organisms that grow in clear ocean water. Over the last few hours some kelp has been taking in carbon from the water around it. Is the kelp in sunlight? What has happened to the number of energy storage molecules in the kelp?

The kelp . . .

b. **is** in sunlight, and the number of energy storage molecules in the kelp has **increased**.



12. A rabbit is eating leafy plants on a sunny day. What is happening to the carbon in the plants and in the rabbit?

c. Carbon is moving into and out of the living things at the same time.

13. A scientist set up an experimental ecosystem in a sealed room with no windows. The experimental ecosystem has plants, and animals that eat those plants. The scientist can control whether the room is light or dark with a light switch outside the room.

The amount of carbon in the air of the ecosystem started out low. Then the amount of carbon in the air started to increase. Is the increase because the scientist switched the light *on* or because she switched the light *off*? What happened to the number of energy storage molecules in the living things?

The scientist . . .

a. switched the light **off**, and the number of energy storage molecules in the living things **decreased**.

14. Scientists are studying photosynthesis in a desert ecosystem that has plants, animals, and decomposers (which consume dead things). Which group or groups of organisms in the desert carry out photosynthesis?

a. plants

15. Scientists are studying cellular respiration in a river ecosystem that has plants, animals, and decomposers (which consume dead things). Which group or groups of organisms in the river carry out cellular respiration?

c. all organisms in the river

16. An ivy plant has been taking in carbon from the air for several hours.

Is the ivy in sunlight? What has happened to the number of energy storage molecules in the ivy?

The ivy . . .

b. is **in** sunlight. The number of energy storage molecules in the ivy has **increased**.

17. A group of giraffes feeds on leaves and grasses during the daytime. Right now, it is dark out and the giraffes are *not* eating. Is carbon moving into the living things, moving out of the living things, or both?

c. Carbon is only moving out of the living things; it is not moving into them.



18. Reza has a glass ball filled with water that contains tiny plants and shrimp that eat those plants. No material can get in or out, but light can get through the glass when it is placed in sunlight.

The number of energy storage molecules in the plants and shrimp started out high, but then the glass ball was moved, and the number of energy storage molecules decreased. Was the glass ball moved into the *light* or into the *dark*? What happened to the amount of carbon in the air?

b. The glass ball was moved into the **dark**, and there is **more** carbon in the water.



2

CLASS

Written-Response
Question #1

Written-Response Question #1



Students complete the first written-response question on the Pre-Unit Assessment.

Instructional Guide

1. Students complete first written-response question. Circulate and assist students with clarifying instructions, as needed.

Possible Responses

This space station has plants growing inside it, and astronauts who eat the fruits and vegetables from those plants. Because it is in space, the station is sealed so no material can get in or out. The space station is in Earth's shadow, so no light is getting into it. The sensors in the space station show that carbon dioxide in the air is increasing. What is happening to the energy storage molecules in the plants and humans in the space station? Explain your answer as completely as possible.

Level 1: Student indicates that the number of energy storage molecules is not increasing because without light plants cannot perform photosynthesis.

Possible student response: Since there is no light in the space station, the plants are not doing photosynthesis, so they are not making energy storage molecules. This means that the number of energy storage molecules in the plants and animals is not increasing.

Level 2: Student demonstrates an understanding of photosynthesis from Level 1 and indicates that the number of energy storage molecules is decreasing as all organisms release carbon dioxide through cellular respiration.



Possible student response: Since there is no light in the space station, the plants are not doing photosynthesis, so they are not making energy storage molecules. However, the organisms are using up energy storage molecules when they do cellular respiration, and that gives off carbon dioxide to the air, which is why it is increasing. This means that the number of energy storage molecules in the plants and animals is decreasing because they are only using them up.

Level 3: Student demonstrates an understanding of Levels 1 and 2 and explains that increasing carbon dioxide necessitates a decrease in energy storage molecules, because there is a fixed amount of carbon in the space station.

Possible student response: Since there is no light in the space station, the plants are not doing photosynthesis, so they are not making energy storage molecules. However, the organisms are using up energy storage molecules when they do cellular respiration, and that gives off carbon dioxide to the air, which is why it is increasing. Because carbon cannot be produced or used up, and since carbon dioxide in the air increased, that means the number of energy storage molecules in the plants and animals is decreasing.



3

CLASS

Written-Response
Question #2

Written-Response Question #2



Students complete the second written-response question on the Pre-Unit Assessment.

Instructional Guide

1. Students complete the second written-response question. Circulate and assist students with clarifying instructions, as needed.

Possible Responses

A scientist is studying an aquarium ecosystem that contains water, plants, and fish that eat those plants. The aquarium has glass walls so light can get in, but it is sealed so no material can move into or out of the tank. When the scientist turned the aquarium's light on, carbon in the water started decreasing. How is carbon moving and what is happening to the amount of carbon in the living things inside the aquarium? Explain your thinking as completely as possible.

Level 1: Student indicates carbon is moving into living things and biotic carbon is increasing as plants perform photosynthesis.

Possible student response: Since the aquarium is exposed to light, the plants are performing photosynthesis. This means carbon dioxide from the air is moving into living things so the plants can use the carbon to make energy storage molecules, which is why carbon in the air is decreasing. Because of this, carbon in living things is increasing.

Level 2: Student indicates an understanding of carbon movement from Level 1 and indicates that there is also carbon moving out of living things as organisms give off carbon dioxide produced through cellular respiration.



Possible student response: Since the aquarium is exposed to light, the plants are performing photosynthesis. This means carbon dioxide from the air is moving into living things so the plants can use the carbon to make energy storage molecules, which is why carbon in the air is decreasing. I also know that some carbon is moving out of living things into the air, because the organisms are giving off carbon dioxide as they use up energy storage molecules through cellular respiration. Because carbon is moving into and out of living things, I am not sure how the amount of carbon in living things is changing.

Level 3: Student indicates an understanding of Levels 1 and 2 and indicates that the amount of carbon in living things must be increasing because there is a fixed amount of carbon in the aquarium.

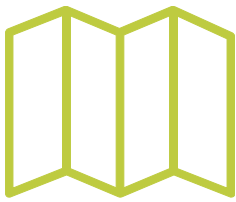
Possible student response: Since the aquarium is exposed to light, the plants are performing photosynthesis. This means carbon dioxide from the air is moving into living things so the plants can use the carbon to make energy storage molecules, which is why carbon in the air is decreasing. Because of this, carbon in living things is increasing. I also know that some carbon is moving out of living things into the air, because the organisms are giving off carbon dioxide as they use up energy storage molecules through cellular respiration. Since the amount of carbon in the air is decreasing, the amount of carbon in living things is increasing. This is because it is a closed ecosystem and there is a set amount of carbon—it can't be produced or used up.



Image Credits

Shutterstock--Joel Stock/Getty Images-- groveb/Getty Images-- Sean Bagshaw/Science Source-- Bryan and Cherry Alexander/Science Source-- William Sherman/Getty Images-- Stephen Muskie/Getty Images-- Frank van den Bergh/Getty Images (Matter and Energy in Ecosystems Pre-Unit Assessment copymaster).





Lesson 1.2

Investigating a Biodome



Lesson at a Glance

ACTIVITY

**Introducing Biosphere 2**

A video introduces students to Biosphere 2, an actual biodome experiment and realistic backdrop for the mission that students will undertake in this unit.



TEACHER

**Warm-Up (5 min)**

Students respond to the video about Biosphere 2, providing an opportunity for students to take an interest in this unit's content.



WARM-UP

**Introducing the Biodome (5 min)**

Students are introduced to their role as student ecologists who are determining why the organisms in the biodome no longer had the resources they needed to release energy.



TEACHER

**Examining the Biodome Files (20 min)**

Students read a chapter of their choice from the *Biodome Files* in order to help them brainstorm some initial ideas about why the organisms in the biodome did not have enough energy storage molecules.



READING

**Introducing the Simulation (15 min)**

An introduction to the *Matter and Energy in Ecosystems* Simulation allows students to become familiar with the tool they will be using to collect evidence throughout the unit.



SIM



DIGITAL RESOURCES

Video: Living in a Biosphere

Biodome File 1: News Stories

Printable article set: Biodome Files

Active Reading Guidelines

Matter and Energy in Ecosystems
Investigation Notebook, pages 5–8

Completed Scientific
Argumentation Wall Diagram

Printable Matter and Energy in
Ecosystems Glossary

Printable Matter and Energy in
Ecosystems Multi-Language
Glossary

Matter and Energy in Ecosystems
Glossary

Matter and Energy in Ecosystems
Multi-Language Glossary



TEACHER

Introducing Biosphere 2



Introducing Biosphere 2

The teacher plays the video, *Living in a Biosphere*, which students respond to during the Warm-Up.

Instructional Guide

1. Project and play *Living in a Biosphere*. Collapse the instructional guide and project the video, using the play button at the bottom of the screen. Let students know that this video introduces the problem they will be trying to solve in this new unit.



1

WARM-UP
Warm-Up

Warm-Up



Students respond to a video about a biosphere, a closed and self-sustaining ecosystem, similar to the one featured in this unit.

Instructional Guide

1. Project Warm-Up; students work independently. Collapse the instructional guide and project the student screen, or have students turn to page 6 in their Investigation Notebooks. Allow a few minutes for students to individually respond to the Warm-Up.

Teacher Support

Rationale

Pedagogical Goals: Warm-Ups

If needed, remind students about the Warm-Up routine. The Warm-Up at the beginning of each lesson is meant to be a sponge activity that engages students in ideas from the unit. This daily routine not only provides low-stakes opportunities for students to reflect on and write about science concepts in order to prepare for the lesson, it also provides a structure for the beginning of each class to make transitioning into class easier for students and for you. Explain that at the beginning of every lesson, there will be a prompt (a question or an activity) for students to independently complete that will help them begin to think about science ideas they will learn. Students should understand that this is a quick, yet focused, activity that you expect them to complete independently.

Possible Responses

Answers will vary.



TEACHER

Introducing the Biodome



Introducing the Biodome



Students are introduced to their role as ecologists who are investigating why the energy needs of the organisms in the biodome were not met.

Instructional Guide

1. Introduce the unit. Point out that students just watched a video about Biosphere 2, a closed ecosystem that is an actual scientific research station built by humans. Explain that in this unit, students will be learning about how matter and energy affect the way ecosystems work.

2. Project message from head ecologist and read aloud. Explain that this is a fictional scenario, but it is based on Biosphere 2. For this unit, the students will work for the Biodome Investigation Team under the direction of Head Ecologist, Dr. Bryan Corry, as he tries to discover some possible reasons why the biodome experiment failed.



To: Student Ecologists
From: Dr. Bryan Corry
Subject: Welcome to Your Mission!

Welcome to the Biodome Investigation Team! You just learned about Biosphere 2, an experimental research facility that was built for learning more about Earth and its ecosystems.

Five years ago, the Ecnauts constructed a biodome similar to Biosphere 2. They recently noticed that the organisms inside the biodome were getting sick and failing to reproduce. To protect the people and organisms inside, they shut down the biodome. The Ecnauts hired us to figure out what caused their biodome to fail, but we need your help. I'm including a presentation that explains your mission in more detail.

Student ecologists, we are counting on you!

Bryan
Dr. Bryan Corry, Head Ecologist
Biodome Investigation Team



3. Project the slideshow about the biodome mission and read, or have a student read, the text on each projection aloud.

Introducing the Biodome.

Introducing the Biodome

Five years ago, a local group called the Econauts began an ambitious project to determine if humans could survive on another planet. They constructed a biodome, an ecosystem inside a glass dome larger than a football field. The ecosystem was filled with plants, animals, and a volunteer group of eight humans.



The Problem.

The Problem

For the first few years, the plants and animals inside the biodome seemed healthy and normal. In the last few years, however, the Econauts began to notice some problems. Animals were getting sick and failing to reproduce.



Plants weren't growing as big or producing as much fruit as they once did. The Econauts realized that something had gone wrong. Although the organisms were safely removed from the biodome, the cause of these problems is still a mystery.



Your Mission. This projection introduces students to the Chapter 1 Question. Show students that this question has also been posted on the classroom wall beneath the Unit Question. Explain to students that they will need to answer both questions in order to solve the mystery of the failed biodome.

Your Mission

The Econauts want to build another biodome, but first, they need to understand what went wrong with this one.

Please help us solve this mystery!

Chapter 1 Question

Why didn't the plants and animals in the biodome have enough energy storage molecules?

4. Invite students to suggest reasons that organisms need energy storage molecules. If necessary, provide examples, such as growing or reproducing.

5. Remind students of the connection between energy storage molecules and releasing energy. Help students connect the Unit Question (about releasing energy) to the Chapter Question (about energy storage molecules).

6. Introduce the vocabulary term *energy storage molecule*, and project the definition. If students have seen this term in previous units, remind them that it should be familiar.

Vocabulary

energy storage molecule: a molecule that organisms can use to release the energy they need to survive



7. Remind students to look at the glossary if they need more support. Based on your selection, go over the glossaries (digital and/or paper) that you want students to use and explain any expectations you have about maintaining or using these glossaries.

Teacher Support

Background

Science Note: The Biodome Context

The fictional biodome in this unit is based on Biosphere 2, a closed ecosystem that was constructed in Arizona in 1991 by a group who wanted to create a self-sustaining ecosystem. It is now a research facility run by the University of Arizona. The organisms featured in this unit are similar to the organisms that were placed in Biosphere 2 with some small modifications. Slightly fictionalizing some details allow us to focus on the key science concepts that will best help students meet the NGSS standards. Refer to the Reference: Science Background document for more information about the Biosphere 2 project.

Rationale

Pedagogical Goal: The Carbon Cycle

We have chosen to focus on a closed ecosystem to better illustrate the processes by which carbon moves in and around ecosystems. With no carbon entering or leaving the ecosystem, it is much easier for students to track its movement so they can make inferences about how the amount of carbon in abiotic and biotic matter of an ecosystem affects ecosystem processes. In the Science Seminar, the culminating activity of the unit, students will consider the scenario of Earth's atmosphere. Students will use evidence to explain why deforestation leads to an increase in carbon dioxide in the air.

Background

Science Note: About Energy Storage Molecules

If you taught the Amplify Science unit, *Populations and Resources*, your students have been introduced to the idea of *energy storage molecules*. This term refers to the molecules that store energy: glucose, glycogen, fats, and starches. These molecules can be broken into glucose or other molecules that react with oxygen to release energy during the process of cellular respiration. If your students have not been introduced to this term already, or need a refresher, you may want to spend time reviewing the idea that living things use these molecules, along with oxygen, to release energy.



2

READING

Examining the Biodome
Files



Examining the Biodome Files



Students read from the *Biodome Files*, which they use to brainstorm initial ideas about the Chapter Question.

Instructional Guide

1. Introduce the *Biodome Files* activity. Explain to students that they will begin to investigate the Chapter Question by examining some documents from the biodome that Dr. Corry left for them.

2. Project “[Biodome File 1: News Stories](#)” from the Amplify Library, or project the printed article using a document camera. Note that this is a set of files—there are five altogether. Tell students to choose at least one of these files to read. Suggest that students may want to annotate as they read in order to remember specific details.

3. Explain that students will use the *Biodome Files* to make some initial claims about the Chapter Question. After reading, students will share their initial claims with a partner.

 As you read, look for information that might help you figure out why there weren’t enough energy storage molecules for plants and animals in the biodome. Remember, these are just your initial claims, so don’t worry about being right or wrong.

If students are using the Investigation Notebook, have them turn to page 7 and point out the space for them to write initial claims.

4. Students read individually. Circulate and offer assistance as needed.

5. After a few minutes, remind students to record their ideas and discuss them with a partner. Allow a few minutes for students to write and discuss their claims.

If students are using digital devices, ask them to press NEXT.

6. Lead a brief class discussion of the *Biodome Files*. Invite some students to share their initial claims with the class.

7. Highlight that students are making claims about different things that could cause an ecosystem to change. Invite students to share their ideas about what an ecosystem is.



8. Introduce the vocabulary words *ecosystem* and *system*, and project the definitions. Collapse the instructional guide and project the student screen. Read (or ask a student to read) these words and definitions aloud. Point out that these word are also posted on the classroom wall and remind students to look at the glossary if they need more support.

9. Invite students to offer examples of different ecosystems and the things that make up these ecosystems. If students are uncertain, provide a few examples of different ecosystems and the things that make them up. Then, ask students to provide some examples of their own, calling attention to the fact that the ecosystem is made up of both living and nonliving things.

 There are many different types of ecosystems, including forest ecosystems, desert ecosystems, and even smaller ecosystems, like the one inside a fish tank. Each of these ecosystems includes both living things, like plants or fish, as well as nonliving things, like sand or water.

10. Establish that an ecosystem is just one type of system. Explain that all scientific systems have certain characteristics in common, such as different parts that interact. Invite students to offer examples of other systems that have interacting parts.

If students are using digital devices, ask them to press NEXT.

11. Introduce the vocabulary terms *biotic matter* and *abiotic matter* that scientists use for parts of an ecosystem, and project the definitions. Collapse the instructional guide and project the student screen. Read (or have a student read) the definitions aloud. Because this is a distinction that students tend to overlook, emphasize that even though biotic matter refers to the living things in an ecosystem, it also includes dead things that used to be alive.

 Scientists use a special term for the living things in an ecosystem—*biotic matter*. Bio- means living, so biotic matter refers to all kinds of living things, but when scientists use the term *biotic matter*, they are also referring to things that were living at one time, like dead leaves or dead animals. Scientists consider dead things to be different from things in an ecosystem that were *never* alive, like air or water. These nonliving things have a different scientific name—*abiotic matter*. The prefix a- means *not* or *opposite*.

12. Remind students to look at the glossary if they need more support.

13. Have students discuss with a partner whether their initial claim about the Chapter Question pointed to biotic matter or abiotic matter. If necessary, provide students an example of a biotic claim and an abiotic claim. Explain that some claims may be both biotic and abiotic.

 An example of a biotic claim might be that Econauts put the wrong animals in the biodome, because animals are living things, and that makes them biotic matter. An example of an abiotic claim might be that the water system in the biodome did not work properly, since water isn't living or dead, that makes it part of abiotic matter.



Teacher Support

Rationale

Student Thinking: Examining the Biodome's Water System

During the development of this unit, we found that students gravitated toward using water—or lack thereof—as the reason that the biodome failed. This is understandable, since students know from experience that access to water is a necessary prerequisite for life. However, since this unit is designed to focus on how carbon moves in an ecosystem, an explanation that hinges on access to water is not conducive to addressing this content. As a result, we added “Biodome File 4: Biodome Water System Diagram” in order to preempt students who might otherwise fixate on water as the cause of the problem. This diagram includes a note from Dr. Corry confirming that the water system in the biodome was properly designed and did not cause any problems for the ecosystem. If students begin to speculate about the role of water in the failure of the biodome, it may be necessary to draw attention to this note in order to prevent a digression into content outside the scope of this unit.

Rationale

Pedagogical Goals: Approach to Science Vocabulary

Our approach to building a strong base of disciplinary vocabulary is based on the idea that words are concepts and that sophisticated word knowledge involves an understanding of how words relate to other words and how words are used in context. For example, a student might have some understanding of the word *ecosystem* if he or she memorized the definition: *all the living and nonliving things interacting in a particular area*. However, our preference is for this student to build a deeper understanding of the word; an understanding that includes knowing why an ecosystem includes both living and nonliving things, that there are different kinds of ecosystems on Earth (deserts, rainforests, ponds, etc), and there are features common to all ecosystems, rather than specific to some, among many other things. To support this deeper level of understanding, we introduce students to a small number of conceptually important words and expose them to these words many times, in many ways, throughout the unit.

Instructional Suggestion

Going Further: Making a T-Chart for Biotic and Abiotic Claims

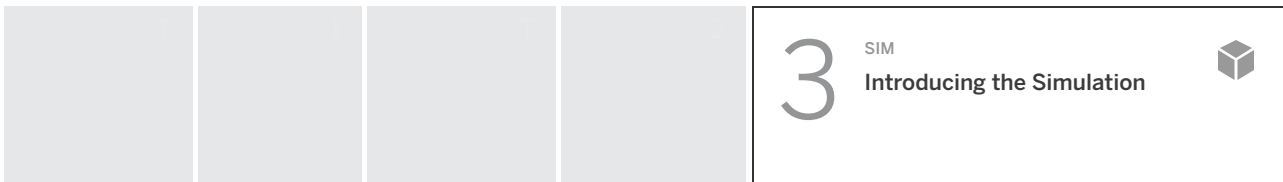
As part of this lesson, students discuss with a partner whether their claims about the Chapter Question refer to biotic matter or abiotic matter, providing an opportunity to begin constructing ideas about the different parts of an ecosystem. This discussion can be made into a multimodal activity: use a piece of chart paper to make a Biotic Matter/Abiotic Matter T-chart, have students write their claims on sticky notes, and place them onto the chart in the category where they think their claim belongs. Although doing this requires additional time, it can be used to facilitate a rich and participatory classroom discussion of these two words, which will help students to understand them in a deeper and more meaningful way.



Possible Responses

Chapter 1 Question: *Why didn't the plants and animals in the biodome have enough energy storage molecules?*

Answers will vary. Students are not expected to have accurate ideas at this point—the purpose of this prompt is to give students a chance to express their initial ideas.



Introducing the Simulation



Students use the Sim to make observations about where the energy storage molecules in an ecosystem come from.

Instructional Guide

1. Set purpose for next activity. Point out the Investigation Question on the board. Connect this investigation to the Chapter Question and to the Sim activity.

Throughout this chapter, we'll be trying to figure out why the plants and animals in the biodome weren't getting enough energy storage molecules. However, in order to figure that out, we need to start with a simpler question: Where do the energy storage molecules in an ecosystem come from? This will be our first investigation, and completing it will bring us one step closer to solving the mystery of the failed biodome. Today, we will begin our investigation by exploring a Simulation that will help us learn about energy storage molecules and ecosystems.

2. Introduce and project the *Matter and Energy in Ecosystems Sim*. Explain to students that they will be using this tool throughout the unit. It is a model of an ecosystem, and it is similar to the models that professional ecologists use to study ecosystems.

3. Set expectations for partner work. Explain that students will work in pairs while they explore the Sim. If students have individual devices, students will each explore with their own devices, but partners should share interesting observations and show each other what they notice. If students are using the Investigation Notebook, have them turn to page 8 and point out the instructions for exploring the Sim.

4. Give pairs several minutes of free exploration time. Circulate as students explore, encouraging students to discuss what they are observing with their partners. Listen for student questions or alternate conceptions as they relate to the basic components of the Sim.

5. Have a few volunteers share their observations. Make sure these key features of the Sim are highlighted for the class:

- **Different types of molecules and atoms:** The Sim includes energy storage molecules, carbon, carbon dioxide, water, and oxygen. Oxygen and water are only visible in cell view.



- **How energy storage molecules move:** These molecules flow between the different parts of the ecosystem, such as when organisms die or eat other organisms.
- **Control buttons:** The Sim includes buttons that allow students to kill organisms, bury dead matter, burn dead matter, trap carbon dioxide, and adjust the amount of sunlight.
- **Graphs:** By pressing the graph icon, students are able to see visual data about the ecosystem and plot nine different quantities.
- **View Cell:** By pressing VIEW CELL, students can zoom in to see what is happening at the cellular level in various parts of the ecosystem.
- **Information:** By pressing the information icon, students can see numerical data rather than a visual representation of the ecosystem.

6. Call attention to the terms *biotic matter* and *abiotic matter* in the Sim. Ask students to share where they saw these labels in the Sim. This will provide further reinforcement for understanding how these terms are connected.

Ask students to press NEXT (to move on to Part 2 on page 8 in the Investigation Notebook) to continue this activity.

7. Resume projecting the Sim and introduce the observation task. Collapse the instructional guide and project the student screen, or have students turn to page 8 in their Investigation Notebooks. Explain that students will now begin to gather evidence about where energy storage molecules come from by observing their movement through the Sim ecosystem.

8. Read the instructions aloud. If students are using individual devices, make sure they understand that the Sim should be open on only one partner's device; partners need to observe the Sim on one device as they record answers (yes or no) in the data table on the other device. Emphasize that both partners should be observing the Sim and that they should take turns filling in the data table. If partners are sharing devices, they should both record their answers in their Investigation Notebooks.

9. Instruct students to use the default settings in the Sim. Explain that in the future, students will have opportunities to experiment with changing the ecosystem settings. Initially, however, emphasize that it is important for students to see how energy storage molecules move through a typical ecosystem.

10. Pairs complete the Sim observation task. Circulate and offer assistance as needed. Allow a few minutes for students to observe the Sim and complete the data table.

11. With any remaining time, invite students to share their ideas about the discussion questions. Encourage students to share anything they observed about the movement patterns of energy storage molecules or where different organisms might get energy storage molecules.



Teacher Support

Rationale

Pedagogical Goals: Importance of Exploration Time

The first time students use a Simulation, they need a few minutes to freely explore the Simulation features. Students are generally quite facile in discovering Simulation features independently or with a partner. This type of open-ended exploration enhances student interest, providing students with the opportunity to share their thinking and learn from their peers. Giving students this exploration time initially reduces distraction in later Sim activities that have more focused goals.

Instructional Suggestion

Going Further: Using the *Populations and Resources* Sim

If you previously taught the Amplify Science unit, *Populations and Resources*, to these students, you may choose to do an additional activity that will make explicit connections between that unit and *Matter and Energy in Ecosystems*. To do this optional activity, launch the [Populations and Resources Sim](#) and explain that students will begin to investigate where an ecosystem's energy storage molecules come from by reviewing what they learned about energy storage molecules in the *Populations and Resources* Sim. Run the *Populations and Resources* Sim in WEB view and discuss where the weebug, furbil and greenleaf populations get energy storage molecules. As students observe, ask and discuss the following questions:

- Where do the weebugs and furvils get the glucose they need? [From eating greenleaves.]
- Where do the greenleaves get the energy storage molecules they need? [The Sim doesn't show how greenleaves get energy storage molecules, just that they are a resource population.]
- Where do the energy storage molecules for all the populations in the ecosystem come from originally? [All the energy storage molecules start with the greenleaves.]

Highlight grouping and representational differences for organisms in the two Sims.

Possible Responses

What students should do and notice:

By exploring and sharing what they notice in the Sim, students become familiar with the features of the Sim.

What students should/might do:

Students should run the Sim with the default settings. In the main view, they should observe the flow of energy storage molecules into and out of the different organism groups. They should then record these observations in the table on the student screen.

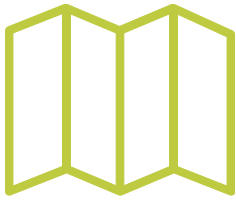
**What students should notice:**

Students should notice that energy storage molecules flow into and out of primary consumers, secondary consumers, and decomposers. Producers are different from the other organisms in that energy storage molecules first appear in producers, and then flow out of producers to the other organisms. Students should realize that producers play some role in the creation of energy storage molecules, though they may not know yet that they are created through photosynthesis.

Correct responses for data table:

- Producers: yes, no, yes
- Consumers: yes, yes, yes
- Decomposers: yes, yes, yes
- Dead Matter: yes, yes, yes
- Abiotic Matter: no, no, no





Lesson 1.3

Sunlight and Life



Lesson at a Glance

ACTIVITY

1

Warm-Up (5 min)

Students are primed to learn about photosynthesis by considering the role that plants play in an ecosystem.

WARM-UP

2

Active Reading: Sunlight and Life (25 min)

Students learn about photosynthesis through Active Reading. The teacher uses this opportunity as an On-the-Fly Assessment of students' ability to engage with scientific texts and summarize main ideas.

READING

3

Discussing Annotations (15 min)

Students discuss their thinking about the reading in order to share important insights and surface alternative conceptions. Students' annotations provide an opportunity for an On-the-Fly Assessment of students' annotation skills, reading comprehension, and content understanding.

STUDENT-TO-
STUDENT
DISCUSSION

4

Homework (8 min)

Students read "What Is Carbon?" as preparation for the next lesson in which they will think further about how the carbon in an ecosystem moves from abiotic matter to biotic matter.



HOMEWORK



DIGITAL RESOURCES

Sunlight and Life

Printable article set: Sunlight and Life

What Is Carbon?

Printable article: "What Is Carbon?"

Active Reading Guidelines

Annotation Tracker Instructions

Annotation Tracker

Annotation Summary Sheet

Example Annotation Trackers and Summary Sheet

Matter and Energy in Ecosystems Investigation Notebook, pages 9–12

Matter and Energy in Ecosystems Glossary

Matter and Energy in Ecosystems Multi-Language Glossary



1

WARM-UP
Warm-Up



Warm-Up



Students share their thoughts about the necessity of having plants in an ecosystem.

Instructional Guide

1. Project Warm-Up; students work independently. Collapse the instructional guide and project the student screen, or have students turn to page 10 in their Investigation Notebooks. Allow a few minutes for students to individually respond to the Warm-Up.

Possible Responses

Could you have an ecosystem without plants?

No

Explain your answer.

You could not have an ecosystem without plants. This is because an ecosystem is made up of living and nonliving things. Without plants, other living things could not survive, because they need to eat plants in order to get energy. Without energy, they can't live, so there would be no living things in the ecosystem without plants.



2

READING

Active Reading: Sunlight
and Life

Active Reading: Sunlight and Life



After the teacher models Active Reading with summarizing, students read and annotate one article from the *Sunlight and Life* article set.

Instructional Guide

- 1. Lead a brief class discussion of the Warm-Up.** Invite students to share their responses with the rest of the class.
- 2. Introduce *Sunlight and Life* by returning to the Investigation Question.** Explain to students that they will do some reading to continue their investigation of where the energy storage molecules in an ecosystem come from.
- 3. Project the *Sunlight and Life* introduction from the Amplify Library, or project the printed article set using a document camera.** Explain that this is the introduction to a set of three articles. The class will read the introduction together so you can model how you want them to read science text. They will then choose one of the three articles to read.
- 4. Highlight how Active Reading will help students in their role as student ecologists.** Call attention to the Active Reading Guidelines poster. If applicable, point out that these guidelines are also on page 11 in the Investigation Notebook. Remind students that scientists frequently read articles to learn about recent research. As student ecologists, reading actively and annotating their articles will help them find information that could be important for figuring out where the energy storage molecules in an ecosystem come from.
- 5. Model Active Reading with a special emphasis on summarizing.** Tell the class that you will think aloud as they read the introduction. Explain that today's reading has an additional goal beyond the other reading strategies they have been using and practicing this year: summarize their thinking as they read. The outline that follows is one suggestion for modeling this; you may adapt it to your own process.
 - **Read the title; ask a question about it.**
Say: "I know that living things are part of an ecosystem, but what about sunlight? Is sunlight part of an ecosystem, too?"
 - Open a note and near the title type, "Is sunlight part of an ecosystem?"



- **Read the entire first paragraph.**

Say: "This says that the bottom of the middle of the lake is referred to as a dead zone. I wonder why that is."

- Open a note near the last sentence of the first paragraph and type, "Why is the bottom of the middle of the lake a dead zone?"

- **Introduce summarizing as a reading strategy.**

Say: "I'm going to show you how to make a summary statement for this paragraph. Summarizing is an important strategy for sophisticated readers. They often pause after larger chunks of text, such as a paragraph, and review their thinking. Then, they write a quick summary. This practice helps to lock the ideas in your brain and the summary you write is something you can refer to later." Say: "I think this paragraph is telling me that there are more organisms living near the edges of the lake than there are in the center. I don't know why this is yet, so my summary is going to be a bit incomplete."

- Open a note near the first paragraph and type, "Sum: More organisms live near the edges of the lake than the center."

- **Read the second paragraph aloud.** Highlight the last sentence ("Some ecosystems contain lots of energy storage molecules, while others don't contain as many.") and connect the statement to the biodome.

Say: "This says that some ecosystems contain more energy storage molecules than others. I bet that information would be very interesting to the Econauts because they had to end their biodome experiment early when the amount of energy storage molecules in plants and animals decreased."

- Open a note near the second paragraph and type, "Why would ecosystems have different amounts of energy storage molecules?"

- **Summarize the second paragraph.**

Say: "I am thinking that this paragraph is mostly about how the number of energy storage molecules in an ecosystem affects the number of organisms that can live there. I'm going to summarize the important parts."

- Open a note near the second paragraph and type, "Sum: Ecosystems with a lot of organisms need a lot of energy storage molecules."

6. Discuss when to summarize. Explain that not every paragraph needs a summary. Sometimes two or more paragraphs together will make up an important idea that needs to be summarized. It is a personal choice based on when there is an especially important idea they want to note. Let students know that you won't require them to summarize every paragraph, but you would like to have them try to use this strategy at least one or two times while reading today. They should also continue to use the other strategies they have been practicing this year.

7. Prompt students to read and annotate while you circulate with the Annotation Tracker. Use the Annotation Tracker to keep track of annotations that you would like to invite students to share during the class discussion. Especially take note of student summaries, since you will return to the idea of summarizing during the end-of-class discussion. The vocabulary terms *producer* and *consumer* will also be introduced during this discussion, so you may want to keep track of annotations that highlight these words.

8. On-the-Fly Assessment: Summarizing Main Ideas from Text. For further suggestions on how to support students as they annotate, press the hummingbird icon and select ON-THE-FLY ASSESSMENT 1.



Embedded Formative Assessment

On-the-Fly Assessment 1: Summarizing Main Ideas from Text

Look for: This reading lesson is an opportunity to check on students' ability to summarize main ideas, as modeled at the beginning of the lesson. As with all reading lessons, students should be encouraged to annotate in the unique ways that are helpful to their own learning and personal style. Look for students to be actively engaged in the reading and annotation process. They may be making a wide range of annotations that reflect their varying levels of science understanding, and that is okay. Have the following questions in mind as you check student annotations:

- Are students attempting to summarize some paragraphs?
- Do these summaries capture the main ideas or do they include peripheral ideas?
- If students have already been taught how to summarize, are they using simple phrases and their own words when summarizing?

Now what? This reading experience is intended to be a space for students to have a personal conversation with the text, but some students may need support with identifying and summarizing main ideas. Consider periodically reading an exemplary annotation aloud. Provide positive, encouraging feedback about why this particular annotation is a good example of Active Reading. You can also offer general prompts to support deeper engagement:

- "What questions do you have about this [illustration, paragraph, photograph]?"
- "Were there any words or phrases that were confusing to you?"
- "Was there something in this text that caused you to wonder or have a question? If so, what?"

To support students as they identify and summarize main ideas, you may want to prompt them with questions such as, "Which parts of this paragraph seem the most important to you?" or "How can you explain that main idea in one short phrase or sentence?"

Teacher Support

Instructional Suggestion

Science Reading: Reviewing Active Reading Processes

In this unit, we assume that your students have already been introduced to the Active Reading approach. If necessary, review the components of Active Reading for your students, reminding them that the goal for reading in your class is to read actively and thoughtfully. Remind students that Active Reading is similar to having a conversation with the text.



Rationale

Pedagogical Goals: Article Sets

Giving middle school students a choice in what they read can be more motivating for them. When different students across the class read different information, it distributes expertise across the class, which in turn provides students with an authentic reason to think about, share, and teach what they learned to others who did not read the same article. This creates an authentic purpose for student-to-student talk, which is important in students' development of science ideas. Sharing knowledge and listening to others share fosters an environment where students are truly learning from one another.

Rationale

Pedagogical Goals: Importance of Teacher Modeling

Active Reading is based on an understanding of how to teach students to read effectively in content areas. Science teachers understand how to read science texts effectively. Active Reading asks teachers to make their thinking processes explicit for students. This is accomplished through modeling one's thought processes aloud while reading a selection of text for students. This apprentices students into the type of thoughtful and sophisticated reading needed to understand science texts. If think-aloud modeling is familiar to you, provide modeling that reflects your own way of reading. The goal is for students to adopt good habits of mind: to be metacognitive and engage in deep and curious reading. Active Reading uses the same strategies and attitudes students use as they engage in inquiry. The more you model this, the more successful it will be.

Background

Environmental Principles and Concepts: Natural Systems and Human Practices

California's Environmental Principles and Concepts are big ideas that underscore the complex relationship that humans have with the natural world. As students work toward understanding these big ideas, students become more environmentally literate, developing the knowledge and skills to address environmental issues. In this unit, students work toward understanding how people depend on, influence, and make decisions about natural systems. They also discover that natural systems proceed through cycles and processes that are required for their functioning. Students develop this understanding as they investigate the processes that are performed in an ecosystem. As students work toward explaining why the biodome failed, they also develop an understanding of human dependence on natural systems.



3

STUDENT-TO-STUDENT
DISCUSSION

Discussing Annotations



Discussing Annotations



Students share annotations with their peers and revisit the summarizing strategy, after which they are introduced to two vocabulary words.

Instructional Guide

- 1. Project annotation discussion instructions.** Collapse the instructional guide and project the student screen, or have students turn to page 11 in their Investigation Notebooks. Prompt students to choose one or two annotations they'd like to share with a partner. Explain that students could share summaries, but they probably wouldn't spark much student-to-student discussion; choosing a question or connection is better.
- 2. Students discuss annotations.** Have partners share and discuss. After a few minutes, ask students to choose an annotation they would like to share or get help with from the rest of the class. Circulate and listen for annotations that would be nice to discuss as a class.
- 3. Hold a class discussion about several student annotations.** Try to have students share questions or ideas that are helpful for supporting deeper content learning or surfacing alternative conceptions about the content.
- 4. Focus on the strategy of summarizing.** If you noticed a particular student summary that you would like to acknowledge, use this opportunity to share that student's work. Ask her to explain how she created the summary and what kinds of thoughts went into making it. If you didn't choose one in advance, ask for student volunteers to share what they did, and follow the same procedure.
- 5. Reflect on the utility of summarizing while reading.** Ask students whether or not they thought this was a useful strategy and how or why it was (or was not) useful. Acknowledge that summarizing can slow you down and interfere with the flow of reading in some ways, but for difficult texts, such as science texts, it is often very helpful to employ this strategy.
- 6. Share any examples that you noted in the Annotation Tracker for the terms *producer* or *consumer*.** Unless you have the students' permission, you may want to share these examples anonymously. Alternatively, you could ask students to share whether they annotated the words *producer* or *consumer* as they read the article.



7. Invite students to offer examples of producers and consumers in an ecosystem. If students are unsure or reluctant to share, provide them with some supporting information from the article about what producers and consumers do in an ecosystem.

If students are using individual devices, ask them to press NEXT.

8. Introduce the vocabulary terms *producer* and *consumer* and project the definitions. Collapse the instructional guide and project the student screen. Read (or ask a student to read) the definitions aloud. Point out that these vocabulary words are also posted on the classroom wall. Remind students to look at the glossary for more support.

9. Highlight that producers and consumers are two different parts of the biotic matter in an ecosystem. Point out that although they get energy storage molecules in different ways, both producers and consumers need them to live.

10. Emphasize that population increases and growth of organisms are limited by access to resources.

 The amount of resources an organism has access to can limit how much it can grow. For example, plants in the arctic can only grow when they have access to sunlight, and they don't grow very large since sunlight is only available in the summer.

 The amount of resources available affects the size of populations too. For example, there couldn't be large populations of fish around coral reefs if they didn't have access to all the energy storage molecules from the other organisms that live in the coral reef environment.

If students are using individual devices, ask them to press NEXT.

11. Prompt students to review annotations on their digital devices and submit annotated articles, or have students answer the reflection question on page 11 in their Investigation Notebooks. Individual students' annotations for *Sunlight and Life* should be visible on their student screens. Have students submit their annotated articles by pressing HAND IN.

12. Return to Investigation Question. Read the question from the board again and provide time for students to reflect on possible answers. Encourage students to think of evidence from the reading and their exploration of the Sim. Facilitate a brief discussion, bringing up key points from the reading.

13. Point out the homework assignment to students (Activity 4 or page 12 in the Investigation Notebook). If students do not have access to Amplify Science at home, provide them with copies of page 12 from the Investigation Notebook and copies of the "What Is Carbon?" article. Make a connection between the text that students just read and the one they will be reading for homework. Explain that students will be reading about another key ingredient in the production of energy storage molecules—carbon.

14. On-the-Fly Assessment: Insight from Student Annotations. For further suggestions on reviewing students' annotations, press the hummingbird icon and select ON-THE-FLY-ASSESSMENT 2.



Embedded Formative Assessment

ON-THE-FLY ASSESSMENT 2: Insight from Student Annotations

Look for: Review submitted student annotations after class. You can use these annotations to assess students' annotation skills, reading comprehension, and content understanding. Use the Annotation Tracker and Annotation Tracker Instructions for guidance.

Now what? See the Annotation Tracker Instructions for suggestions on how to further support students.

Teacher Support

Rationale

Science Reading: The Importance of Making Time to Discuss and Share Annotations

Making time to discuss students' annotations can help achieve the following goals in your classroom:

- **Promote a culture of inquiry.** When students can discuss their own connections and pursue answers to their questions collaboratively, they are able to see how feeling confused and challenged by a text is a normal and productive part of science reading.
- **Help students see value in the Active Reading approach and cultivate intrinsic motivation for reading.** Students annotate their articles in unique and creative ways. When students are exposed to many different ways to annotate a text, they can take ownership of the Active Reading process.
- **Provide an opportunity for formative assessment.** Students' thinking, made visible by their annotations and discussions, can help you identify concepts for which students need more support.



4

HOMEWORK
Homework



Homework



Students read “What Is Carbon?” in the Amplify Library and answer a focus question about carbon in the biodome.

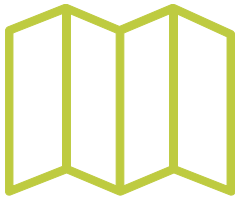
Instructional Guide

1. If needed, make additional time to introduce the homework. If students do not have access to Amplify Science at home, provide them with copies of page 12 from the Investigation Notebook and copies of the “What Is Carbon?” article.

Possible Responses

Reading Focus Question: *Which parts of the biodome contain carbon?*

All the living things in the biodome contain carbon. The air in the biodome also contains carbon. If there are any diamonds in the biodome, they also contain carbon.



Lesson 1.4

How Energy Storage Molecules Are Made



Lesson at a Glance

ACTIVITY

1

Warm-Up (10 min)

Students examine several different types of energy storage molecules in order to learn more about what they are, how they are used, and where they come from.



WARM-UP

2

Revisiting Sunlight and Life (20 min)

Students practice connecting scientific text with visual representations in order to help them learn more about where energy storage molecules come from.



READING

3

Observing Photosynthesis Close Up (15 min)

Students use the Sim to get a dynamic visualization of photosynthesis at the cellular level that will help them think more about where energy storage molecules come from.



SIM

4

Homework

Students watch a video of an experiment to help them think about what factors can affect the number of energy storage molecules in an ecosystem. They also read a short article to learn more about chloroplasts and how they became an important part of producers' cells.



HOMEWORK



DIGITAL RESOURCES

Video: Photosynthesis and Elodea

Sunlight and Life

Printable article set: Sunlight and Life

Where Did Chloroplasts Come From?

Printable article: “Where Did Chloroplasts Come From?”

Matter and Energy in Ecosystems Investigation Notebook, pages 13–19

Matter and Energy in Ecosystems Glossary

Matter and Energy in Ecosystems Multi-Language Glossary



1

WARM-UP
Warm-Up

Warm-Up



Working in groups, students learn more about energy storage molecules.

Instructional Guide

1. Distribute one Energy Storage Molecule card to each student.

2. Project Warm-Up; students work independently. Collapse the instructional guide and project the student screen, or have students turn to page 14 in their Investigation Notebooks and focus on Part 1. Allow a few minutes for students to individually respond to the Warm-Up.

Have students press NEXT (or move on to Part 2 on page 14 in their Investigation Notebooks) when you are ready to move to the second part of the Warm-Up.

3. Review Investigation Question. Remind students that to learn more about what could have gone wrong in the biodome, they read an article in the previous lesson about the importance of sunlight in ecosystems. You can also remind students that energy storage molecules in an ecosystem are important for each organism's survival. Point out the Investigation Question on the board and read it aloud: *Where do energy storage molecules in an ecosystem come from?* Let students know that they will continue learning more about energy storage molecules today, using the article and the Sim.

4. Review the jigsaw activity instructions. Collapse the instructional guide and project the student screen, or have students refer to Part 2 on page 14 in their Investigation Notebooks.

- Let students know that before they investigate where energy storage molecules come from, they'll first get a chance to learn more about them.
- Review the instructions for the activity and group discussion questions.

5. Groups of four discuss their cards. Have students form groups of four, with each student in the group representing one type of energy storage molecule (fat, glucose, glycogen, and starch). Remind students to be ready to share information from their group discussions with the whole class. Circulate for a few minutes and listen in on group discussions.



6. Hold a whole-class discussion that focuses on similarities and differences among energy storage molecules. Be sure all the following points are mentioned:

- **Similarities:** Energy storage molecules all contain carbon, hydrogen, and oxygen. They can be found in foods we eat. When needed, they can be used for energy.
- **Differences:** Different types of organisms make different energy storage molecules. Different types of foods have different types of energy storage molecules. Glucose can be used for energy right away, or it can be turned into other energy storage molecules, which can be used later.

If students are using individual devices, ask them to press NEXT to continue.

7. Introduce the vocabulary word *carbon* and project the definition. Collapse the instructional guide and project the student screen. Read (or ask a student to read) the word and definition aloud. Point out that students saw this word on their Energy Storage Molecule cards, that it's also part of the term *carbon dioxide*, and that both terms are posted on the classroom wall. Remind students to look at the glossary if they need more support.



You just saw that all four energy storage molecules are made of carbon, hydrogen, and oxygen. These are necessary elements for living things, but scientists often describe life on Earth as “carbon-based” because carbon is so important in forming the basic structure of most molecules that make up living things—cell parts, DNA, and energy storage molecules. As we continue our investigation into where energy storage molecules come from and why the biodome didn't have enough energy storage molecules, we are going to focus on carbon.

Teacher Support

Background

Science Note: The Importance of Carbon

Although all the energy storage molecules contain carbon, hydrogen, and oxygen, scientists focus on carbon as the most important component of biological molecules. This stems from carbon's ability to form four bonds at a time, and because of this, carbon is part of a very diverse range of molecules comprising the major structure of organic molecules. These include energy storage molecules and other macromolecules that comprise an organism's cells and tissues, such as proteins, nucleic acids, carbohydrates and lipids.

Possible Responses

Answers will vary.



2

READING

Revisiting Sunlight and Life



Revisiting Sunlight and Life



Students revisit the article and focus on using a diagram to help them deepen their understanding of photosynthesis.

Instructional Guide

1. Review the focus of the day. Let students know that they'll be using the Sim and a part of the *Sunlight and Life* article set to help them answer the Investigation Question: *Where do the energy storage molecules in an ecosystem come from?* Since they just learned that carbon is an important part of energy storage molecules, they will pay close attention to where the carbon comes from.

2. Discuss today's first set of diagrams. Collapse the instructional guide and project the student screen, or have students turn to page 15 in their Investigation Notebooks and refer to Part 1.

- Point out that scientists and scientific texts often use diagrams to help clarify concepts and explain ideas, using common features—captions, arrows, titles, labels, and keys.
- Note that this particular diagram has no caption. It comes from the Sim's close-up view of producer cells. Students will look at it, see if they can tell what is going on, and then write their own captions. Let students know that they'll return to this diagram later in the lesson and have the opportunity to revise their captions.

3. Give students a few moments to write their captions. Circulate and assist students as needed.

4. Hold a brief whole-class discussion about what students think is happening in these images. Have a few students share their responses. Accept all answers.

Ask students to press NEXT (or to move onto Part 2 in their Investigation Notebooks).

5. Introduce the purpose of the second read. Let students know that they are going to take a closer look at several parts of an article they already read so they can find out more about where energy storage molecules in an ecosystem come from.



6. Review exemplary annotations from Lesson 1.3. From the analysis you did with the Annotation Tracker, share exemplary annotations that demonstrate thoughtfulness or creativity. You may also want to review and discuss any alternate conceptions that were revealed in students' annotations.

7. Review instructions for the activity. Collapse the instructional guide and project the student screen, or have students refer to Part 2 on page 15 in their Investigation Notebooks. Read the instructions aloud and highlight the objective—to better understand where energy storage molecules in an ecosystem come from.

8. Model making connections between diagram and text. Point out that the diagram is an important tool for understanding the text, but to get the most information, you must examine all aspects of the diagram thoroughly and do some careful thinking about the text. Let students know that you will model how to do this. Refer to the diagram of photosynthesis on the projected article, or project the printed article using a document camera.

 **Titles or keywords:** Looking at the title, I see this diagram is about photosynthesis, so I am going to look for places in the text that mention photosynthesis. Identifying keywords that appear both in the diagram and in the text can be a good place to start when you want to make connections—to link two or more things, either things you learned before or your ideas.

 **Special features:** Next, I see there are many different types of molecules in this diagram, but only the carbon atom is in a box by itself with some extra text. This makes me think that carbon plays a special role in photosynthesis. When I read through the text, I'm going to look for connections about carbon.

 **Investigation Question:** Since we're focusing on the Investigation Question about where energy storage molecules come from, I'm going to look for information that will help me answer this question. I don't see much about energy storage molecules in the diagram, but maybe the text can help me understand this diagram better. I am going to refer back to the diagram continuously as I read the text.

 Finally, here are a few more questions to ask yourself as you look for connections between the diagram and the text:

- **Caption:** What does the caption tell about this diagram? How does that connect to something in the text?
- **Process or action shown:** What is going on in the diagram? How does that connect to something in the text?
- **Puzzling parts:** What is something you don't understand in the diagram? Can you find something about that in the text? Does the text help you understand the diagram better?

9. Students read and annotate the passage and diagram. As students read and annotate, circle the classroom, observe the annotations that students are making, and answer any questions they may have.

10. Have students share evidence they collected from the text and diagram with a partner. Pairs should discuss some of the evidence they found that might help them answer the Investigation Question.

11. Make a connection to the crosscutting concept of Energy and Matter. Point out how within a natural system, the transfer of energy drives the motion and/or cycling of matter.



In an ecosystem, during the process of photosynthesis, energy is transferred from the sun to producers, and carbon is moved from abiotic to biotic matter. The transfer of energy that takes place during photosynthesis moves carbon through the biotic and abiotic matter in an ecosystem.

Teacher Support

Rationale

Science Reading: The Interaction Between Text and Diagrams

Both adult and student readers often completely ignore diagrams as they read informational text. Yet, science text relies heavily on diagrams to convey information. Drawing explicit attention to the diagrams in the text will help students see how much information is contained in each diagram. As you model using both the text and the diagram to make sense during reading, you will help students see that often the most powerful understanding comes from neither the text nor the diagram alone, but in connecting the two.

Instructional Suggestion

Science Reading: Rereading Texts for a Specific Purpose

Rereading is an important method for obtaining information from texts and supporting comprehension. Setting the expectation that students will read texts more than once helps them learn to read closely and to develop an attitude of persistence when they read. The first time students read this article, it's for the purpose of understanding the overall content and surfacing questions and initial ideas. Rereading a section of the article in this lesson is for a specific purpose—getting more evidence about where the energy storage molecules in an ecosystem come from. When possible, highlight the different purposes for the first and second reads and help students develop the expectation that they need to read a science text multiple times in order to build their understanding.

Background

Crosscutting Concept: Energy and Matter

Throughout Middle School, students gain experience with the crosscutting concept of Energy and Matter, including the idea that within a natural system the transfer of energy drives the motion and/or cycling of matter. In this unit, students figure out that photosynthesis is a process that drives the movement of carbon in an ecosystem. During the process of photosynthesis, producers take in energy from the sun and carbon dioxide from the atmosphere—moving carbon from abiotic to biotic matter. Students also think about this aspect of the crosscutting concept of Energy and Matter in other domains. For example, in the earth science unit, *Rock Transformations*, students investigate the cycling of matter (rock material) on Earth and how energy from the sun and from Earth's interior drive different rock transformation processes.



Possible Responses

Write a caption for this diagram to describe why you think the chloroplast at Time 1 is different from the same chloroplast at Time 2.

At Time 1, there is carbon dioxide and water. At Time 2, there is an energy storage molecule and oxygen. The carbon dioxide and water disappeared and then the oxygen and the energy storage molecule appeared. I think the molecules at Time 1 were used to make the molecules at Time 2.

Answers will vary. Students will return to this later, so they don't need to know the "correct" answer yet.

Annotations will vary.



3

SIM

Observing Photosynthesis
Close Up

Observing Photosynthesis Close Up



Students compare the Sim with the photosynthesis diagram and gather more evidence about where energy storage molecules come from.

Instructional Guide

1. Make a connection between this Sim activity and the previous activity. Let students know that they will be looking at another type of visual—zooming in with the Sim to look at what’s happening inside a cell during photosynthesis. This will give them another model, and they can compare that to the diagram in the article. All these things will help them gather more evidence about where energy storage molecules come from.

2. Review instructions for the activity. Collapse the instructional guide and project the student screen, or have students turn to page 16 in their Investigation Notebooks.



We are starting to gain a better understanding of where energy storage molecules in an ecosystem come from. Use the Sim to watch what happens inside the chloroplast, a part of producer cells where photosynthesis occurs. This is the same diagram we saw earlier, but now it is moving. Try to follow what is happening as molecules enter and leave the chloroplast. As you do so, discuss the prompts on your screen with your partner. To help you work together, (a) one partner should launch the Sim and press VIEW CELL in the Producers box; (b) the other partner’s screen should be on Activity 3 with the photosynthesis diagram from the article and the discussion questions visible.

3. Have students observe the Sim and discuss. Give students a few minutes to observe the Sim and discuss the prompts. Circulate and assist pairs as needed.

Ask students to press NEXT (or to turn to the next page in their Investigation Notebooks) to continue this activity.

4. Collapse the instructional guide and project the student screen, or have students refer to Part 2 on page 17 in their Investigation Notebooks. If you need to, point out that students are looking at the diagram from earlier in the lesson and their first try at writing a caption. Using what they learned, they can now revise their captions to make them even more informative.



5. Have students revise their captions. Make sure students see the sentence-completion activity below the caption activity.

6. Have students share with a partner. When all students have finished writing, have each student share with their partner.

7. Hold a brief class discussion. Call on student volunteers to share their captions and how their thinking has changed.

If using digital devices, ask students to press NEXT to continue this activity.

8. Project the two key concepts. Read the key concepts aloud or have a student read them aloud.



Key Concept

- Carbon is part of carbon dioxide, which is abiotic matter. Carbon is also part of energy storage molecules, which are biotic matter.
- During the process of photosynthesis, producers make energy storage molecules, using carbon from carbon dioxide and energy from sunlight. This moves carbon from abiotic to biotic matter.



We have collected evidence from the article and the Sim to come to these conclusions. In every ecosystem we looked at, we found the same thing happened: producers used carbon from carbon dioxide to make energy storage molecules. We found this pattern just as scientists would. Even though there may be exceptions, when scientists find a pattern, they assume the same thing happens in other similar systems. So, we can assume this happens in the biodome, too. This knowledge will help us understand what happened in the biodome.

9. Point out that students have learned a lot about where energy storage molecules come from. Review that the process that makes energy storage molecules is called *photosynthesis*. Remind students that they can find this word and its definition in their glossaries.



Do you have some thoughts on which types of organisms do photosynthesis?
[Producers, which are plants; algae; and some types of bacteria.]

10. Conclude today's lesson and introduce the homework (Activity 4 or pages 18–19 in the Investigation Notebook). If students do not have access to Amplify Science at home, adjust your schedule to make time to watch the video in class and provide students with copies of pages 18–19 from the Investigation Notebook and printed copies of the “Where Did Chloroplasts Come From?” article.



Now that we know producers make energy storage molecules using carbon dioxide and sunlight, we know where these molecules come from and how they enter an ecosystem. We still have to explain to the Econauts **why** there weren't enough energy storage molecules in the biodome. In order to do that, we'll have to use what we've learned so far to think about what can cause the number of energy storage molecules in an ecosystem to change. For homework, you'll watch a video that will help you start thinking about that.

Let students know that they will also read an article to learn more about chloroplasts.

Teacher Support

Instructional Suggestion

Clarifying Terminology: Chloroplast and Mitochondrion

You may wish to review the terms *chloroplast* and *mitochondrion*. These cell parts are shown in the Sim, but not defined or discussed in the unit, other than as the location in the cell where the processes of photosynthesis and cellular respiration take place. You might point out that *mitochondrion* is a singular form, while *mitochondria* is the plural form of the word. In Chapter 1, the focus is on photosynthesis and students should focus on the process that is occurring in the chloroplast when they select VIEW CELL in the Sim. Some students may become distracted by seeing the mitochondrion on the right-hand side of the screen. It may be helpful to redirect distracted students by getting them to focus on the chloroplast (left side of the screen), and let them know they will learn more about what is happening in the mitochondrion in the next chapter. Also, remind students that the definitions for both *chloroplast* and *mitochondrion* can be found in the glossary. Additionally, we have provided optional articles about both chloroplasts and mitochondria that can be used to enhance student understanding.

Assessment

Rationale

Pedagogical Goals: Understanding the Nature of Science

One goal set forth by the Next Generation Science Standards (NGSS) is for students to understand the nature of science as a discipline and how scientific knowledge develops over time. The NGSS calls out eight understandings about the nature of science that are woven throughout the Amplify Science curriculum. This unit gives students an opportunity to experience the understanding that Scientific Knowledge Assumes an Order and Consistency in Natural Systems. Specifically, the discussion of key concepts in this activity illustrates the idea that science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation.

Possible Responses

1. Student responses will vary, but should include the idea that, in both images, carbon dioxide goes into the chloroplast; energy storage molecules and oxygen come out of the chloroplast.



2. The models show that energy storage molecules come from the chloroplast of producers, where the carbon from carbon dioxide is used to make energy storage molecules.
3. Producers are the only organisms that produce energy storage molecules.

What students should/might do:

Students should run the Sim with the default, stocked ecosystem. Students should press VIEW CELL to look inside the producer cells, and watch what is happening in the chloroplasts.

What students should notice:

Students should notice that water and carbon dioxide are taken in by the chloroplasts, and energy storage molecules are produced along with oxygen. Students may point out that energy from sunlight is not shown in the producer cells, but is only shown in the main view. They may notice that the amount of carbon, indicated by the small black dots on the carbon dioxide molecules and energy storage molecules, is conserved in this process, but it is not necessary that they notice this conservation.

This is the caption you wrote earlier. Using what you learned in the reading and the Sim, write a new caption or revise your first caption to describe what you now think about why the chloroplast looks different at Time 1 than at Time 2.

At Time 1, there is carbon dioxide and water. At Time 2, there is an energy storage molecule and oxygen. I think the molecules in Time 1 were used to make the molecules seen at Time 2. This happens through the process of photosynthesis in the chloroplast. Producers use carbon dioxide and sunlight to make energy storage molecules, which is their food.

Complete the following sentences about photosynthesis.

Photosynthesis is done by *producers*. This process requires *energy* from sunlight and *carbon dioxide* from abiotic matter. Photosynthesis makes *energy storage molecules* and *oxygen* for an ecosystem.



4

HOMEWORK
Homework

Homework

Students watch a video of an experiment and read a short article in order to learn more about photosynthesis.

Instructional Guide

- 1. If needed, make additional time to explain the homework.** If students do not have access to Amplify Science at home, adjust your schedule to make time to watch the video in class.
- 2. If needed, make additional time to explain the second part of the homework.** If students do not have access to Amplify Science at home, provide students with copies of page 19 from the Investigation Notebook and printed copies of the “Where Did Chloroplasts Come From?” article.

Teacher Support

Rationale

Pedagogical Goals: Additional Reading About Chloroplasts

In this unit, students learn that photosynthesis takes place inside the chloroplasts of producers. Students read an article for homework to gain a deeper understanding of chloroplasts. Students learn about the origins of chloroplasts, how they ended up in producers, and why they are important to our ecosystems today. This helps students understand the unique origin of chloroplasts as well as contributing to their understanding of the special functions performed by particular cell structures.

Assessment

Additional Assessment Opportunity: Student Understanding of Structures Within Cells

This activity can be used to assess students’ understanding that cells have structures inside them that are responsible for particular cellular functions, including the chloroplasts that carry out photosynthesis. Look for whether students can describe that organelles are the parts of cells that perform important functions for the cell, and whether they can name some organelles in plant cells—including chloroplasts, as well as a nucleus, mitochondria, and a cell membrane. If students have trouble describing the idea of particular organelles in a cell that each carry out particular functions, consider spending some time in class looking at more examples. Useful images of the parts inside cells, with lists of their functions, can be found using the search terms “cell organelles and their functions.” You might point out mitochondria and chloroplasts and ask students to describe the function of each of these structures. You can also point



out that these structures are in some ways similar to the organs in the body. Like the body, a cell has particular sub-parts that each do a different and important thing to help the cell function. Note that students will have the opportunity to extend their understanding of organelles and their functions in Lesson 2.4.

Possible Responses

What are organelles?

Organelles are the special parts of cells that perform important functions in the cell.

What are some of the organelles in a plant cell?

Some organelles in plant cells are a nucleus, mitochondria, a cell membrane, and chloroplasts.

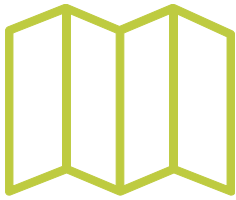
How did chloroplasts end up in producers' cells?

At some point, a cell engulfed a bacterium that could perform photosynthesis. Then the bacterium and the cell it lived in became one organism. The bacterium became a chloroplast.



Image Credits

Audiojungle, Shutterstock (Video: Photosynthesis and Elodea).



Lesson 1.5

Photosynthesis in Ecosystems



Lesson at a Glance

ACTIVITY

1

Warm-Up (5 min)

Students revisit their initial claims about the biodome to reflect on what they have learned so far.



WARM-UP

2

Modeling Energy Storage Molecules (20 min)

Students model what they know about how energy storage molecules enter an ecosystem in preparation for learning more about the new Investigation Question. This activity provides an On-the-Fly Assessment for students' early ideas about photosynthesis.

MODELING
TOOL

3

Decreasing Energy Storage Molecules (20 min)

Students use the Sim to gather evidence for the new Investigation Question—finding out what factors can cause energy storage molecules in an ecosystem to decrease.



SIM

4

Homework

Students use the Sim to gather evidence for the new Investigation Question—this time, finding out what could cause an increase in energy storage molecules.



HOMEWORK



DIGITAL RESOURCES

Matter and Energy in Ecosystems
Investigation Notebook, pages
20–26

Hands-On Flexextension lesson guide:
Plant Growth Investigations

Hands-On Flexextension copymaster:
Plant Growth Investigations

Matter and Energy in Ecosystems
Glossary

Matter and Energy in Ecosystems
Multi-Language Glossary



1

WARM-UP
Warm-Up



Warm-Up



Students revisit the Chapter 1 Question to see how their thinking has changed.

Instructional Guide

1. Project Warm-Up; students work independently. Collapse the instructional guide and project the student screen, or have students turn to page 21 in the Investigation Notebook. Allow a few minutes for students to individually respond to the Warm-Up.

Possible Responses

1. The biodome did not have enough energy storage molecules because producers were making fewer energy storage molecules through the process of photosynthesis.
2. The article and the Sim showed that producers use carbon dioxide from the air and energy from sunlight to make energy storage molecules, so if there are fewer energy storage molecules in the biodome, it must mean that producers are not making as many.
3. Answers will vary.



2

MODELING TOOL

Modeling Energy Storage
Molecules

Modeling Energy Storage Molecules



Students are introduced to the Modeling Tool, and afterward, build a model to show where an ecosystem's energy storage molecules come from.

Instructional Guide

1. Elicit new ideas about Chapter Question. Have several students share their new ideas about the Chapter Question: *Why didn't the plants and animals in the biodome have enough energy storage molecules?* Highlight new ideas learned since the beginning of the unit. If time permits and as a way to include prior knowledge, ask student volunteers to remind you why an ecosystem needs energy storage molecules. [Energy storage molecules are what all organisms use to release energy for cell functions, growth and reproduction, and survival in their ecosystems.]

2. Review key concepts from previous lesson. Point out the key concepts that were posted on the classroom wall. Relate them to the first Investigation Question—where energy storage molecules come from. Let students know that posted key concepts are available whenever they need to refer to them.



3. Introduce and project new key concept; connect to the crosscutting concept of systems and to upcoming Modeling Tool activity. Read the key concept aloud.



Key Concept: Systems and System Models

If one part of a system changes, this affects the rest of the system.



Remember that a system is a set of interacting parts that form a complex whole. For example, the human body has many parts that all work together to form a whole complex human body system. When one part of the body system changes, like the heart stops beating, this will affect all the other parts of the body system and the body will not work properly. Like any system, the biodome ecosystem also has many parts that need to work together for the system to function properly. When scientists study any system, they often look at how one part of a system affects the other parts of the system.



Through your investigations in the last few days, you've been able to see that photosynthesis is a process that connects the abiotic and biotic parts of the system. Can anyone describe how this is possible?
[During photosynthesis, producers take in carbon dioxide from the abiotic part of the ecosystem (air or water) and use it to make energy storage molecules. Carbon from the abiotic part of the ecosystem is now in producers, and they are in the biotic part of the ecosystem.]

Let students know that in a few moments, they will be able to show their understanding of photosynthesis and where energy storage molecules come from, using a new tool called the Modeling Tool.

4. Project the Modeling Tool activity: [Energy Storage Molecules](#) and describe the purpose of the tool.



Scientists use models to work out and share their ideas. This digital tool will help you make a visual model that shows where the energy storage molecules in an ecosystem come from.



The Modeling Tool and the Sim are different. In the Modeling Tool, you make diagrams or models of your ideas about ecosystems. It represents your thinking. It doesn't run or move to show how the items in your model affect the ecosystem, and it won't give you feedback about whether your ideas are accurate or not.



It's important to represent your thinking as completely as you can. As part of the Biodome Investigation Team, you'll need to communicate your findings to the Econauts, and one way to share information is with a screenshot of your completed model.

5. Students open the Modeling Tool activity and explore its features. Ask students to use the next five minutes to explore what the tool includes and what can be manipulated. Support students who seem confused. If students are using the Investigation Notebook, have them turn to page 22 for instructions.

6. Students share with a partner. After students have had a few minutes to explore the tool, ask them to share with a partner, either something they noticed or something they have a question about.

7. Regain students' attention and demonstrate how to use the Modeling Tool. Explain that in order to build models in the Modeling Tool, students will first need to understand some basic functions and options.

- **Activity:** Select Energy Storage Molecules.
- **Goal:** Point out the goal at the top of the screen and explain that this indicates what their models should show.
- **Ecosystem items:** Point out the menu on the right. Students can drag these items into their models to represent different parts of the ecosystem. They don't need to add all the items, just the ones that help them meet the goal.
- **Matter items:** Point out that students can add either carbon dioxide or energy storage molecules to different parts of the ecosystem.
- **Movement arrows:** Point out that these show the movement of matter or energy between parts of the ecosystem. For example, you can place an Energy storage molecules movement arrow between producers and primary consumers to indicate that energy storage molecules move from producers to consumers (during eating).
- **Connect boxes:** These are reminders that each end of a movement arrow needs to be connected to a part of the ecosystem.
- **Process:** To complete your model, represent the processes taking place in each type of organism. Drag the Process editor to an organism box. Press the pencil icon to open the window of the Process editor. Drag a label to indicate the process category—photosynthesis or cellular respiration—then add items from the Matter category to indicate the inputs and outputs of the process.

Ask students to press NEXT (or to move onto Part 2 in their Investigation Notebooks).

8. Review Modeling Tool instructions. While projecting the Modeling Tool, press INSTRUCTIONS. Review that the goal is to use the Modeling Tool to show where the energy storage molecules in an ecosystem come from. Communicate that students' models should represent all they know about photosynthesis as well as where energy storage molecules in an ecosystem come from, so they should think very carefully about how to represent that. If students are using the Investigation Notebook, point out that the instructions are also on page 22.

9. Instruct students to return to the Modeling Tool and create their models.



10. On-the-Fly Assessment 3: Modeling Energy Storage Molecules. Circulate as students work and answer any questions that students might have. Check for understanding by observing how students are constructing their models. For suggestions on what to look for in students' early ideas about photosynthesis, press the hummingbird icon and select ON-THE-FLY ASSESSMENT.

NOTE: There will be a chance to revise these models in the next lesson before students upload a screenshot of the final model.



Embedded Formative Assessment

On-the-Fly Assessment 3: Modeling Energy Storage Molecules

Look for: In this first Modeling Tool activity, students demonstrate their current understanding of the source of energy storage molecules in an ecosystem through the practice of developing and using models. Students will have the opportunity to revise their models in the following lesson. Look for students to show that only producers make energy storage molecules because only producers perform photosynthesis. Models should show that photosynthesis requires the inputs of both energy (sunlight) and matter (carbon dioxide) in order to create the output of energy storage molecules. This activity allows students to express their ideas about how matter that is essential for all living things can move into the biotic part of an ecosystem. Select the Possible Responses tab to see a proficient student model.

Now what? Students who are having trouble expressing their ideas visually might benefit from talking through their ideas with a partner. It might also help to refer students back to evidence they examined in Lesson 1.4 as a way of developing support for their claims. Students will continue to explore how quantities of energy storage molecules can affect entire ecosystems in Chapters 2 and 3. Students who are struggling with this content could benefit from extra coaching during the next Sim activity and during the reasoning and Modeling Tool revision activities in Lesson 1.6.

Teacher Support

Background

Crosscutting Concept: Systems and System Models

Systems and System Models is a crosscutting concept called out by the Next Generation Science Standards as one of seven ideas that are widely useful across scientific topics and disciplines. To study phenomena in the natural world, scientists imagine boundaries around the parts of the world they are investigating; that is, they define the system they are studying. Defining a system allows scientists to take something in the complex world and make it easier to think about by isolating its parts. Scientists can then study and describe the interactions between parts and describe how things outside the boundaries they have defined affect what happens inside the system. Defining a system allows scientists to create conceptual models of a phenomenon they can test. They can then use their models to predict a system's behavior or to diagnose a problem. This isolation and simplification allow scientists to investigate the roles and relations of the different parts of a system in a way that would be impossible if they were trying to account for everything at once. In the *Matter and Energy in Ecosystems* unit, students gain experience with systems by considering ecosystems as systems composed of interacting parts: types of organisms, dead matter, and other abiotic reservoirs. Students consider a range of ecosystems in this way: the biodome ecosystem, the Arctic, and coral reef and rain forest ecosystems in the article "Sunlight and Life," and the forest/grassland ecosystem discussed in the Science Seminar. They use and analyze system models to gather evidence about interactions among parts of systems and about the



causes of changes to the system. These system models include the *Matter and Energy in Ecosystems* Simulation and a physical token model (which allow students to make a change to one part of the system and observe the effect on other parts), and the digital modeling tool (which allows students to show their ideas about relationships among parts of a system and to make choices about what to include in their system models).

Instructional Suggestion

Science Practices: Using Models in Science

It may be useful to discuss the importance and limitations of using models in science. Ask students to share what kinds of models they have seen or used before. Point out that scientists develop and use models to help them conceptualize, investigate, and communicate ideas about the natural world. A model can involve a physical setup that is smaller or larger than what it represents; a diagram that depicts the invisible; or a computer simulation that represents salient features of a phenomenon, system, or process. Throughout the unit, students will use several types of models, including the *Matter and Energy in Ecosystems* Simulation and Modeling Tool. The *Matter and Energy in Ecosystems* Simulation is a scientific model of an ecosystem. Although this Simulation is different from the natural world, it is very accurate in many ways (refer to the document, Reference: Apps in This Unit, for more information). The Modeling Tool is a way for students to display their understanding of important content in the unit. Helping students understand the ways in which the Sim and Modeling Tool both represent and are different from the natural world can be useful for students.

Instructional Suggestion

Crosscutting Concepts: Making Connections Across Science Topics

Students can use the focal crosscutting concept in this unit, Systems and System Models, to make connections across science topics. Ask students to think of another topic or content area (in this grade or in a previous grade) in which they also used the crosscutting concept Systems and System Models, for example in the *Geology on Mars* or the *Metabolism* units. Ask students what patterns they looked for during those investigations.

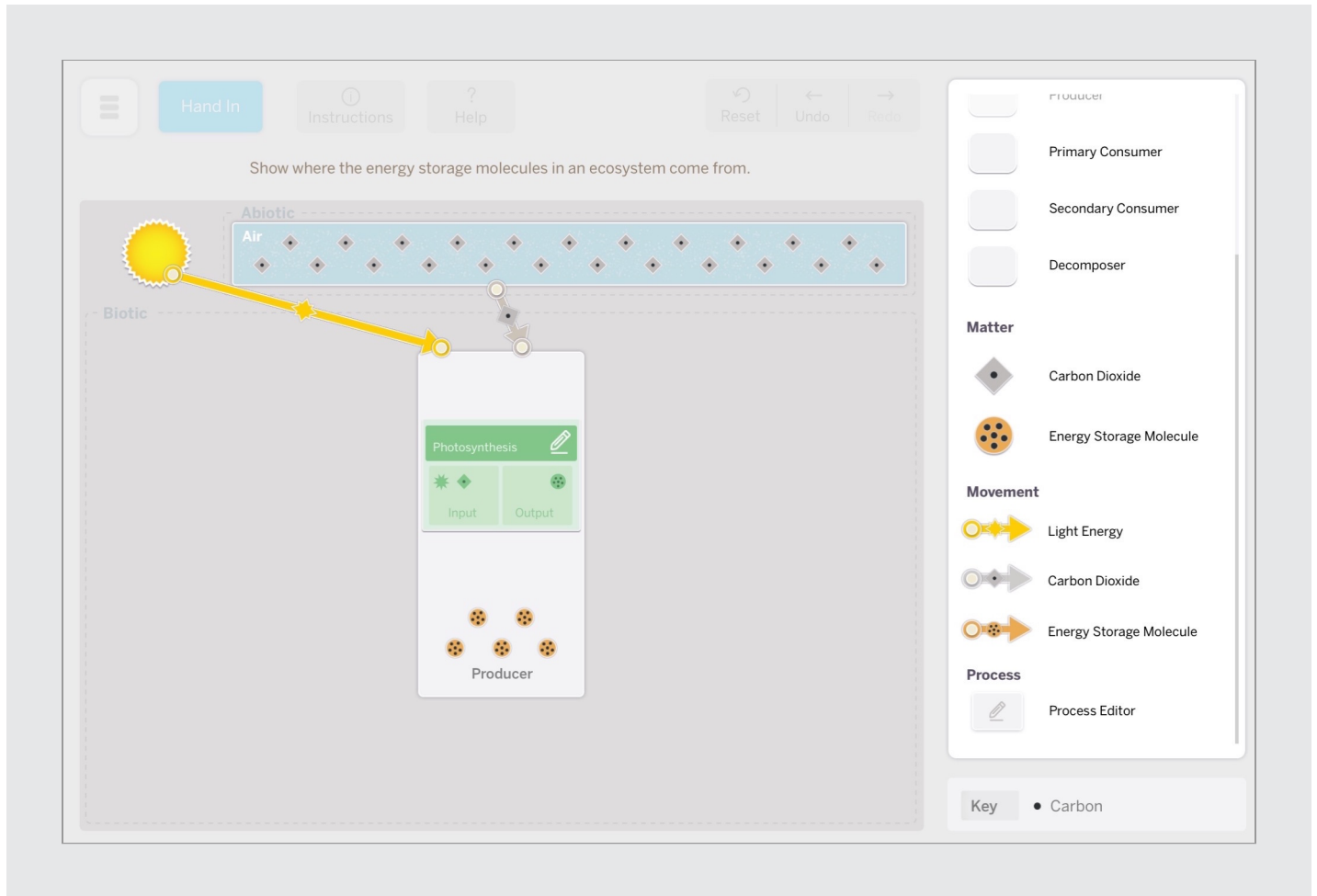
Pose the following questions:

- What kinds of systems were we analyzing when we were studying the *Metabolism* unit? How is that similar and different to the systems we are analyzing now? [Example: In the *Metabolism* unit, we looked at body systems and how they work together. In this unit, we are looking at ecosystems. In both cases, we can see how changes to one part of the system affect the whole system.]

Possible Responses

Modeling Tool Response

A possible proficient model is shown below. The model shows that producers make energy storage molecules through photosynthesis. Producers use energy from the sun and carbon dioxide to make energy storage molecules. Students might show consumers in their models or add arrows that show the flow of energy storage molecules from producers to consumers, though this is not necessary for a proficient model.





3

SIM

Decreasing Energy Storage
Molecules

Decreasing Energy Storage Molecules



Students use the Sim to find ways to decrease energy storage molecules in an ecosystem's living things.

Instructional Guide

- 1. Introduce new Investigation Question.** Explain to students that since they now have a better idea about where energy storage molecules in an ecosystem come from, they will focus on a new Investigation Question: *What factors affect how many energy storage molecules producers are able to make?*
- 2. Revisit homework from the previous session.** Remind students that they watched a video of an experiment with the producer, *Elodea*. Ask students to turn to a partner and discuss this video, saying anything they remember that might help them answer today's Investigation Question.
- 3. Students make claims about Investigation Question.** Collapse instructional guide and project student screen, or have students turn to page 23 in their Investigation Notebooks.

 We know that organisms in the biodome were not getting enough energy storage molecules and that producers are the organisms that make energy storage molecules. Think about how energy storage molecules are made and write a claim that answers the Investigation Question, *What factors affect how many energy storage molecules producers are able to make?*
- 4. Have students share their claims.** Call on student volunteers to share their claims. Accept all answers. [Most students will say that the amounts of sunlight or carbon dioxide affect how many energy storage molecules are made.] Let students know that in a few moments they will use the Sim to find out more about the factors that affect how many energy storage molecules can be made.

Ask students to press NEXT (or to move onto Part 2 on pages 23–24 in the Investigation Notebook).



5. Review instructions for Sim activity. Collapse the instructional guide and project the student screen, or have students turn to pages 23–24 in their Investigation Notebooks. Review the Sim mission: Since energy storage molecules decreased in the biodome, students will focus on finding ways in the Sim to *decrease* energy storage molecules made by producers. Later, for homework, students will use the Sim to investigate how to *increase* energy storage molecules in the biotic part of an ecosystem.

6. Prompt students to plan their Sim activity. Have students plan their Sim activity by completing Plan 1 and Plan 2 on their student screens or in their Investigation Notebooks.

7. Model how to use the graphs. Run the Sim and press the graph icon. Point out that students will use the graphs as they work on the Sim mission. Review the following features:

- There are three preset options—for carbon, processes, and molecules. When students press one of the presets, colored line graphs appear. The graphs give information about three categories, Ecosystem, Biotic, and Abiotic. Students can toggle the graph lines on or off, using the buttons to the left of their names.
- To scroll forward or backward through time, students can drag the blue vertical line on the graph. The label(s) to the right of this line show the value and units for each graph, and the values change as you move the blue line.
- User Changes icons appear at the top of the graph and reflect changes that were made in the Sim (such as pressing the Kill buttons). The key for these change icons is located at the top right-hand corner of the screen.

8. Students open the Sim and complete the Sim mission. Circulate and assist students as needed. Remind students to run the Sim for 20 time units before making any changes. After making changes to the ecosystem, they should observe the Sim for 50 additional time units. Make sure they refer to the graphs and that they reset the Sim when they want to test another change (this resets time units).

9. When 5–6 minutes remain, instruct students to complete the remaining items on their screens or in their Investigation Notebooks. Remind them to discuss with a partner how they would revise the claims they wrote earlier.

10. Have the class share briefly about the Sim investigation. Cover the following points:

- how students were able to decrease the number of energy storage molecules that producers made [Decreasing sunlight or trapping a lot of carbon dioxide in the atmosphere decreased the energy storage molecules in the biotic part of the ecosystem.]
- how students would revise their claims about the Investigation Question

11. Point out the homework (Activity 4 or pages 25–26 in the Investigation Notebook). If students do not have access to Amplify Science at home, adjust your schedule to make time to complete the Sim activity in class. For homework, students will use the Sim to find ways to *increase* the amount of energy storage molecules that producers are able to make.



Teacher Support

Instructional Suggestion

Going Further: Mathematical Thinking

Students can make quantitative comparisons for the changes they make in the ecosystem by calculating the total amount of glucose produced during the observed amount of time units before and after they make the change to the ecosystem. After students run the default setting for 20 time units, have them calculate the total amount of glucose produced by multiplying the glucose produced per time unit by the total amount of time. Alternatively, students can write the amount of glucose produced as a function of time. For example, if the amount of glucose produced per time unit was 682, the function would be $f(t) = 682t$. They can then use the function to calculate the total amount of glucose produced for any amount of time. After students make a change in the Sim, they can do the same with the new value for glucose produced per time unit. In this case, students may need to wait until the value remains steady or estimate the value. The purpose of this activity is for students to use quantitative data to understand relationships.

Possible Responses

You just made a model showing where energy storage molecules come from. Refer to your model and think back to what you know about how energy storage molecules are made and the factors that affect photosynthesis. Write a claim that can answer the new Investigation Question: What factors affect how many energy storage molecules producers are able to make?

Answers will vary, but here are several examples:

- I think the amount of sunlight affects the amount of energy storage molecules that producers can make.
- I think the amount of carbon dioxide available affects the amount of energy storage molecules that producers can make.
- I think the amounts of sunlight and carbon dioxide affect how many energy storage molecules producers can make.

Plans 1 and 2: decrease sunlight / trap carbon dioxide

6: decrease sunlight / trap carbon dioxide

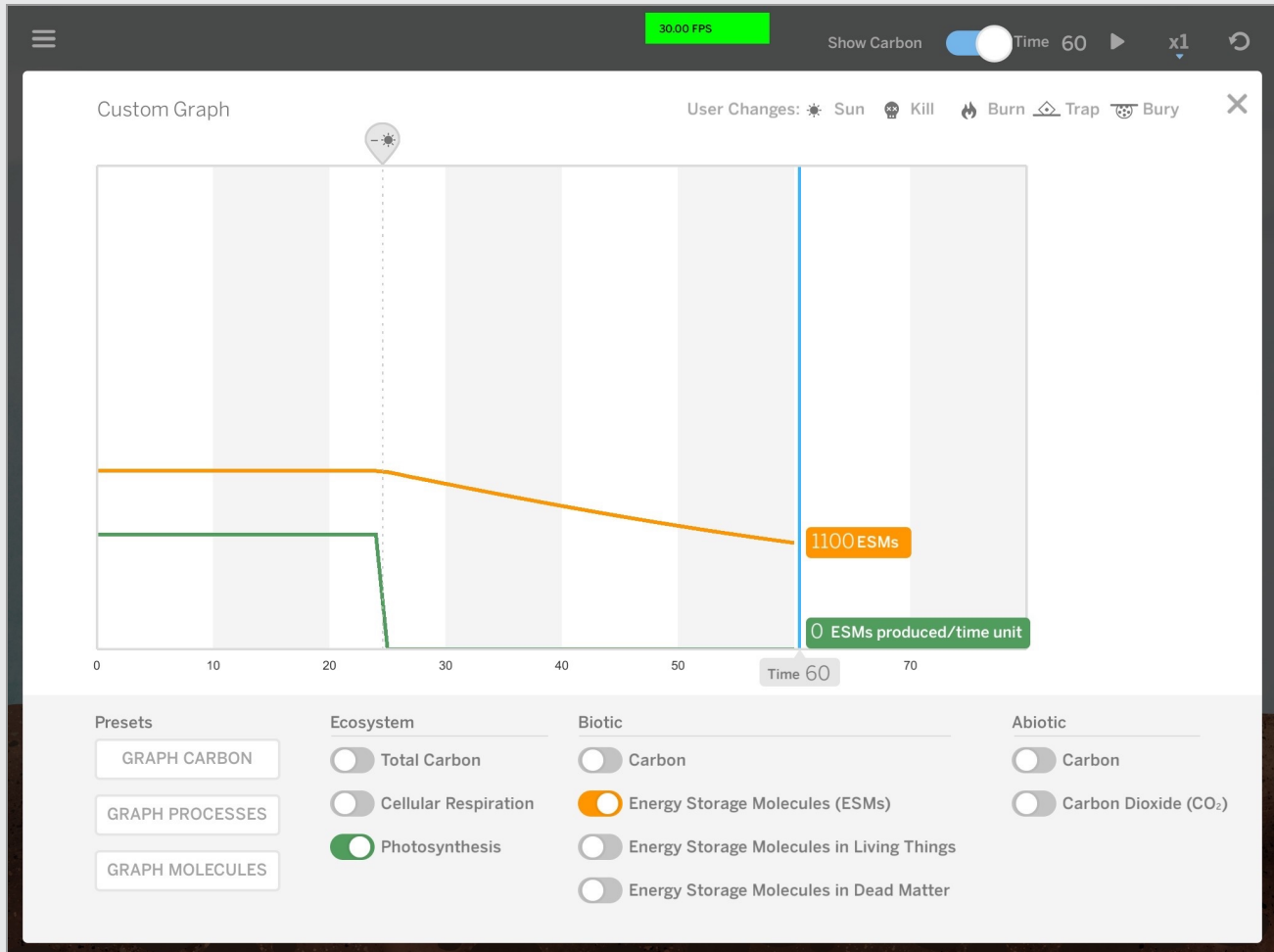
What students should/might do:

In order to decrease the number of energy storage molecules that producers can make, students can decrease sunlight or trap carbon dioxide.

Students might try to accomplish this mission by killing producers. If so, remind them that they are trying to discover what factors could have caused producers to make fewer energy storage molecules in the biodome, not what would happen if there were fewer producers.



An indirect way that students can accomplish this mission is by burying dead matter. This leads to less cellular respiration by decomposers and therefore, less carbon dioxide in abiotic matter. If students discover this, make sure they can fully explain why this leads to fewer energy storage molecules (less carbon in abiotic matter to make energy storage molecules).

**What students should notice:**

Students should notice that by decreasing either the amount of sunlight or the amount of available carbon dioxide, the rate of photosynthesis in producers decreases. This leads to fewer energy storage molecules being available to all living things in the ecosystem.



4

HOMEWORK

Homework



Homework

Students use the Sim to find ways to increase the amount of energy storage molecules that producers make.

Instructional Guide

1. If needed, make additional time to explain the homework. If students do not have access to Amplify Science at home, adjust your schedule to make time to complete the Sim activity in class.

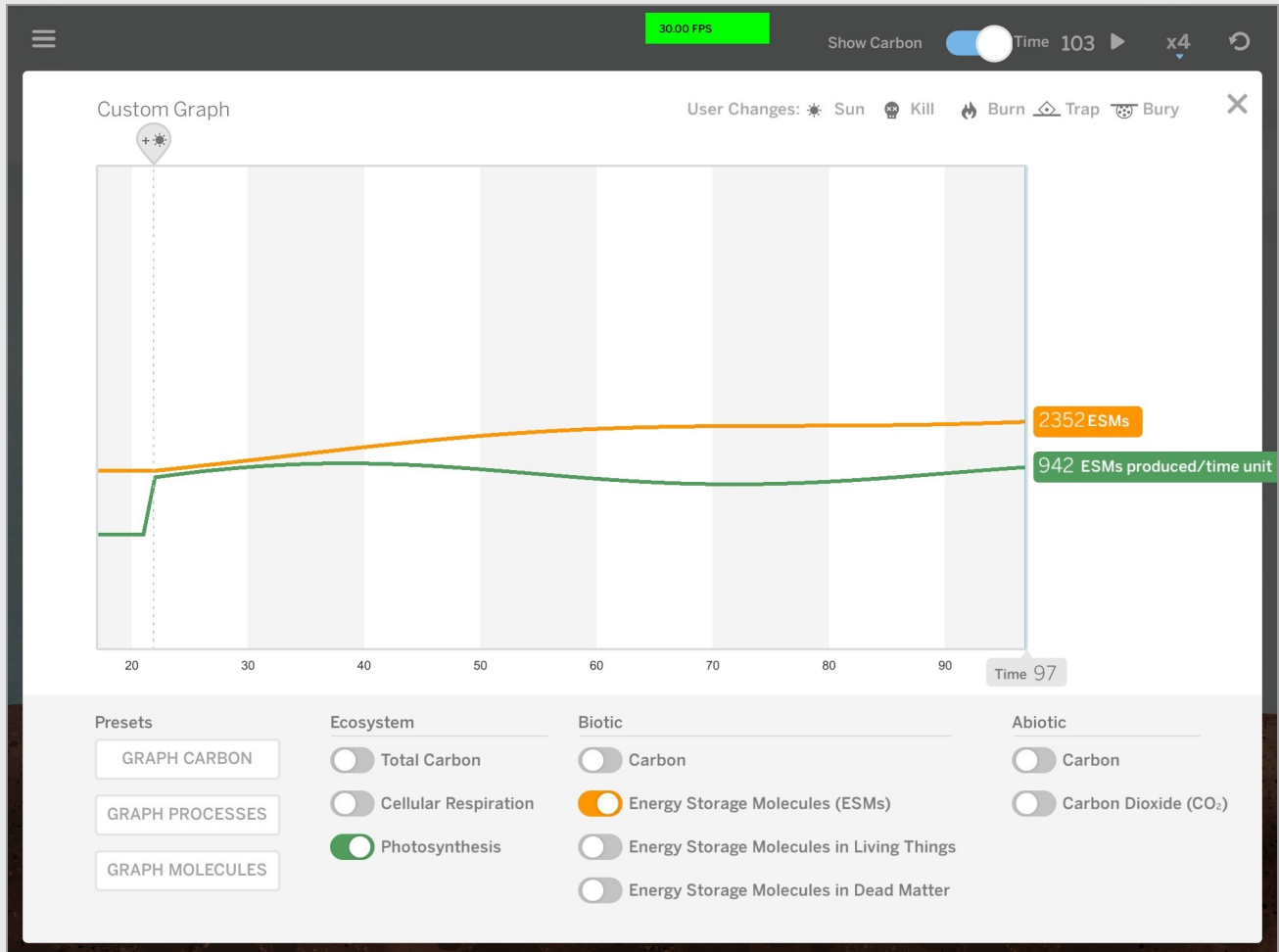
Possible Responses

Plans 1 and 2: increased sunlight / burned dead matter

6: increased sunlight / burned dead matter

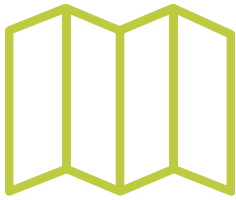
What students should/might do:

In order to increase the number of energy storage molecules producers can make, students can increase sunlight or burn dead matter. Burning dead matter is the only way to increase the amount of available carbon dioxide once the Sim has started running.



What students should notice:

Students should notice that either increasing the amount of sunlight OR the amount of available carbon dioxide (by burning dead matter) increases the rate of photosynthesis in producers. This leads to more energy storage molecules being available to all living things in the ecosystem.



Lesson 1.6

Examining Data from the Biodome



Lesson at a Glance

ACTIVITY

1

Warm-Up (5 min)

Students answer questions to apply their understanding of what factors can change how many energy storage molecules that producers make.



WARM-UP

T

A New Message from Dr. Corry (5 min)

The teacher introduces new key concepts and presents new evidence about the biodome in order to prepare students to answer the Chapter Question.



TEACHER

2

Examining Data from the Biodome (10 min)

Students examine graphs of sunlight, carbon dioxide, and water in the biodome to determine which of the two claims about the Chapter Question is best supported by this evidence.

STUDENT-TO-
STUDENT
DISCUSSION

3

Reasoning About Data from the Biodome (15 min)

Students use the Reasoning Tool to connect how much carbon dioxide is in the biodome and how many energy storage molecules producers make.



WRITING

4

A Model for the Econauts (10 min)

Students revise their models and produce written explanations. This activity provides an opportunity for an On-the-Fly Assessment of students' understanding of how carbon dioxide, photosynthesis, and energy storage molecules are connected.

MODELING
TOOL

5

Homework

Students read a short article about a scientist who studies how plants' roots get water.

HOMEWORK



6

Self-Assessment (Optional)

Students check their understanding of key content in the unit, and are given a chance to reflect on additional questions they have about ecosystems.



HOMEWORK

**DIGITAL RESOURCES**

Matter and Energy in Ecosystems
Investigation Notebook, pages
27–33

Homework: Reading "Meet a
Scientist Who Studies How Plants
Find Water Underground"
copymaster

Printable article: "Meet a Scientist
Who Studies How Plants Find Water
Underground"

Matter and Energy in Ecosystems
Glossary

Matter and Energy in Ecosystems
Multi-Language Glossary

Meet a Scientist Who Studies How
Plants Find Water Underground



1

WARM-UP
Warm-Up

Warm-Up



Students answer questions about the factors that can increase the number of energy storage molecules made by producers in an ecosystem.

Instructional Guide

1. Project Warm-Up; students work independently. Collapse the instructional guide and project the student screen, or have students turn to page 29 in their Investigation Notebooks. Allow a few minutes for students to individually respond to the Warm-Up.

Possible Responses

What should Jaime do to increase the number of energy storage molecules that producers can make? You may choose more than one answer.

Increase the amount of sunlight in the ecosystem.

Increase the amount of carbon dioxide in the ecosystem.

Explain your choice(s).

Producers need sunlight in order to make energy storage molecules. If there is more sunlight producers can make more energy storage molecules. Producers also need the carbon from carbon dioxide to make energy storage molecules. If there is more carbon available in the form of carbon dioxide producers can make more energy storage molecules.



TEACHER

A New Message from Dr.
Corry



A New Message from Dr. Corry



The teacher reviews the key concepts and introduces two claims about the biodome.

Instructional Guide

- 1. Lead a brief class discussion of the Warm-Up.** Invite students to share their ideas. Highlight the fact that both carbon dioxide and sunlight play an important role in the production of energy storage molecules.
- 2. Use the Warm-Up discussion to project and introduce the four new key concepts.** Read, or have a student read, the key concepts aloud.

Key Concept

When there is *more* carbon (in the form of carbon dioxide) in abiotic matter, *more* carbon is available to producers for making energy storage molecules.



When there is *less* carbon (in the form of carbon dioxide) in abiotic matter, *less* carbon is available to producers for making energy storage molecules.





Key Concept

When there is *more* sunlight, producers can make *more* energy storage molecules from the carbon in carbon dioxide.



When there is *less* sunlight, producers cannot make as many energy storage molecules from the carbon in carbon dioxide.



3. Connect key concepts to the biodome. Emphasize to students that understanding the relationships in the key concepts will help them explain to the Econauts why the plants and animals in the biodome did not have enough energy storage molecules.

4. Project message from Dr. Corry. Read this message aloud. Explain that Dr. Corry has sent students some evidence about the carbon dioxide and sunlight in the biodome in order to help them choose between claims.



To: Student Ecologists
From: Dr. Bryan Corry
Subject: Claims About the Biodome

Based on your investigations so far, it seems like there are two possible explanations for the plants and animals in the biodome not having enough energy storage molecules:

Claim 1: A change in the amount of **carbon dioxide** led to a decrease in the amount of energy storage molecules made by producers in the biodome.

Claim 2: A change in the amount of **sunlight** led to a decrease in the amount of energy storage molecules made by producers in the biodome.

Before you share your findings with the Econauts, you'll need to decide which explanation is best. I'm sending along some data that might help you decide. After you examine the data, send a message to the Econauts with a visual model and a written explanation.

Bryan
Dr. Bryan Corry, Head Ecologist
Biodome Investigation Team



2

STUDENT-TO-STUDENT
DISCUSSIONExamining Data from the
Biodome

Examining Data from the Biodome



In pairs, students discuss graphical data about the amounts of carbon dioxide, sunlight, and water in the biodome.

Instructional Guide

1. Introduce new biodome data. Collapse the instructional guide and project the student screen, or have students turn to page 30 in their Investigation Notebooks. Read the prompt aloud and draw attention to the graph on the left.

2. Briefly discuss graph features. Highlight key aspects of the graph.

- **Title.** This indicates the graph is about carbon dioxide, sunlight, and water in the biodome.
- **Key.** The different colors represent carbon dioxide, sunlight, and water.
- **X-axis.** The x-axis is labeled Year, which indicates this graph shows changes in the biodome over time.
- **Y-axis.** The y-axis is labeled Amount, and that's for carbon dioxide, sunlight, and water in the biodome. Explain that the y-axis amounts do not have numbers or units because these resources are measured in different ways. What students really need to see is whether these resources changed over time, and exact numbers are not necessary for that.

3. In pairs, students discuss the evidence. Tell students to use the discussion questions to determine what the graph shows and whether it will help them to answer the Chapter Question. Allow a few minutes for students to discuss the graph. Circulate and offer assistance as needed.

Teacher Support

Background

Science Note: Atmospheric Carbon Dioxide

In the context of the biodome, students may conclude that ecosystems benefit from high levels of atmospheric carbon dioxide. To students, this may seem like a reasonable conclusion, as high levels of atmospheric carbon dioxide mean



that more carbon is available for producers, thus enabling the production of more energy storage molecules through photosynthesis. Given that students are encouraged to think of energy storage molecules as a necessary prerequisite for survival, it is possible that students will assume that high levels of atmospheric carbon dioxide have only positive consequences for the organisms in an ecosystem. However, this view overlooks other ways that atmospheric carbon dioxide can alter the conditions of an ecosystem, chiefly by absorbing and reemitting light waves before they can escape Earth's atmosphere, thereby intensifying Earth's natural greenhouse effect and leading to climate changes that endanger many of the organisms in an ecosystem. Although this content is peripheral to this unit on *Matter and Energy in Ecosystems*, it is central to other Amplify Science units, such as *Earth's Changing Climate*. In order to prevent students from developing a positive view of carbon emissions, you may want to point out that although atmospheric carbon dioxide is necessary for producers to perform photosynthesis as part of a functioning ecosystem, the artificially elevated levels of atmospheric carbon dioxide that result from excessive burning of fossil fuels can negatively impact an ecosystem in ways that are beyond the scope of this unit.



3

WRITING

Reasoning About Data
from the Biodome



Reasoning About Data from the Biodome

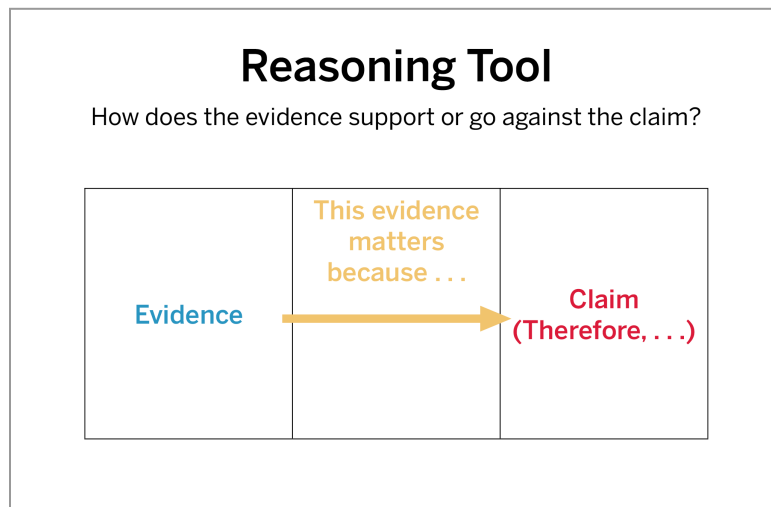


Students use the Reasoning Tool to explicitly connect the graphical evidence about the biodome to one of Dr. Corry's claims.

Instructional Guide

1. Introduce reasoning. Remind students that reasoning is the process of connecting evidence to a claim in a scientific argument. Scientists use what they know about science to make these connections, and it is an important practice of science to make reasoning clear in a scientific argument.

2. Project and explain the Reasoning Tool. If you are displaying the Scientific Argumentation Wall in your classroom, point to the Reasoning Tool and remind students to refer to this as needed.



It can be challenging to clearly say how evidence supports or goes against a claim; however, the process of reasoning is what strengthens a scientific argument or explanation.



3. Explain that students will use the Reasoning Tool to connect the evidence they discussed to one of Dr. Corry's claims. Collapse the instructional guide and project the student screen, or have students turn to page 31 in their Investigation Notebooks.



The Reasoning Tool is meant to help you make your reasoning about the connections between evidence and a claim clear, just as scientists do. We will use the Reasoning Tool today to think about the evidence for the two claims.

4. Model how to use the Reasoning Tool. Show students how to use the Reasoning Tool by demonstrating the following steps on the projected student screen or by using a document camera to project page 31 of the Investigation Notebook:

- **Choose a claim.**

Say: "I am going to choose Claim 2 for this demonstration."

- In the third column of the Reasoning Tool, type (or write), "Claim 2: A change in the amount of sunlight led to a decrease in the amount of energy storage molecules in the biodome."

- **Select a piece of evidence.**

Say: "This graph is about carbon dioxide, sunlight, and water, so it contains more than one piece of evidence. I'm going to select a piece of evidence about sunlight, because as many of you discussed with your partners, the graph shows that the amount of sunlight in the biodome did not change over time. Since Claim 2 is also about sunlight, that seems like an important piece of evidence."

- In the first column of the Reasoning Tool, type (or write), "The amount of sunlight in the biodome did not change over time."

- **Connect the evidence to the claim.**

Say: "Making this connection means explaining why the evidence matters for the claim. If the amount of sunlight in the biodome did not change, that matters because producers need sunlight to make energy storage molecules through photosynthesis. Since my claim is that a change in the amount of sunlight led to a decrease in the amount of energy storage molecules made by producers, this piece of evidence goes against my claim—producers in the biodome got the same amount of sunlight in Year 5 as they did in Year 1."

- In the second column of the Reasoning Tool, type (or write), "If the amount of sunlight in the biodome did not change, then the producers had the same amount of sunlight to make energy storage molecules."

- **Decide whether the evidence supports or goes against the claim.**

Say: "Now you need to indicate your decision—does the evidence support or go against the claim?"

- In front of Claim 2 (A change in the amount of sunlight led to a decrease in the amount of energy storage molecules made by producers in the biodome.), and in the third column of the Reasoning Tool, type (or write), "This evidence goes against."

5. Instruct pairs of students to use one of the other pieces of evidence to argue for or against Claim 1. Remind students that they can use the key concepts posted on the wall or the example that you just completed to help them.



6. Pairs complete the Reasoning Tool. Circulate and support students as they work. Take note of how they fill in the middle column of the Reasoning Tool to gauge student understanding. Allow several minutes for students to fill out the Reasoning Tool.

7. If time permits, invite students share their ideas with the class. Ask volunteers to share some of the thinking they used to explain how the evidence about carbon dioxide connects to Claim 1.

Teacher Support

Rationale

Pedagogical Goals: Understanding the Nature of Science

One goal set forth by the Next Generation Science Standards (NGSS) is for students to understand the nature of science as a discipline and how scientific knowledge develops over time. The NGSS calls out eight understandings about the nature of science which are woven throughout the Amplify Science curriculum. This unit gives students an opportunity to experience the understanding that Scientific Knowledge is Based on Empirical Evidence. Specifically, students' use of the reasoning tool illustrates the idea that science knowledge is based upon logical and conceptual connections between evidence and explanations.

Possible Responses

Evidence: The amount of carbon dioxide in the biodome decreased.

This matters because: If the carbon dioxide in the biodome decreased, that means there was less carbon available for producers to make energy storage molecules.

Therefore: Claim 1: A change in the amount of carbon dioxide led to a decrease in the amount of energy storage molecules made by producers in the biodome.



4

MODELING TOOL

A Model for the Econauts



A Model for the Econauts



Students add to their models from the previous lesson.

Instructional Guide

1. Inform students of opportunity to revise models created during previous lesson. Before students write to the Econauts and answer the Chapter Question, they can update their earlier models showing where energy storage molecules come from.

2. Introduce the activity. Collapse the instructional guide and project the student screen, or have students turn to page 32 in their Investigation Notebooks. Read the instructions aloud. Explain that the Reasoning Tool and their updated models will be there to help them write their explanations to the Econauts.

3. Students work independently to revise their models. If students worked with partners to create their models in the previous lesson, have students pair up again with those same partners to make their revisions. Circulate and offer assistance as needed. Allow a few minutes for students to make changes to their models.

4. Students begin writing their explanations. After students have updated their models, they can begin writing to the Econauts. Remind them to refer to their models and Reasoning Tools as they write.

5. Point out the homework assignment. Explain that if students did not finish their explanations for the Econauts, they should finish them for homework. Remind students who have to finish writing at home to refer to their Reasoning Tools and models, as they write. If students do not have access to Amplify Science at home, provide them with printed copies of the “Meet a Scientist Who Studies How Plants Find Water Underground” article, and the Reading “Meet a Scientist Who Studies How Plants Find Water Underground” student sheet.

6. Optional: Point out the Self-Assessment (Activity 6 or page 33 in the Investigation Notebook). If students do not have access to Amplify Science at home, provide them with copies of page 33 from the Investigation Notebook. Explain to students that in order to reflect on their own learning, they will revisit these questions at the end of every chapter. Some of the questions are based on learning that will come later in the unit, so it’s fine if students select NOT YET for some of their responses.

7. On-the-Fly Assessment: Explaining Why Decreased Carbon Dioxide Affected Photosynthesis. Students’ models and explanations provide an opportunity for formative assessment. For further suggestions on how to support student modeling and argumentation, press the hummingbird icon and select ON-THE-FLY ASSESSMENT 4.



Embedded Formative Assessment

On-the-Fly Assessment 4: Explaining Why Decreased Carbon Dioxide Affected Photosynthesis

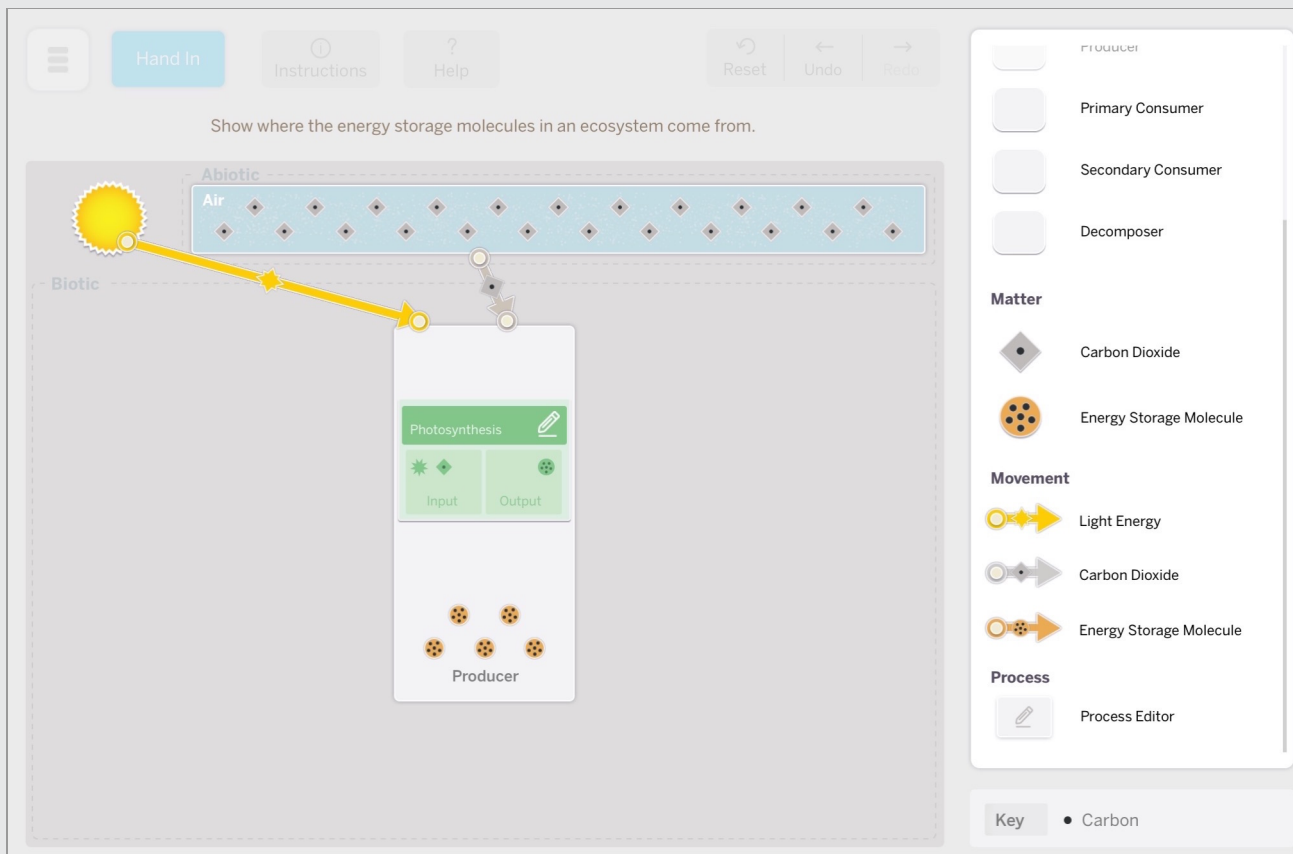
Look for: Reviewing student models and explanations can give insight into individual student understanding of the Chapter 1 content (Level 1 of the Progress Build), as well as how students are developing with the practice of argumentation from evidence. Student models should show that producers need both carbon dioxide and sunlight to do photosynthesis. In their explanations, students should be able to connect the evidence (carbon dioxide in the biodome decreased) with the claim (a decrease in carbon dioxide led to a decrease in energy storage molecules through reduced photosynthesis). Some students might also say that because energy from the sun didn't change, there was still enough energy for plants to do photosynthesis, so the limiting factor was carbon dioxide.

Now what? Students will begin to learn about how energy storage molecules are used for cellular respiration in the next chapter. At this point, it is important to make sure students understand the relationship between the decrease in carbon dioxide and a decrease in energy storage molecules in the biodome. You may consider taking some extra time to review this concept. You can do this review as a whole class or with smaller groups. You could use the Sim to demonstrate how a decrease in carbon dioxide in the atmosphere leads to the production of fewer energy storage molecules in biotic matter.

Possible Responses

Modeling Tool Response

The possible proficient model shown below is the same as the 1.5 model. The model shows that producers make energy storage molecules through photosynthesis. Producers use energy from the sun and carbon dioxide to make energy storage molecules. Students might show consumers in their models or add arrows that show the flow of energy storage molecules from producers to consumers. This is not necessary for a proficient model.



Explain to the Econauts why the plants and animals in the biodome were not getting enough energy storage molecules. Use your Reasoning Tool and your model to help you as you write.

The plants and animals in the biodome were not getting enough energy storage molecules because the amount of carbon dioxide in the air of the biodome decreased over time. As my model shows, this matters because the producers in an ecosystem need carbon dioxide in order to make energy storage molecules through the process of photosynthesis. So if the amount of carbon dioxide in the biodome decreased over time, then the amount of energy storage molecules made by producers must have decreased, too. If the amount of energy storage molecules made by producers decreased, then that explains why the plants and animals in the biodome were not getting enough energy storage molecules.



5

HOMEWORK
Homework

Homework

Students read and annotate the article, “Meet a Scientist Who Studies How Plants Find Water Underground.”

Instructional Guide

1. If needed, make additional time to explain the homework. If students do not have access to Amplify Science at home, provide copies of the “Meet a Scientist Who Studies How Plants Find Water Underground” article, and the Reading “Meet a Scientist Who Studies How Plants Find Water Underground” student sheet.

Teacher Support

Instructional Suggestion

Going Further: “Meet a Scientist Who Studies How Plants Find Water Underground”

This article provides an excellent opportunity for students to learn about how scientists study plants’ roots and how they bring water to the plant. If you make time in class to discuss this article, invite students to ask questions and contribute ideas about how scientists study plants. Don’t worry if you don’t know the answers to all their questions. For more information about the types of tools that Dinneny uses in his lab, you can search his name on the internet and read more about his work.

Rationale

Pedagogical Goals: Scientists from All Demographic Groups

It’s important for students to know that people from all demographic groups have made important contributions to society through science and technology. This diversity includes people of different ethnicities; people with disabilities; as well as lesbian, gay, bisexual, and transgender people. Often, students assume that scientists are older white men. In our curriculum, we strive to present students with an array of diverse scientists so they can see that the important ingredients for being a scientist are hard work, curiosity, and collaboration rather than skin color, gender, physical ability, or sexual orientation. You may want to have a conversation with your students about diversity among scientists. Noticing and discussing differences among people can help combat stereotypes more than ignoring these differences.



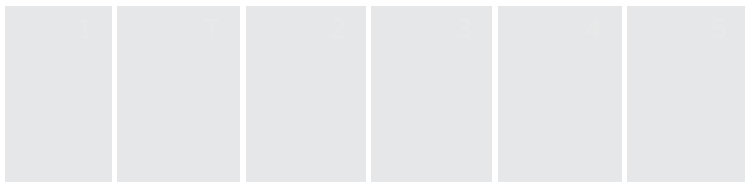
Possible Responses

How do plants gather water in a way that is different from how they get sunlight and air?

Plants spread their leaves to absorb sunlight and air, but in order to get more water they can grow their roots to reach where the water is.

José Dinneny says that being curious is important for being a scientist. What are you curious about?

Answers will vary



6

HOMEWORK

Self-Assessment
(Optional)

Self-Assessment (Optional)

This optional homework provides a chance for students to reflect on their learning so far.

Instructional Guide

1. If needed, make additional time to explain the optional self-assessment. If students do not have access to Amplify Science at home, provide them with copies of page 33 from the Investigation Notebook. Explain that in order to reflect on their own learning, students will answer these questions at the end of each chapter. Some of the questions are about ideas that will be addressed later in the unit, so it's okay if students select “not yet” for some of their responses.

Teacher Support

Rationale

Student Self-Assessment: Reflecting on the Unit

This is the first of four student self-assessments that invite students to reflect on their progress in solving the overall problem of the unit—figuring out how organisms in an ecosystem get enough energy to survive, through the context of what went wrong in the biodome. This quick, important activity appears at the end of each of the four chapters of this unit and asks students to reflect on what they do or do not yet understand about the core concepts from the unit. Reviewing students' responses can give you a sense of what students think they know. Students' responses can also provide insight about what students are curious about, and this insight can help you provide motivation for the investigations that follow.

Rationale

Pedagogical Goals: Student Self-Assessment

Having students assess their own learning progress can help them develop habits of self-reflection as well as remind them of the purpose of learning about why populations change size in an ecosystem. Assign the self-assessment as homework or provide time for students to complete it during class. Encourage students to be open and honest when they respond. Emphasize that the goal of this type of reflection is for students to gauge their own learning in order to better understand what they need to focus on in the remainder of the unit. Also, let them know that they aren't expected to understand everything at the beginning of the unit—each chapter will help them understand a little more about the scientific concepts. Engaging in self-assessment may increase students' motivation and focus throughout the unit.



Possible Responses

Answers will vary. This is a self-reflection.





Chapter 2

Cellular Respiration in Ecosystems



Chapter Overview

Chapter Question

What caused carbon dioxide to decrease in the air (abiotic matter) of the biodome?

Investigation Questions

- Where does the carbon dioxide in abiotic matter come from? (2.1) ?
- How do organisms give off carbon dioxide? (2.2)

Key Concepts

- As organisms release energy during cellular respiration, carbon dioxide is produced from the carbon in energy storage molecules. This process moves carbon from biotic to abiotic matter. (2.3)



Chapter 2 Activities

Lesson 2.1: Carbon Dioxide in Ecosystems

1 Warm-Up	WARM-UP
2 Carbon Dioxide in Ecosystems	SORTING TOOL
3 The Snail and Elodea Experiment	MEDIA
T Snail and Elodea Experiment Video	TEACHER
4 Introduction to A Feast for Decomposers	READING
5 Homework	HOMEWORK

Lesson 2.2: How Carbon Dioxide Enters the Air

1 Warm-Up	WARM-UP
2 Observing Cellular Respiration	SIM
3 Modeling How Organisms Give Off Carbon Dioxide	MODELING TOOL
4 Sharing Models	STUDENT-TO-STUDENT DISCUSSION
5 Homework	HOMEWORK

Lesson 2.3: An Explanation for the Econauts

1 Warm-Up	WARM-UP
2 Discussing the Data	TEACHER-LED DISCUSSION
3 Testing a Claim in the Sim	SIM
4 Word Relationships Routine	STUDENT-TO-STUDENT DISCUSSION
5 Homework	HOMEWORK

Lesson 2.4: Critical Juncture Assessment

1 Multiple-Choice Questions	CLASS
2 Written-Response Question #1	CLASS
3 Written-Response Question #2	CLASS
4 Homework	HOMEWORK



Lesson 2.5: Investigating Econauts' Claims

- 1 Warm-Up
- T Preparing to Investigate Claims
- 2 Investigating Ecosystem Claims
- 3 Word Relationships Routine
- 4 Homework
- 5 Self-Assessment (Optional)

WARM-UP

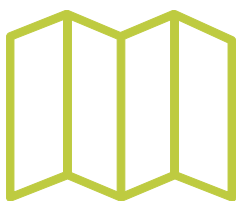
TEACHER

SIM

STUDENT-TO-STUDENT DISCUSSION

HOMEWORK

HOMEWORK



Lesson 2.1

Carbon Dioxide in Ecosystems



Lesson at a Glance

ACTIVITY

1

Warm-Up (5 min)

Students use their prior knowledge to consider what might have caused carbon dioxide in the biodome's air to decrease.



WARM-UP

2

Carbon Dioxide in Ecosystems (10 min)

Students use the Sorting Tool to make claims about what parts of the ecosystem release carbon dioxide to the atmosphere.



SORTING TOOL

3

The Snail and Elodea Experiment (10 min)

Students make predictions and then observe an experiment in order to think more about what types of organisms produce carbon dioxide.



MEDIA

T

Snail and Elodea Experiment Video

The teacher plays the first half of the video—the experimental setup—followed by the second half, showing the results.



TEACHER

4

Introduction to A Feast for Decomposers (20 min)

Students read the introduction to an article set about decomposers and then revise their ideas from earlier about which parts of an ecosystem give off carbon dioxide. This activity provides an On-the-Fly Assessment for determining how well students understand that all organisms give off carbon dioxide.



READING

5

Homework

Students learn more about decomposers and how they use dead matter to release energy.



HOMEWORK



DIGITAL RESOURCES

Video: Snail and Elodea Experiment, Part 1

Video: Snail and Elodea Experiment, Part 2

A Feast for Decomposers

Printable article set: A Feast for Decomposers

Matter and Energy in Ecosystems Investigation Notebook, pages 35–40

Matter and Energy in Ecosystems Glossary

Matter and Energy in Ecosystems Multi-Language Glossary



1

WARM-UP
Warm-Up



Warm-Up



Students use their prior knowledge to generate claims about why the carbon dioxide in the biodome might have decreased.

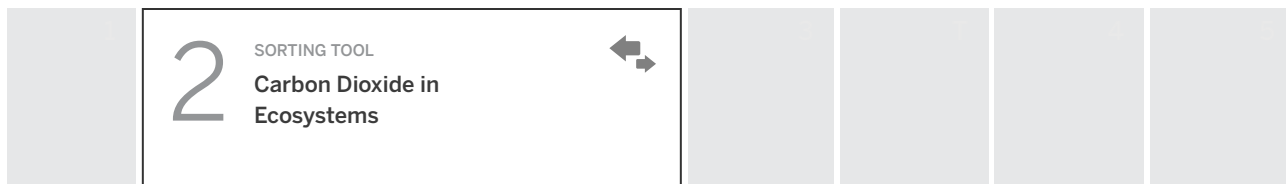
Instructional Guide

1. Project Warm-Up; students work independently. Collapse the instructional guide and project the student screen, or have students turn to page 36 in the Investigation Notebook. Allow a few minutes for students to individually respond to the Warm-Up.

Possible Responses

At the end of the last lesson, you learned there was not enough carbon dioxide in the biodome's air, which led to a decrease in energy storage molecules inside the biodome. What are some ideas you have about what might have caused the decrease in carbon dioxide? Record some initial claims. You will have an opportunity to revise them after you learn more.

Answers will vary. The purpose of this activity is to elicit students' initial ideas, and they are not expected to have an accurate answer at this time.



Carbon Dioxide in Ecosystems



Students sort parts of an ecosystem to show their initial ideas about whether they give off carbon dioxide or not.

Instructional Guide

1. Debrief the Warm-Up. Have students share their ideas about what could have caused carbon dioxide to decrease in the air of the biodome. Accept all answers. If students have alternative ideas that are related to global climate change or factors outside the biodome, remind them that the biodome is a closed ecosystem. In this type of system, the parts can only influence each other; things outside the system do not affect them.

2. Review key concepts and introduce new questions. Point out the key concepts you posted after the last lesson and read them aloud. Then point out the newly posted Chapter 2 Question and today's Investigation Question on the board, and read them aloud.



In the last chapter you learned that producers did not have enough carbon from carbon dioxide to make the energy storage molecules that organisms in the biodome needed. In Chapter 2, we will focus on trying to discover what caused carbon dioxide to decrease in the air (abiotic matter) of the biodome. But before we do that, we have to figure out where the carbon dioxide in the air comes from.

3. Introduce the Sorting Tool activity: [Carbon Dioxide in Ecosystems](#). Explain that they will now have a chance to discuss different parts of the biodome ecosystem and consider whether or not they give off carbon dioxide. Point out that it is fine if they are not yet sure; the goal is just to record their initial ideas.

4. Pairs sort parts of the ecosystem. Provide students approximately 5 minutes to discuss and sort parts of the ecosystem with their partners. If students are using the Investigation Notebook, point out that the instructions and discussion questions can be found on page 37 in the Investigation Notebook. Circulate and assist pairs as necessary.

5. Conduct a class poll. After pairs have finished discussing and sorting the parts of the ecosystem, remind students to respond to the class poll on their screens or have students raise their hands as you read out the options. If students are raising their hands, tally up the votes for each option on the board.



6. Share poll results with the class. Ask students to share some ideas they have about why they think some parts of the ecosystem release carbon dioxide while other parts don't. At this point accept all answers, and let students know that they will investigate this further.

7. Clarify abiotic matter in Investigation Question. Refer to the Investigation Question on the board (*Where does the carbon dioxide in abiotic matter come from?*), and remind students that *carbon dioxide in abiotic matter* could be referring to either the air or the water of an ecosystem, or even to both places. Let students know that they will continue to think about this question, and that they will revisit their ideas later in the lesson.

Teacher Support

Instructional Suggestion

Supporting Language: “Releasing” Energy and “Giving Off” Carbon Dioxide

In this unit, the word *release* is used to describe how organisms access the energy in energy storage molecules during cellular respiration. To describe output products, such as carbon dioxide, that are expelled or discarded by an organism, we use the term *give off* to avoid confusion. However, distinguishing between these terms may still be difficult for students, so you may want to provide some examples to illustrate how these meanings are different. Examples of releasing or providing access to something could include peeling a piece of fruit for eating, opening a bottle of water for drinking, or breaking the glass on a fire extinguisher before using it. Examples of things being given off (expelled or discarded) could include water evaporating from a puddle, smoke coming from a fire, or the scent from a flower.

Possible Responses

Gives off carbon dioxide:

snail: primary consumer
soil bacteria: decomposer
mushroom: decomposer
snake: secondary consumer
Elodea plant: producer

Does not give off carbon dioxide:

fallen leaves: dead matter



3

MEDIA

The Snail and Elodea
Experiment

The Snail and Elodea Experiment



Students watch a video to get evidence about whether producers and consumers give off carbon dioxide.

Instructional Guide

- 1. Introduce the experiment video.** Read the questions on the student screen or page 38 in the Investigation Notebook, and let students know that you will play the first part of the video before they write their predictions.
- 2. Play the video (select the next activity: *Snail and Elodea Experiment Video*).**

Teacher Support

Rationale

Science Note: Snail and *Elodea* Experiment

To avoid a complicated setup and possible inconsistent results, we have provided a video of the snail and *Elodea* experiment. However, if you have additional time and would like your students to gather this evidence for themselves, you can set up this experiment using the following materials:

- bromothymol blue (BTB) solution or any other chemical indicator which can detect carbon dioxide
- *Elodea* plants or other freshwater aquarium plant
- sealable vials or test tubes
- incandescent lamp or grow light
- foil or a dark location
- freshwater snails

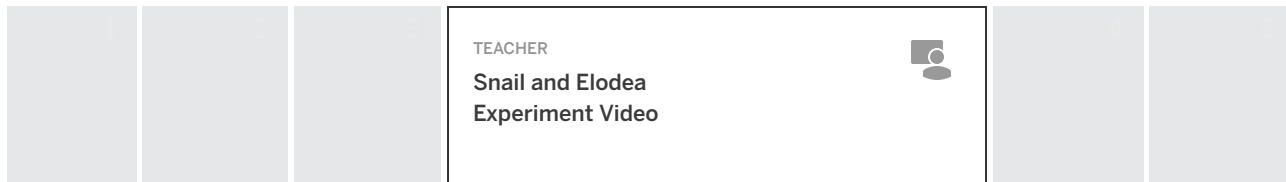
If students set up and run the experiment themselves, it may require up to 30 minutes for the setup on one day and another 30 minutes for gathering data, discussing results, and cleaning up the experiment on the following day.



Possible Responses

Discuss with your partner:

1. Answers will vary.
2. Producers give off carbon dioxide because the BTB in the tube turned from blue to yellow, which means a lot of carbon dioxide was added. Some students may also say that in the last chapter they learned that plants do photosynthesis, and that requires them to take in carbon dioxide.
3. Consumers give off carbon dioxide because the BTB in the tube turned from blue to yellow, which means a lot of carbon dioxide was added.
4. Carbon dioxide in abiotic matter can come from both producers and consumers.



Snail and Elodea Experiment Video

The video, *Snail and Elodea Experiment*, gives students evidence that both producers and consumers give off carbon dioxide.

Instructional Guide

- 1. Project and play *Snail and Elodea Experiment, Part 1*.** Collapse the instructional guide and project the video, using the play button on the bottom of the screen. This part of the video discusses the experimental setup. Answer any student questions about the experiment.
- 2. Instruct students to make predictions on their screens or in the table on page 38 in their Investigation Notebooks.** Tell students to think about the setup and what they might expect to see. Have them record their predictions about which organisms will give off carbon dioxide during the experiment.
- 3. Briefly survey the class with a show of hands.** Ask how many students think the snail will give off carbon dioxide, and how many think the plant will give off carbon dioxide.
- 4. Press NEXT to play the second part of the video.**
- 5. Project and play *Snail and Elodea Experiment, Part 2*.**
- 6. Students record results and discuss the experiment with a partner.** After recording the experimental results in the table, students should discuss the questions (below the table) with their partners.
- 7. Debrief the partner discussion.** Be sure the following points are covered if students do not bring them up:
 - Review that you can tell whether carbon dioxide is added or removed by the color of the BTB solution. When carbon dioxide is added to the solution, it becomes more yellow, and when carbon dioxide is removed from the solution, it becomes more blue.
 - The *Elodea* plant produced carbon dioxide when it was in the dark (the BTB solution changed from blue to yellow).



- The snail produced carbon dioxide (the BTB solution changed from blue to yellow).
- Conclude that both producers and consumers can give off carbon dioxide.



4

READING

Introduction to A Feast for
Decomposers

Introduction to A Feast for Decomposers



Students annotate the introduction to the article set, *A Feast for Decomposers*, in order to learn more about how decomposers contribute to ecosystems.

Instructional Guide

1. Project and introduce "A Feast for Decomposers" from the Amplify Library or project a printed copy with a document camera. Remind students that they predicted whether producers, consumers, or decomposers would give off carbon dioxide. The experiment in the video provided evidence that both producers and consumers give off carbon dioxide, but decomposers are still an unknown. Explain that students will read an introduction to an article set that will help them get evidence about whether decomposers give off carbon dioxide to the air. After that, they will choose one of the articles in the set to read for homework.

2. Students read and annotate the article's introduction. As students are reading and annotating, circulate and answer questions while looking over annotations that students are making.



3. **Project partner discussion question.** Have students discuss briefly with a partner.

A Feast for Decomposers

Based on what you just read in the text, discuss this question with your partner:

Do decomposers give off carbon dioxide to abiotic matter (air or water)?

Ask students to press NEXT (or to move onto Part 2 on page 39 in the Investigation Notebook).

4. **Students review card sorts.** Using what they learned from the video and the article introduction, have students take another look at their card sorts. To reflect their new understanding of the parts of an ecosystem that give off carbon dioxide, have them update their sorts and move those cards that were incorrectly placed. If students are using the Investigation Notebook, have them turn to page 39 to see the instructions for revisiting the Sorting Tool.

5. **On-the-Fly Assessment: Organisms That Release Carbon Dioxide.** For suggestions on what to look for in students' ideas about which organisms give off carbon dioxide, see the ON-THE-FLY ASSESSMENT 5.

6. **Conduct a brief class discussion about which parts of the ecosystem give off carbon dioxide.** Ask students to share how they categorized the cards for each part of the ecosystem. As they share, ask them to provide evidence from the video and the article introduction. Below are suggestions to touch on, if not brought up by students:

- **Mushrooms and soil bacteria:** According to the article, decomposers consume dead organisms in order to get energy storage molecules and in the process, produce carbon dioxide.
- **Elodea:** According to the experiment, plants produce carbon dioxide. You could tell this because the BTB for the plants in the dark, which were not doing photosynthesis, changed color from blue to yellow, indicating carbon dioxide. This means that plants give off as well as take in carbon dioxide.
- **Snail and snake:** In the experiment, the BTB in the tube with the snail changed from blue to yellow, indicating carbon dioxide. Therefore, consumers give off carbon dioxide.
- **Dead matter:** Students did not get any evidence about whether dead matter gives off carbon dioxide. You might ask students to clarify why they do or do not think that dead matter and abiotic matter give off carbon dioxide. Ask students if they think something needs to be alive in order to give off carbon dioxide. Let students know that they will continue gathering evidence in upcoming lessons.



7. Briefly return to the Investigation Question. Point out that today students learned that producers, consumers, and decomposers all give off carbon dioxide to abiotic matter (air or water).

8. Point out the homework (Activity 5 or page 40 in the Investigation Notebook). If students do not have access to Amplify Science at home, provide them with copies of page 40 from the Investigation Notebook and copies of the *A Feast for Decomposers* article set. Students should choose and then read and annotate at least one of the articles in the article set, *A Feast for Decomposers*. These articles will help them learn more about the importance of decomposers in ecosystems.



Embedded Formative Assessment

On-the-Fly Assessment 5: Organisms That Release Carbon Dioxide

Look for: As students revisit the card sort, look for them to place all organisms (producers, consumers, and decomposers) into the Gives-off-carbon-dioxide category. It is important that students reach this conclusion—using prior knowledge and evidence from the *Snail and Elodea Experiment* video and *Feast for Decomposers* article—so they can work toward a comprehensive understanding of cellular respiration in subsequent lessons.

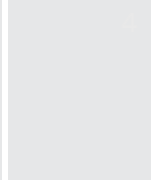
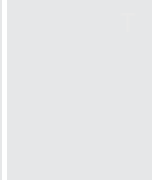
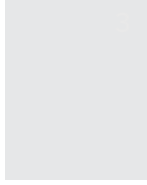
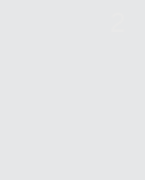
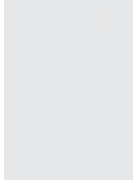
Now what? Students who need more support in understanding that all organisms give off carbon dioxide may benefit from taking extra time to review the evidence that students found in the video and the article. This includes reviewing the results of the experiment as well as text evidence. Emphasize that the experiment showed both producers and consumers give off carbon dioxide, while the text showed that decomposers also give off carbon dioxide. This review could be done as a whole-class discussion or in small groups. Let students know that they will learn more in upcoming lessons about this process where organisms give off carbon dioxide, as well as why this process is important to solving the biodome problem.

Teacher Support

Background

Science Note: Clarifying Experimental Results

To simplify the results of the snail and *Elodea* experiment for students, the experiment only looked at producers and consumers in the dark. This achieves the lessons' purpose of giving students evidence that both producers and consumers give off carbon dioxide. However, simplifying the experiment in this manner may lead students to the incorrect thinking that producers and consumers ONLY give off carbon dioxide in the dark, when in fact, they can give off carbon dioxide at any time of the day. It is not necessary to correct students' ideas about this in today's lesson because in the next lesson, they will learn more about the process of cellular respiration and will get evidence from the Sim that the amount of light has no effect on the amount of carbon dioxide given off through cellular respiration.



5

HOMEWORK

Homework



Homework

Students choose one article from the article set, *A Feast for Decomposers*, to read and annotate.

Instructional Guide

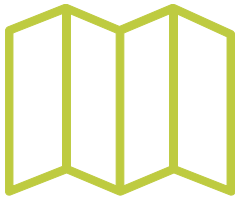
1. If needed, make additional time to introduce the homework. If students do not have access to Amplify Science at home, provide them with copies of page 40 from the Investigation Notebook and copies of the *A Feast for Decomposers* article set.



Image Credits

Audiojungle (Video: Snail and Elodea Experiment, Part 1).





Lesson 2.2

How Carbon Dioxide Enters the Air



Lesson at a Glance

ACTIVITY

1

Warm-Up (5 min)

Students think individually about cellular respiration, using a visual representation from *A Feast for Decomposers*.



WARM-UP

2

Observing Cellular Respiration (20 min)

Students use the Sim to observe the dynamic process of cellular respiration, which provides further evidence that all living organisms give off carbon dioxide.



SIM

3

Modeling How Organisms Give Off Carbon Dioxide (15 min)

Students answer the Investigation Question by creating a model that shows which organisms give off carbon dioxide. This activity provides an On-the-Fly Assessment for understanding that organisms give off carbon dioxide through the process of cellular respiration.

MODELING
TOOL

4

Sharing Models (5 min)

Students reflect on their understanding of the key concept, the practice of modeling, and the unit vocabulary terms, as they explain their models to a partner.

STUDENT-TO-
STUDENT
DISCUSSION

5

Homework

Students read a short article about mulberry trees and silkworms, and then use the Sim to compare the amount of producer photosynthesis and cellular respiration.



HOMEWORK



DIGITAL RESOURCES

The Mulberry Tree and the Silkworm

Printable article: "The Mulberry Tree and the Silkworm"

Matter and Energy in Ecosystems
Investigation Notebook, pages
41–46

Matter and Energy in Ecosystems
Glossary

Matter and Energy in Ecosystems
Multi-Language Glossary



1

WARM-UP
Warm-Up

Warm-Up

Students interpret a visual representation of cellular respiration.



Instructional Guide

1. Project Warm-Up; students work independently. Collapse the instructional guide and project the student screen, or have students turn to page 42 in their Investigation Notebooks. Allow a few minutes for students to individually respond to the Warm-Up.

Teacher Support

Rationale

Pedagogical Goals: Interpreting Diagrams

Visual representations are a vital component of science texts because scientists often share their conceptual thinking through diagrams. Students need to learn how to “read” diagrams, using clues like title, colors, arrows, etc., in order to comprehend the particular science concept that the author is trying to convey. Comprehending science texts also requires students to coordinate a reading of the regular text with a reading of the accompanying diagrams. In this activity, students are presented with a diagram of cellular respiration from *A Feast for Decomposers*. Because the coordination between diagram and text is challenging, presenting the diagram in isolation allows students to focus only on interpreting the diagram.

Possible Responses

What do you think this diagram shows about cellular respiration?

This diagram shows that cellular respiration turns oxygen molecules and glucose (energy storage molecules) into energy, carbon dioxide molecules, and water molecules.



2

SIM

Observing Cellular
Respiration

Observing Cellular Respiration



Students gather evidence about the Investigation Question by comparing the diagram of cellular respiration to its depiction in the Sim.

Instructional Guide

- 1. Lead a brief class discussion of the Warm-Up.** Invite students to share what they wrote about the diagram of cellular respiration.
- 2. Review what students learned during the previous investigation.** Remind students that they have been investigating how carbon dioxide gets into the air so they can figure out why there was less and less of it in the biodome. Remind students that the experiment in the video showed evidence that producers and consumers give off carbon dioxide and the article they read for homework indicated that decomposers do this, too.
- 3. Introduce the vocabulary word *decomposer* and project the definition.** Collapse the instructional guide and project the student screen. Read (or ask a student to read) the word and definition aloud.
- 4. Invite students to give examples of decomposers from the articles they chose.** [Worms, termites, mushrooms, fungi of various types, soil bacteria, mold, aquatic bacteria, or small insects.]
- 5. Remind students to look at the glossary if they need more support.**
- 6. Introduce the new Investigation Question on the board.** Explain that students are now going to be investigating exactly *how* organisms give off carbon dioxide.



Now we know that producers, consumers, and decomposers all give off carbon dioxide, which ends up in the abiotic matter of an ecosystem, usually in the air. Today, we are going to use the Sim to learn in more detail about how this actually happens.

Ask students to press NEXT (or to turn to page 43 in the Investigation Notebook).

- 7. Introduce first part of Sim activity.** Collapse the instructional guide and project the student screen, or have students turn to page 43 in their Investigation Notebooks. Explain that students will now be making a comparison between the diagram they saw in the Warm-Up and the one they will see when they press VIEW CELL for organisms in the Sim.



Remind students that they did something similar in Chapter 1, when they compared a diagram of photosynthesis to cells in the Sim. This comparison will help students answer the Investigation Question about how organisms give off carbon dioxide.

8. Review instructions. Make sure students know that they will be working in pairs, with the Sim running on one device and the instructions on the other. If you only have one device for every two students, students should refer to the instructions on page 43 of the Investigation Notebook while completing the Sim activity in pairs. If necessary, go over the expectations for students working in pairs.

9. In pairs, students observe cells of different organisms. Circulate and assist as needed. Remind students to press VIEW CELL for each organism and to discuss what they observe with their partners, using the discussion questions.

10. Conduct a brief class discussion of this part of the Sim activity. Invite students to share what they observed in the Sim about how cells of organisms give off carbon dioxide. Encourage them to discuss any similarities or differences between the different organisms as well as any similarities or differences between cells shown in the Sim and the diagram from the Warm-Up.

Ask students to press NEXT (or to move onto Part 2 on page 43 in the Investigation Notebook).

11. Instruct students to revise their answers to the Warm-Up question. Remind students that scientists update their ideas whenever they get new evidence.

12. Invite students to share their revisions. Ask if there are any volunteers who would like to explain what they think *cellular respiration* means.

13. Make a connection to the crosscutting concept of Energy and Matter. Point out that during cellular respiration, matter is conserved because atoms are conserved in physical and chemical processes.



If you look closely at the diagram, you can see that it shows that during cellular respiration, atoms rearrange but none appear or disappear. This means that all of the atoms from carbon dioxide and water are still there after the reaction, they are just rearranged into new molecules. Let's look at carbon atoms as an example. Carbon atoms are represented by black spheres in the diagram. How many carbon atoms are there before the reaction (shown on the left side of the diagram) [6] How many carbon atoms are there after the reaction? (shown on the right side of the diagram) [6] The same six carbon atoms are still there, they have just rearranged. You can count the oxygen or hydrogen atoms before and after the reaction as well, they are represented by red and white spheres.

If students are using devices, ask them to press NEXT.

14. Introduce the vocabulary term *cellular respiration* and project the definition. Collapse the instructional guide and project the student screen. Read (or ask a student to read) the word and definition aloud.

15. Remind students to look at the glossary if they need more support.

Ask students to press NEXT (or to move onto Part 3 in the Investigation Notebook).



16. Introduce second part of Sim activity. Collapse the instructional guide and project the student screen, or have students refer to Part 3 on page 43 in their Investigation Notebooks. Explain that students will be using the Sim to observe whether cellular respiration is affected by the amount of sunlight in the ecosystem.



We know the process of photosynthesis requires sunlight and now you will investigate whether the process of cellular respiration also requires sunlight.

17. In pairs, students observe the Sim. Circulate and assist as needed. Remind students to adjust the amount of sunlight in the ecosystem so they can answer the question about sunlight.

18. Conduct a brief class discussion of this part of the Sim activity. Invite students to share what they learned. Point out that you can tell which organisms are doing cellular respiration by observing which organisms give off carbon dioxide to abiotic matter. Confirm that sunlight does not affect which parts of the ecosystem give off carbon dioxide, so sunlight must not be required for cellular respiration.

19. Make a comparison between the processes of cellular respiration and photosynthesis. Highlight the ways that cellular respiration is similar to and different from photosynthesis.



Both photosynthesis and cellular respiration are processes that take place inside the cell, but photosynthesis only happens in producers, while cellular respiration happens in all organisms, including producers. In a way these processes are opposites: Through photosynthesis, producers make energy storage molecules. Through cellular respiration, all organisms use these molecules to release energy. Photosynthesis requires energy from the sun to happen, but in cellular respiration energy is released.

Teacher Support

Background

Crosscutting Concept: Energy and Matter

Throughout Middle School, students gain experience with the crosscutting concept of Energy and Matter, including the idea that matter is conserved because atoms are conserved in physical and chemical processes. In this unit, students learn about two chemical reactions essential to ecosystems: photosynthesis and cellular respiration. They examine diagrams of each reaction that show the same number and type of each atom both in the reactants and the products. To reinforce this concept have students count one type of atom (for example oxygen) on each side of the diagram in order to confirm that no atoms have been lost or gained. Students also think about this aspect of Energy and Matter in other domains. For example, in the physical science unit *Chemical Reactions*, students gather evidence that atoms are never created, destroyed, or transformed during a chemical reaction. Students reinforce the idea that all the matter that goes into a chemical reaction must come out in some form.

Instructional Suggestion

Scientific Language: Emphasizing Cellular Respiration as a Process

Since many scientific words are used across content areas, landing on a consistent definition of these words represents a curricular challenge. In this unit, the term *cellular respiration* is defined as a chemical reaction, and this is an accurate definition that works well in other areas of this curriculum. However, for students in this unit, that definition may be confusing. *Cellular respiration* is referred to as a process (not chemical reaction) in the key concept introduced in the



next lesson and as a category in the process editor of the Modeling Tool. Referring to both photosynthesis and cellular respiration as processes will help students draw comparisons between the two. As you introduce the definition of *cellular respiration*, it is recommended that you take a moment to explicitly label it as a process so students will have this knowledge before using the process editor in the next activity.

Possible Responses

What students should/might do:

Students should open the cells of the different organism types by pressing VIEW CELL and observe what is happening in the mitochondria of the cells. They should compare cellular respiration, as shown in the Sim, to a visual representation of cellular respiration.

What students should notice:

During cellular respiration, energy storage molecules change into carbon dioxide and water. The carbon from energy storage molecules becomes part of carbon dioxide. Students may notice that the energy released through cellular respiration is not shown in the Sim, while it is shown in the diagram.

What do you think this diagram shows about cellular respiration?

This diagram shows that cellular respiration turns oxygen molecules and glucose (energy storage molecules) into energy, carbon dioxide molecules, and water molecules. This process happens inside the cells of all organisms, including producers, consumers, and decomposers.

What students should/might do:

Students should first observe which organisms do cellular respiration, and then decrease sunlight to zero to observe if cellular respiration is affected. Students can observe whether cellular respiration is affected by observing the carbon dioxide being given off by organisms or by looking at Info view.

What students should notice:

By observing that all living organisms give off carbon dioxide, students should conclude that producers, primary consumers, secondary consumers, and decomposers perform cellular respiration. Dead matter does **not** perform cellular respiration. Students should also observe that sunlight does **not** affect cellular respiration.



3

MODELING TOOL

Modeling How Organisms
Give Off Carbon Dioxide

Modeling How Organisms Give Off Carbon Dioxide



Students demonstrate their knowledge of cellular respiration by modeling their answers to the Investigation Question.

Instructional Guide

- 1. Inform students that they are now ready to answer the Investigation Question.** Explain that students will use what they saw in the Sim and in the diagram to construct a model that shows how organisms give off carbon dioxide.
- 2. Project and introduce the Modeling Tool activity: [Carbon Dioxide in Air](#).** Collapse the instructional guide and go over the instructions on the student screen, or on page 44 in the Investigation Notebook, as a class.
- 3. Emphasize that students should show which organisms give off carbon dioxide as well as how this happens.** If necessary, model how to add an organism group to the model and open the process editor.
- 4. Inform students that they will be sharing their finished models with a partner (or if they complete the models in pairs, with another pair) at the end of class.** Encourage students to begin thinking about what to say and share as they are building their models.
- 5. Students create models.** Circulate and offer assistance as needed. A sample in the Possible Responses tab offers some guidance.
- 6. On-the-Fly Assessment: Modeling Cellular Respiration in an Ecosystem.** After class, you can review students' work and assess their modeling ability, as well as their understanding of how organisms give off carbon dioxide through cellular respiration. For further suggestions on how to support students, press the hummingbird icon and select ON-THE-FLY ASSESSMENT 6.



Embedded Formative Assessment

On-the-Fly Assessment 6: Modeling Cellular Respiration in an Ecosystem

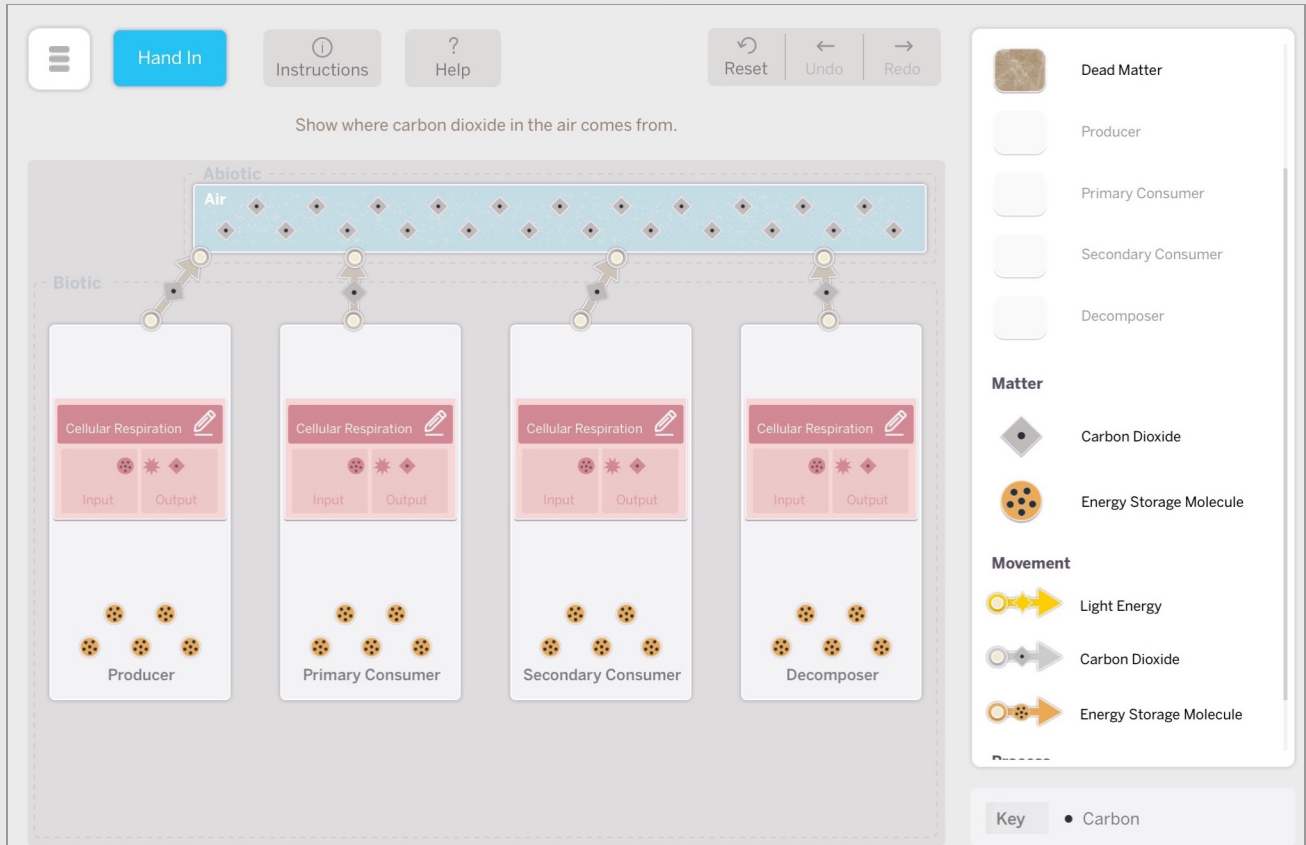
Look for: This Modeling Tool activity provides insight into individual student understanding that all organisms in an ecosystem give off carbon dioxide through cellular respiration as they release energy from energy storage molecules (Level 2 of the Progress Build). Look for models to indicate that all organisms (producers, consumers, and decomposers) perform cellular respiration, and that an output of this process is carbon dioxide. Students are likely to show energy (for organisms to use for survival) as an output of cellular respiration, though this is not the focus of this unit. Additionally, students should use the carbon dioxide arrow to show that carbon dioxide moves from living things (biotic matter) to abiotic matter, which allows them to demonstrate their understanding of the crosscutting concept of systems and the connections between parts of a system. A proficient student model example can be found by selecting the Possible Responses tab.

Now what? Students will continue to use the ideas that all organisms perform cellular respiration and that this process moves carbon from biotic to abiotic matter in Lesson 2.3 when they examine data and find evidence in the Sim that a decrease in the decomposer population led to a decrease in the amount of carbon dioxide in abiotic matter. You could take this opportunity to conduct a full-class or small-group discussion of the connection between cellular respiration and the amount of carbon in abiotic matter. For students who struggle to make verbal explanations during class, you might pay special attention to providing feedback and coaching as these students write explanations to the Econauts in Lesson 2.3.

Possible Responses

Modeling Tool Response

A possible proficient model is shown below. The model shows that carbon dioxide is given off by all organisms during cellular respiration. During cellular respiration, organisms use energy storage molecules to release energy, while giving off carbon dioxide. Students might show that energy storage molecules are transferred between organisms, but this is not necessary for a proficient model.



Explain how your model answers the Investigation Question.

My model answers the Investigation Question by showing that carbon dioxide is given off by all the organisms in an ecosystem through cellular respiration. This is a process that happens in the cells of producers, consumers, and decomposers. In cellular respiration, cells use energy storage molecules as inputs to release energy and make water and carbon dioxide as outputs.



4

STUDENT-TO-STUDENT
DISCUSSION

Sharing Models

Sharing Models



Students share their models, explaining to a partner how their model answers the Investigation Question.

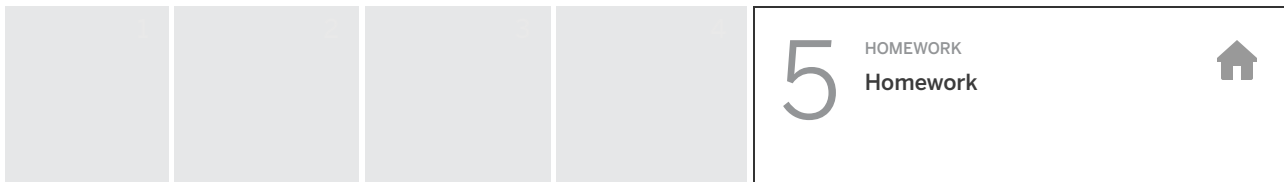
Instructional Guide

- 1. Prepare students to share their models.** Collapse the instructional guide and project the student screen, or have students turn to page 45 in their Investigation Notebooks. Read the instructions aloud.
- 2. Partners, or groups of four, share their models.** Circulate and offer assistance as needed. Listen for how students are using the vocabulary terms. Encourage students to use as many of the terms as they can to describe their models.
- 3. If time permits, invite a few students to share their models with the class.**
- 4. Point out the homework assignment to students (Activity 5 or page 46 in the Investigation Notebook).** If students do not have access to Amplify Science at home, provide them with copies of page 46 from the Investigation Notebook and copies of the “Mulberry Tree and the Silkworm” article and adjust your schedule to make time to complete the Sim activity in class. Students will be reading a short article about mulberry trees and silkworms and using the Sim to help them understand how much photosynthesis producers perform compared with cellular respiration.

Possible Responses

How do organisms give off carbon dioxide?

Producers, consumers, and decomposers give off carbon dioxide through cellular respiration. During this process, energy storage molecules plus oxygen combine to make carbon dioxide plus water, releasing energy. Through this process, carbon moves from the biotic matter of an ecosystem to abiotic matter.



Homework

Students read a short article about mulberry trees and silkworms and use the Sim to compare the amount of producer photosynthesis and cellular respiration.

Instructional Guide

1. If needed, make additional time to explain the homework. If students do not have access to Amplify Science at home, provide them with copies of page 46 from the Investigation Notebook and copies of the “Mulberry Tree and the Silkworm” article and adjust your schedule to make time to complete the Sim activity in class.

Possible Responses

Explain your answer.

Producers must do more photosynthesis than cellular respiration because they make energy storage molecules for their own cellular respiration and they also provide energy storage molecules to organisms that eat them. If they only made enough for their own cellular respiration, there would not be enough for the organisms that eat the producers.

What do you notice?

I noticed that producers do more photosynthesis than cellular respiration. They make more energy storage molecules than they use during cellular respiration.

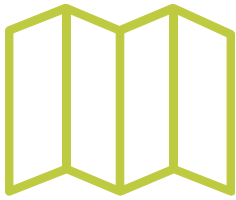
What students should/might do:

Students should observe producer photosynthesis and cellular respiration in Info view.

What students should notice:

Producers perform more photosynthesis than cellular respiration.





Lesson 2.3

An Explanation for the Econauts



Lesson at a Glance

ACTIVITY

1

Warm-Up (5 min)

Students get graphical data about decomposers in the biodome that they will use to support a claim about why the amount of carbon dioxide decreased in the biodome's air.



WARM-UP

2

Discussing the Data (10 min)

The teacher introduces a key concept and reviews what students have learned so far in order to prepare students to apply these ideas to the biodome.

TEACHER-LED
DISCUSSION

3

Testing a Claim in the Sim (15 min)

Students use the Sim to test a claim so they have direct evidence that they can cite in their messages to the Econauts.



SIM

4

Word Relationships Routine (15 min)

Students use key terms to reflect on Chapter 2, and this provides an opportunity for an On-the-Fly Assessment of students' ideas about why the amount of carbon dioxide in the biodome decreased.

STUDENT-TO-
STUDENT
DISCUSSION

5

Homework

Students demonstrate their understanding of cellular respiration by writing an explanation, which answers the Chapter 2 Question, for the Econauts.



HOMEWORK



DIGITAL RESOURCES

Matter and Energy in Ecosystems
Investigation Notebook, pages
47–51

Matter and Energy in Ecosystems
Glossary

Matter and Energy in Ecosystems
Multi-Language Glossary



1

WARM-UP
Warm-Up



Warm-Up

Students analyze data from the biodome, which shows producer, consumer, and decomposer populations over time.



Instructional Guide

1. Project Warm-Up; students work independently. Collapse the instructional guide and project the student screen, or have students turn to page 48 in the Investigation Notebook. Allow a few minutes for students to individually respond to the Warm-Up.

Possible Responses

Can this graph help you explain why the amount of carbon dioxide in the air of the biodome decreased?

Students may have different ideas at this point in the lesson. Both possible responses are shown below:

Yes. The graph helps because it shows the decomposer population decreased before Year 3. This decrease could explain the decrease in carbon dioxide, since decomposers do cellular respiration, which means they give off carbon dioxide. Fewer decomposers could mean less cellular respiration and therefore, less carbon dioxide.

No. The graph does not help because it does not show anything about the air or carbon dioxide.



2

TEACHER-LED DISCUSSION

Discussing the Data



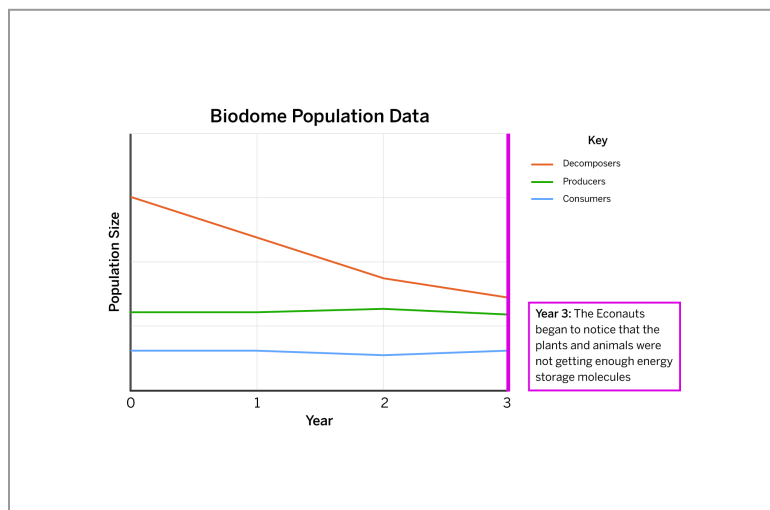
Discussing the Data



After a debrief of the Warm-Up, the teacher introduces the key concept and connects it back to what happened in the biodome.

Instructional Guide

1. Project Biodome Population Data and lead a brief class discussion of the Warm-Up. Establish that the graph shows (a) the population of decomposers in the biodome decreased over time, but (b) the populations of producers and consumers did not change over time. If students are working in the Investigation Notebook, explain that this graph shows the same data as the one on page 48 in their Investigation Notebooks, just with colored lines instead of dashed lines.



2. Invite students to share their Warm-Up responses. Ask students to explain why the graph is or is not helpful in explaining the decrease in carbon dioxide.

3. Help students make a connection between organisms in the biodome and the amount of carbon dioxide in the air. If necessary, remind students of the evidence they collected about cellular respiration from the video, the article, and the Sim.



4. **Project key concept.** Read the key concept aloud or have a student read it aloud.



Key Concept

As organisms release energy during **cellular respiration**, carbon dioxide is produced from the carbon in energy storage molecules. This process moves carbon from *biotic* to *abiotic* matter.

5. **Connect this key concept to the problem in the biodome.** Emphasize the importance of the carbon dioxide that organisms give off during cellular respiration—producers need that carbon dioxide to make energy storage molecules. Remind students that the Econauts need to know what went wrong so they can build a better biodome next time.



3

SIM

Testing a Claim in the Sim



Testing a Claim in the Sim



Students use the Sim to test the claim that a decrease in decomposers led to a decrease in carbon dioxide in the air of the biodome.

Instructional Guide

1. Introduce the Sim activity. Collapse the instructional guide and project the student screen, or have students turn to page 49 in the Investigation Notebook. Introduce the claim by reading it aloud. Connect the claim to the discussion of the biodome data that students examined during the Warm-Up.

2. Review the instructions. Read these aloud.

3. Project the graph in the Sim. Project the Sim and press Play. Open the graph by selecting the icon in the bottom left-hand corner.

4. Lead a brief discussion of what students might choose to display on the graph. Inform students that they will only be able to graph 4 or fewer lines at a time. Model how to use the toggles to change what is displayed on the graph.

Note: Though it might look like line selections require a sliding action, tapping is what produces the intended result.

5. Students work in pairs to test the claim in the Sim. Circulate and offer assistance as needed. If some of your students struggled to interpret the graphical data in the Warm-Up, be sure to provide them with extra support. Allow several minutes for observing the Sim, before reminding students to take a screenshot of the graph and answer the question or to record their observations on page 49 in their Investigation Notebooks.

6. Once all students are finished writing, lead a brief discussion of the Sim evidence. Invite students to share what they observed in the graphs and how this serves as evidence for or against the claim.



How did reducing the number of decomposers affect the amount of carbon dioxide in the ecosystem?
[The amount of carbon dioxide went down because killing decomposers reduced the amount of cellular respiration, so less carbon dioxide was given off to the air.]



Teacher Support

Instructional Suggestion

Going Further: Mathematical Thinking

Students can make quantitative comparisons for the change they made to test the claim by calculating the total amount of glucose used per time unit before the change and after the change. After students run the default setting for 20 time units, have them calculate the total amount of glucose used by multiplying the glucose used per time unit by the total amount of time. Alternatively, students can write the amount of glucose used as a function of time. For example, if the amount of glucose used per time unit was 592, the function would be $f(t) = 592t$. They can then use the function to calculate the total amount of glucose for any time unit. After students kill decomposers in the Sim, they can do the same with the new value of glucose used per time unit. In this case, students may need to estimate the value if it is not constant. The purpose of this activity is for students to use quantitative data to understand relationships.

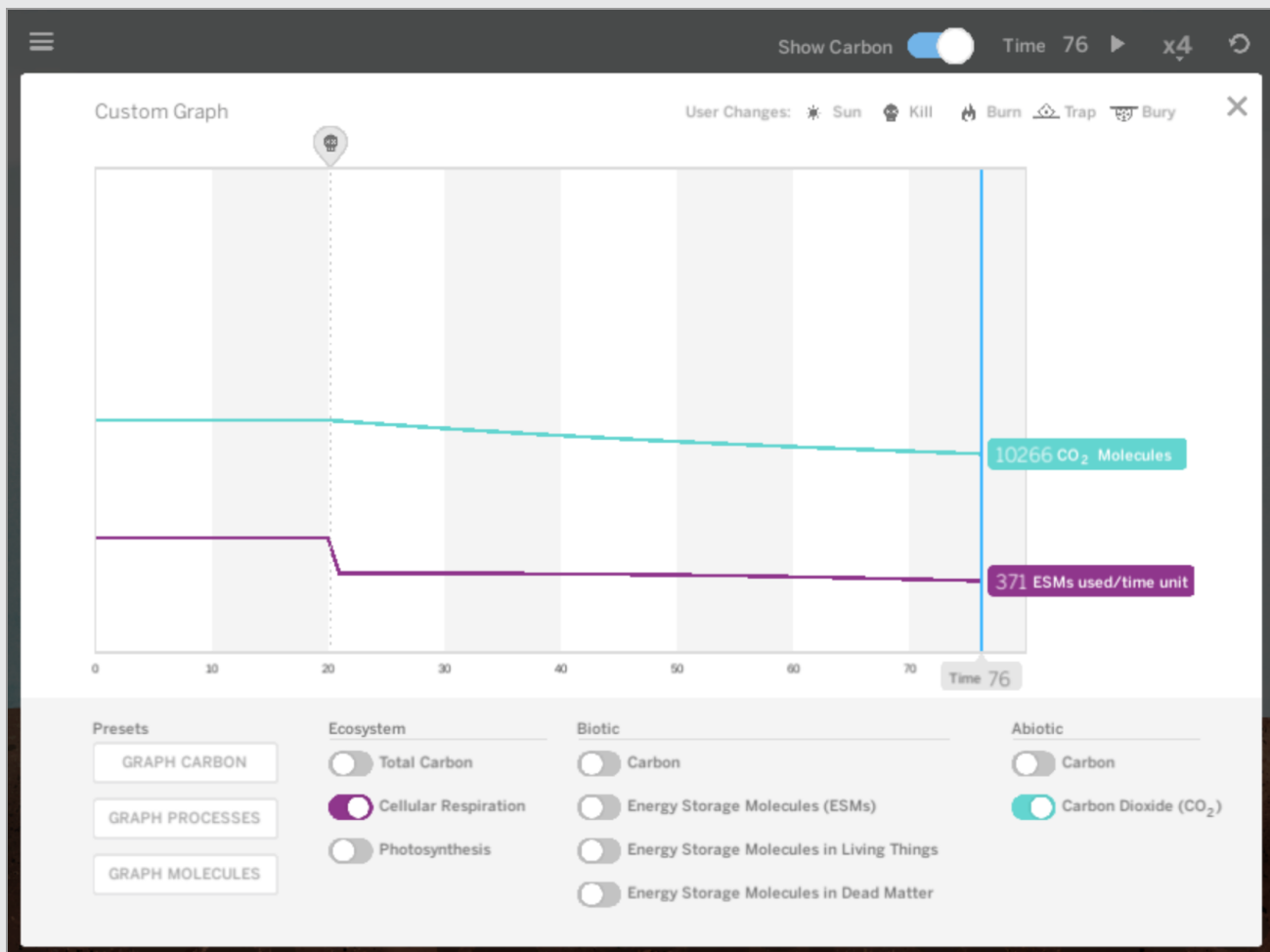
Possible Responses

This image is evidence for the claim because it shows that after I killed a lot of decomposers, the amount of carbon dioxide in the abiotic matter of the ecosystem decreased.

Optional response: It also shows why this change occurred, because when I killed the decomposers, the amount of cellular respiration in the biodome decreased. During cellular respiration, living organisms give off carbon dioxide, so less cellular respiration means less carbon dioxide in the abiotic matter.

What students should/might do:

Students run the default ecosystem for 20 time units. Then, students should kill all the decomposers. After killing decomposers, students observe the Sim and collect evidence to either support or refute the claim using the graph. They may either graph carbon dioxide in abiotic or carbon in abiotic matter. They might also graph cellular respiration.

**What students should notice:**

Students should notice that after they kill decomposers, the amount of carbon dioxide in abiotic matter decreased. The rate of cellular respiration in the ecosystem also decreased. Students may also notice that the amount of dead matter has significantly increased.



4

STUDENT-TO-STUDENT
DISCUSSIONWord Relationships
Routine

Word Relationships Routine



Students discuss their answers to the Chapter 2 Question in small groups, using key vocabulary terms from the unit.

Instructional Guide

- 1. Introduce Word Relationships routine.** Explain that students will now reflect on the work they did in the Sim by working in small groups to answer a question. Inform students that they will be using a routine called Word Relationships. This comes with a set of cards that will support them as they construct sentences that answer the Chapter Question. Emphasize that the most important part of the activity is students discussing their ideas in groups because talking about their ideas will help them prepare for the homework—writing an explanation to the Econauts.
- 2. Introduce the vocabulary word *connect* and project the definition.** Collapse the instructional guide and project the student screen. Read (or ask a student to read) the word and definition aloud.
- 3. Remind students to look at the glossary if they need more support.**
- 4. Explain that students will connect different words and ideas as they participate in their group discussions.** Remind students that they have already been making connections like these throughout the unit.



In order for scientists to answer complicated questions, they need to connect lots of different ideas. As student ecologists, you've already made some of these connections. For example, you answered the Chapter 1 Question by connecting a decrease in carbon dioxide in the biodome to a decrease in the amount of energy storage molecules made by producers. In today's routine, you and your group are going to answer the Chapter 2 Question by constructing sentences that connect different words and ideas.

Ask them to press NEXT (or to turn to page 50 in the Investigation Notebook) to continue this activity.

- 5. Collapse the instructional guide and project student screen, or have students turn to page 50 in their Investigation Notebooks, and review Word Relationships routine.** Emphasize that group members should take turns speaking and listening as they create sentences with the Word Relationships cards.
- 6. Model how to create a sentence.** Hold up the cards for *decomposer* and *ecosystem* and demonstrate how a student might create a sentence using these terms.



Based on what we saw in the Sim, I might want to create a sentence that connects the decomposers to the biodome ecosystem. Using these two cards, I might offer this sentence: The number of *decomposers* in the biodome *ecosystem* decreased.

Point out that this is just one possible answer and it is incomplete. Explain that it will take more than one sentence for students to completely answer the Chapter Question.

7. Distribute one set of Word Relationships cards to each small group and have students begin constructing sentences.

8. Students create sentences with their groups. Circulate and offer assistance as needed.

9. On-the-Fly Assessment: Explaining How Changing Cellular Respiration Affected the Biodome. For further suggestions on how to support students' understanding of the decrease in carbon dioxide in the biodome, press the hummingbird icon and ON-THE-FLY ASSESSMENT 7.

10. Point out the homework assignment to students (Activity 5 or page 51 in the Investigation Notebook). If students do not have access to Amplify Science at home, provide them with copies of page 51 from the Investigation Notebook. Encourage students to use some of the sentences they created as they write their explanations to the Econauts.



Embedded Formative Assessment

On-the-Fly Assessment 7: Explaining How Changing Cellular Respiration Affected the Biodome

Look for: Through this discourse routine, students reflect on how the regular movement of matter in an ecosystem can be disrupted by changes to the system. In their verbal explanations, students should use science content from Chapter 2 (Level 2 of the Progress Build) to explain how the decrease in the decomposer population led to a decrease in carbon dioxide in the atmosphere of the biodome. To do this, students should apply their understanding that all living organisms give off carbon dioxide, which is produced using the carbon in energy storage molecules when organisms release energy (cellular respiration). Can students use the ideas in the key concept introduced in this lesson to connect the decrease in the decomposer population with the decrease in cellular respiration? Do they explain how this change led to a decrease in atmospheric carbon dioxide? Are some students able to go further and relate this change to a decrease in the amount of carbon in abiotic matter?

Now what? There are a number of reasons why a student might not be able to use the vocabulary terms to answer the Chapter 2 Question. Students who struggle with this task may need extra support with the content of Chapter 2, but it is also possible that students who have understood the content may be struggling to express their ideas via this routine. If some students are struggling with expressing their ideas orally, invite them to try to answer the Chapter 2 Question in writing or through a drawing. For students struggling with this scientific vocabulary, invite them to try answering in their own words first. By giving students an opportunity to demonstrate their understanding in alternative ways, you can identify more accurately which students will benefit from reviewing Chapter 2 content during the differentiated activities in Lesson 2.5.

Teacher Support

Rationale

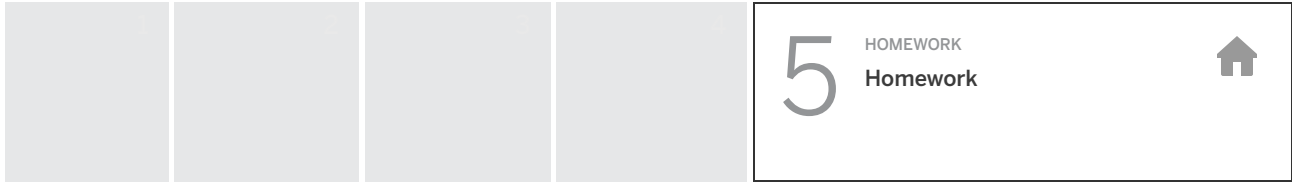
Pedagogical Goals: Word Relationships

Word Relationships is a discourse routine that supports students in incorporating scientific language into their discussions. Today, students will discuss possible answers to the Chapter 2 Question: *What caused carbon dioxide to decrease in the air (abiotic matter) of the biodome?* Working in small groups, students will use the given vocabulary words in their discussions, before independently writing their explanations. Providing students with the vocabulary words, time to discuss with a small group, and exposure to responses from their peers supports students in their acquisition and utilization of academic language. In addition, students are being provided with multiple experiences with the vocabulary and concepts, which will help them to gain a deeper understanding.

Instructional Suggestion

Providing More Support: Have Students Use Scratch Paper to Record Sentences

You may wish to provide groups with scratch paper for recording the sentences they construct. This will help students keep track of the words they used. You might also challenge students to see how many different words they can use in their sentences.



Homework

Students write to the Econauts and explain that a decrease in decomposers caused a decrease in carbon dioxide in the air of the biodome.

Instructional Guide

1. If needed, make additional time to explain the homework. If students do not have access to Amplify Science at home, provide them with copies of page 51 from the Investigation Notebook.

Teacher Support

Instructional Suggestion

Providing More Support: Making Time to Write Explanations in Class

Although students are assigned to write their explanations to the Econauts as homework, you may wish to instead set aside some time at the beginning of the next lesson for this activity. Since this writing assignment constitutes the culminating application of the Chapter 2 content prior to the Critical Juncture lesson, making time for students to do this writing in the supportive environment of the classroom may give you a better sense of where your students are in their understanding of this content.

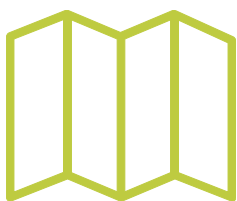
Possible Responses

Support a claim that answers the Chapter 2 Question, using evidence that you collected throughout this chapter. Be sure to explain how the evidence supports the claim. The Word Bank includes vocabulary terms that will help you write.

A decrease in the population of **decomposers** caused a decrease in **carbon dioxide** in the **abiotic matter** of the biodome. The evidence from Dr. Corry shows that the decomposer population went down but the **producer** and **consumer** populations did not. In the Sim, I saw evidence that killing decomposers led to a decrease in the amount of carbon dioxide in abiotic matter. This is because decomposers do **cellular respiration**. Cellular respiration affects the amount of carbon dioxide in abiotic matter because in order to release energy, cells have to take in **energy storage**



molecules and oxygen and give off carbon dioxide and water. So as the decomposers died, there were fewer organisms in the biodome doing cellular respiration, and so there was less carbon dioxide being given off. As a result, the amount of carbon dioxide in the air of the biodome decreased.



Lesson 2.4

Critical Juncture Assessment



Lesson at a Glance

ACTIVITY

1

Multiple-Choice Questions (25 min)

These multiple-choice questions provide an auto-scored measure of students' placements on the Progress Build.

CLASS

2

Written-Response Question #1 (10 min)

This written-response question provides additional information about students' placements on the Progress Build. This item can be scored by referencing the provided rubric in the *Matter and Energy in Ecosystems* Critical Juncture Assessment Answer Key and Scoring Guide (in the Digital Resources).

CLASS

3

Written-Response Question #2 (10 min)

This written-response question provides additional information about students' placements on the Progress Build. This item can be scored by referencing the provided rubric in the *Matter and Energy in Ecosystems* Critical Juncture Assessment Answer Key and Scoring Guide (in the Digital Resources).

CLASS

4

Homework

Students have the opportunity to read about the part of the cell that performs cellular respiration and how it became part of the cell.



HOMEWORK



DIGITAL RESOURCES

Matter and Energy in Ecosystems
Critical Juncture Assessment
copymaster

Matter and Energy in Ecosystems
Critical Juncture Assessment
Answer Key and Scoring Guide

How Did We Get Mitochondria?

Printable article: "How Did We Get
Mitochondria?"

Matter and Energy in Ecosystems
Investigation Notebook, page 52

Matter and Energy in Ecosystems
Glossary

Matter and Energy in Ecosystems
Multi-Language Glossary



1

CLASS

Multiple-Choice Questions



Multiple-Choice Questions



Students complete 12 multiple-choice questions to show their understanding of the content at this point in the unit.

Instructional Guide

1. Students complete multiple-choice questions. Circulate and assist students with clarifying instructions, as needed.

Teacher Support

Assessment

Pedagogical Goals: Assessing Complex Ideas

The Critical Juncture Assessment is different from traditional multiple-choice tests. Rather than testing recall of isolated facts, the questions are designed to assess the deep, explanatory understanding called for in NGSS and the Progress Build. Students are required to figure out and explain or make predictions about phenomena and as a result, students should expect to spend more time with each question as they think through the scenarios and work out their answers.

Possible Responses

1. Algae are plantlike organisms that live in the water. These algae have been in sunlight for several hours now. What can the algae do because they are in sunlight? What does this mean for the number of energy storage molecules in the algae?

The sun caused the phytoplankton to . . .

a. **take in** carbon from the air. The carbon is used to make energy storage molecules.



2. Dugongs are animals that live in the ocean and eat underwater grasses. The sun is shining on the shallow ocean water where the grasses and dugongs live. What is happening to the carbon in the water around the grasses and dugongs? Is carbon moving into the water, moving out of the water, or both?

c. Carbon is moving into the water **and** out of the water, at the same time.

3. A scientist built a model ecosystem that contains air, plants, and animals that eat those plants. It is sealed so no material can get in or out, but the glass sides allow light to get in. The model ecosystem can also be covered to prevent light from entering.

The amount of carbon in the air inside the model ecosystem started out high. Now the amount of carbon in the air is decreasing. Is the model ecosystem now in sunlight or is it covered? What is happening to the number of energy storage molecules in the plants and animals as a result?

b. The model ecosystem is in sunlight, and there are **more** energy storage molecules in the plants and animals.

4. These pea plants have been in the sunlight since early morning.

What can the pea plants do because they are in sunlight? What does this mean for the number of energy storage molecules in the pea plants?

The pea plants can...

d. **take in** carbon from the air. The carbon is used to make energy storage molecules.

5. Hippos spend most of their time in rivers, but they come out of the water to eat grass. It is dark out, and this hippo is not eating. What is happening to the carbon in the air around the hippos and the grass nearby?

d. Carbon is only moving into the air; it is not moving out of the air.

6. Julietta has a glass ball filled with water. In the water are tiny plants and shrimp that eat the plants. No material can get in or out, but sunlight can get through the glass. The glass ball can also be covered to prevent light from entering.

The number of energy storage molecules in the plants and shrimp started out low but now it is increasing. Is the glass ball in sunlight or is it covered? What is happening to the carbon in the water inside the glass ball?

c. The glass ball is in sunlight, and there is less carbon in the water now than there was before.



7. Some trees are taking in carbon from the air around them. Are the trees in sunlight? What is happening to the number of energy storage molecules in the trees?

The trees . . .

c. **are** in sunlight, and the number of energy storage molecules in the trees is **increasing**.

8. Parrotfish live in the ocean and eat plantlike organisms called algae. Sunlight is shining on the fish and the algae. Is carbon moving into the living things, moving out of the living things, or both?

a. Carbon is moving into **and** out of the living things, at the same time.

9. Bonnie has an aquarium filled with water, plants, and fish that eat those plants. It is sealed so no material can get in or out, but the glass sides allow light to get in. The aquarium can also be covered to prevent light from entering.

The amount of carbon in the water started out low. Now, the amount of carbon in the water is increasing. Is the aquarium now in light or is it covered? What is happening to the number of energy storage molecules in the living things?

b. The aquarium was covered (so it's dark), and there are **fewer** energy storage molecules in the living things.

10. Some rice plants on a hillside are taking in carbon from the air around them.

Are the plants in sunlight? What is happening to the number of energy storage molecules in the plants?

The plants . . .

d. **are** in sunlight, and the number of energy storage molecules in the plants is **increasing**.

11. This zebra is eating grass on a sunny day. Is carbon moving into the living things, moving out of the living things, or both?

a. Carbon is moving into and out of the living things at the same time.

12. A scientist built a model ecosystem that contains air, plants, and animals that eat those plants. The model ecosystem is sealed so no material can get in or out, but the glass sides allow light in when the scientist switches the light on. When the scientist switches the light *off*, the model ecosystem is in the dark.



The number of energy storage molecules in the plants and animals inside the model ecosystem started out high. Then the number of energy storage molecules began to decrease. Was the decrease because the light was switched on or because it was switched off? What happened to the amount of carbon dioxide in the air?

b. The scientist switched the light **off**, and there is **more** carbon dioxide in the air.



2

CLASS

Written-Response
Question #1



Written-Response Question #1



Students complete the first written-response question on the Critical Juncture Assessment.

Instructional Guide

1. Students complete the first written-response question. Circulate and assist students with clarifying instructions, as needed.

Possible Responses

Kai has a see-through glass tank with air, plants, and animals that eat those plants. He sealed the tank so no material can get into or out of it, but light can get in when the tank is not covered.

The light for the tank has been on all day, and Kai measured the carbon in the air and found that it is decreasing. How is carbon moving between the air and the living things in the tank? What is happening to the amount of carbon in living things? Explain your thinking as completely as possible.

Level 1: Student indicates carbon is moving into living things and biotic carbon is increasing as plants perform photosynthesis.

Possible student response: Since the tank is exposed to light, the plants are performing photosynthesis. This means carbon dioxide from the air is moving into living things so the plants can use the carbon to make energy storage molecules, which is why carbon in the air is decreasing. Because of this, carbon in living things is increasing.

Level 2: Student indicates an understanding of carbon movement from Level 1 and indicates that there is also carbon moving out of living things as organisms give off carbon dioxide produced through cellular respiration.



Possible student response: Since the tank is exposed to light, the plants are performing photosynthesis. This means carbon dioxide from the air is moving into living things so the plants can use the carbon to make energy storage molecules, which is why carbon in the air is decreasing. I also know that some carbon is moving out of living things into the air, because the organisms are giving off carbon dioxide as they use up energy storage molecules through cellular respiration. Because carbon is moving into and out of living things, I am not sure how the amount of carbon in living things is changing.

Level 3: Student indicates an understanding of Levels 1 and 2 and indicates that the amount of carbon in living things must be increasing because there is a fixed amount of carbon in the tank.

Possible student response: Since the tank is exposed to light, the plants are performing photosynthesis. This means carbon dioxide from the air is moving into living things so the plants can use the carbon to make energy storage molecules, which is why carbon in the air is decreasing. I also know that some carbon is moving out of living things into the air, because the organisms are giving off carbon dioxide as they use up energy storage molecules through cellular respiration. Since the amount of carbon in the air is decreasing, the amount of carbon in living things is increasing. This is because it is a closed ecosystem and there is a set amount of carbon—it can't be produced or used up.



3

CLASS

Written-Response
Question #2



Written-Response Question #2



Students complete the second written-response question on the Critical Juncture Assessment.

Instructional Guide

- 1. Students complete the second written-response question.** Circulate and assist students with clarifying instructions, as needed.
- 2. Point out the homework assignment to students (Activity 4 or page 52 in the Investigation Notebook).** Explain that students will read a short article to learn more about the part of the cell where cellular respiration occurs. If students do not have access to Amplify Science at home, provide them with copies of page 52 from the Investigation Notebook and copies of the “How Did We Get Mitochondria?” article.

Possible Responses

A group of engineers has created a biodome filled with air, plants, and animals. No material can get in or out, but sunlight can get in during the daytime.

The walls of the biodome are made of a material that absorbs and locks away carbon dioxide from the air so it is not available to the living things inside. What do you predict will happen to carbon in the air over time? How could this affect the living things in the dome? Explain your thinking.

Level 1: Student indicates that carbon in the air will decrease over time, and that this will negatively impact living things because plants will not have material (carbon dioxide) to perform photosynthesis.



Possible student response: Over time there will be less carbon in the air because the carbon dioxide will be absorbed into the walls. When this happens, the plants will do less photosynthesis and make fewer energy storage molecules. This is because plants use the carbon from carbon dioxide to produce energy storage molecules. If fewer energy storage molecules are available to the plants and animals, then living things will start to die.

Level 2: Student demonstrates an understanding of Level 1 and describes how organisms give off carbon dioxide through cellular respiration (which will be absorbed into the biodome walls).

Possible student response: As organisms use energy storage molecules through cellular respiration, they give off carbon dioxide to the air. This is because the carbon in energy storage molecules becomes part of carbon dioxide through cellular respiration. Over time, there will be less carbon in the air because the carbon dioxide that living things give off will be absorbed into the walls. When this happens, the plants will do less photosynthesis, and make fewer energy storage molecules. If fewer energy storage molecules are available to the plants and animals, then living things will start to die.

Level 3: Student demonstrates an understanding of Levels 1 and 2 and describes that increasing carbon dioxide in the walls indicates decreasing carbon elsewhere in the biodome, because there is a fixed amount of carbon in a closed ecosystem.

Possible student response: As organisms use energy storage molecules through cellular respiration, they give off carbon dioxide to the air. This is because the carbon in energy storage molecules becomes part of carbon dioxide through cellular respiration. Over time, there will be less carbon in the air because the carbon dioxide that living things give off will be absorbed into the walls. Because carbon in the wall is increasing, it is decreasing everywhere else—in the air and in the living things. When this happens, the plants will do less photosynthesis, and make fewer energy storage molecules. If fewer energy storage molecules are available to the plants and animals, then living things will start to die.



4

HOMEWORK

Homework



Homework

Students read an article to learn about the part of the cell that performs cellular respiration and how it became part of the cell.

Instructional Guide

1. If needed, make additional time to explain the homework. If students do not have access to Amplify Science at home, provide them with copies of page 52 from the Investigation Notebook and copies of the “How Did We Get Mitochondria?” article.

Teacher Support

Rationale

Pedagogical Goals: Reading About Mitochondria

In this chapter, students have worked extensively with visual representations that include mitochondria, the organelle inside the cell that performs cellular respiration. In order to get more experience with the NGSS Performance Expectation MS-LS 1-2: Develop and use a model to describe the function of a cell as a whole and ways parts of cells contribute to the function, students read the “How Did We Get Mitochondria?” article for homework. Students learn that mitochondria are the parts of the cell where the important process of cellular respiration occurs. They also learn how mitochondria became part of the cell.

Assessment

Additional Assessment Opportunity: Student Understanding of the Functions of Structures Within Cells

This activity can be used to assess students’ understanding that the structures inside cells carry out particular important functions for the cell. Look for whether students can explain that mitochondria are organelles inside cells that are important because they can carry out cellular respiration, providing the cell with energy. If students are not able to explain what mitochondria are and what they do, consider spending some time in class looking at the article. Ask students to read the first paragraph of the article, and then ask them to explain how cellular respiration works [oxygen and glucose react, releasing energy]. Then ask where in the cell this takes place [the mitochondria]. Finally, ask students how mitochondria became part of cells in the first place [they were bacteria that were absorbed into larger microorganisms]. Project the first image in the article and point out that mitochondria are a particular structure inside



cells, and that they do just one particular function: cellular respiration. Remind students that as they've learned, cells have many specific structures (organelles) inside them, and each of these carries out a particular important function for the cell.

Possible Responses

What are mitochondria, and why are they an important part of cells?

Mitochondria are organelles inside cells that carry out cellular respiration. They are important because they provide cells with a lot of energy.

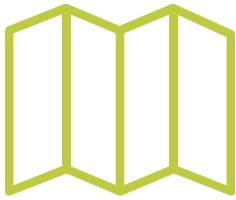
How did mitochondria become part of the cell?

Mitochondria became part of the cell when a cell engulfed a bacterium that could perform cellular respiration, and then reproduced and created a new cell that had DNA with instructions for including mitochondria.



Image Credits

Shutterstock--marcinhajdasz/Getty Images-- Mariya Bibikova/Getty Images-- LifeJourneys/Getty Images-- Richard Carey/Getty Images-- Eric Isselée--e/Getty Images-- 3DSculptor/Getty Images (Matter and Energy in Ecosystems Critical Juncture Assessment copymaster).



Lesson 2.5

Investigating Econauts' Claims



Lesson at a Glance

ACTIVITY

1

Warm-Up (5 min)

Students are introduced to a new claim and a new ecosystem to investigate.



WARM-UP

T

Preparing to Investigate Claims (3 min)

The teacher introduces the activities and explains how each group will access their instructions.



TEACHER

2

Investigating Ecosystem Claims (22 min)

Through text and a Sim activity, students review specific content they did not get from Chapters 1 and 2. Students who have mastered all the content think about a more advanced context.



SIM

3

Word Relationships Routine (15 min)

Students are provided with an opportunity to share information and learn from one another through Word Relationships, a discourse routine conducted in small groups.

STUDENT-TO-
STUDENT
DISCUSSION

4

Homework

Students complete their messages to the Econauts. They also read a short article to learn more about differences between ecosystems and the importance of defining the boundaries of an ecosystem in scientific studies.



HOMEWORK

5

Self-Assessment (Optional)

Students check their understanding of key content in the unit and reflect on any additional questions they have about ecosystems.



HOMEWORK



DIGITAL RESOURCES

Getting Energy in a Cave Ecosystem

Printable article: “Getting Energy in a Cave Ecosystem”

Getting Energy Near a Deep-Sea Vent

Printable article: “Getting Energy Near a Deep-Sea Vent”

Getting Energy in a Coastal Prairie Ecosystem

Printable article: “Getting Energy in a Coastal Prairie Ecosystem”

Glacier Mice: Living Arctic Tumbleweeds

Printable article: “Glacier Mice: Living Arctic Tumbleweeds”

Matter and Energy in Ecosystems Investigation Notebook, pages 53–67

Matter and Energy in Ecosystems Glossary

Matter and Energy in Ecosystems Multi-Language Glossary



1

WARM-UP
Warm-Up



Warm-Up



Students read a short description of an ecosystem and explain why they agree or disagree with a claim about that ecosystem.

Instructional Guide



PURPLE GROUP

1. Direct students to complete Warm-Ups independently. Allow a few minutes for students to individually respond to the Warm-Up. If students are using the Investigation Notebook, make sure they know which group they are assigned to, and direct them to turn to the correct page (page 55 for the Purple Group, 58 for the Blue Group, and 61 for the Green Group).



BLUE GROUP

1. Direct students to complete Warm-Ups independently. Allow a few minutes for students to individually respond to the Warm-Up. If students are using the Investigation Notebook, make sure they know which group they are assigned to, and direct them to turn to the correct page (page 55 for the Purple Group, 58 for the Blue Group, and 61 for the Green Group).



GREEN GROUP

1. Direct students to complete Warm-Ups independently. Allow a few minutes for students to individually respond to the Warm-Up. If students are using the Investigation Notebook, make sure they know which group they are assigned to, and direct them to turn to the correct page (page 55 for the Purple Group, 58 for the Blue Group, and 61 for the Green Group).



Teacher Support



PURPLE GROUP

Instructional Suggestion

Classroom Management: Providing Direction to Students Assigned to Different Tasks

In this Warm-Up, as well as in Activity 2, each color group has a slightly different set of instructions and tasks that are tailored to support mastery of particular ideas. In an effort to make managing these different tasks easier on the teacher, the instructions in this instructional guide are the same for each of the color groups.

Instructional Suggestion

Classroom Environment: Students Assigned to Different Tasks

Consider how you want to treat the issue of students being assigned different tasks. Some students may react badly when they find out that they are being assigned a review of more basic material than other students, especially if that is publicly acknowledged. On the other hand, knowing that this lesson's activities are selected specifically to help students master a particular idea based on your assessment of their earlier work may help motivate students.



BLUE GROUP

Instructional Suggestion

Classroom Management: Providing Direction to Students Assigned to Different Tasks

In this Warm-Up, as well as in Activity 2, each color group has a slightly different set of instructions and tasks that are tailored to support mastery of particular ideas. In an effort to make managing these different tasks easier on the teacher, the instructions in this instructional guide are the same for each of the color groups.

Instructional Suggestion

Classroom Environment: Students Assigned to Different Tasks

Consider how you want to treat the issue of students being assigned different tasks. Some students may react badly when they find out that they are being assigned a review of more basic material than other students, especially if that is publicly acknowledged. On the other hand, knowing that this lesson's activities are selected specifically to help students master a particular idea based on your assessment of their earlier work may help motivate students.



GREEN GROUP

Instructional Suggestion

Classroom Management: Providing Direction to Students Assigned to Different Tasks

In this Warm-Up, as well as in Activity 2, each color group has a slightly different set of instructions and tasks that are tailored to support mastery of particular ideas. In an effort to make managing these different tasks easier on the teacher, the instructions in this instructional guide are the same for each of the color groups.

Instructional Suggestion

Classroom Environment: Students Assigned to Different Tasks

Consider how you want to treat the issue of students being assigned different tasks. Some students may react badly when they find out that they are being assigned a review of more basic material than other students, especially if that is publicly acknowledged. On the other hand, knowing that this lesson's activities are selected specifically to help students master a particular idea based on your assessment of their earlier work may help motivate students.

Possible Responses

PURPLE GROUP

Do you agree or disagree with this claim? Explain your answer.

Answers will vary for all three groups.

BLUE GROUP

Do you agree or disagree with this claim? Explain your answer.

Answers will vary for all three groups.

GREEN GROUP

Do you agree or disagree with this claim? Explain your answer.

Answers will vary for all three groups.



TEACHER

Preparing to Investigate
Claims

Preparing to Investigate Claims



The teacher introduces the next set of activities and explains how each group can access their directions.

Instructional Guide

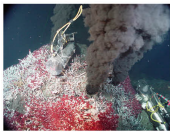
1. Project message from Dr. Corry and introduce the day's focus. Read the message aloud. Explain that students will investigate the claim they were given in the Warm-Up by reading a short article from Dr. Corry and by running some tests in the Sim.



To: Student Ecologists
From: Dr. Bryan Corry
Subject: Help with Econaut Claims

I hope you received an email from the Econauts. They have been thinking about several different ecosystems (images attached) and developed some interesting ideas. I think you can use what you've been learning to see if they're on track. Take a look at one of the short articles and use the Sim to see what results you get. When you finish your investigation, please send the Econauts a message with your findings.

Bryan
Dr. Bryan Corry, Head Ecologist
Biodome Investigation Team


Deep-Sea Vent Ecosystem


Coastal Prairie Ecosystem


Cave Ecosystem

2. Direct students to begin the activity. Students should navigate to Activity 2, or if using the Investigation Notebook, turn to the correct page in their Investigation Notebooks (pages 56–57 for the Purple Group, 59–60 for the Blue Group, and 62–64 for the Green Group).



Teacher Support

Instructional Suggestion

Classroom Management: Providing Direction to Students Assigned to Different Tasks

These reading and Sim activities have slightly different sets of instructions and tasks that have been tailored to support mastery of particular ideas. Activities are clearly labeled with the color group to which they belong. In an effort to make managing these different tasks easier on the teacher, the directions in this instructional guide are the same for each color, so it is only necessary to read the instructions for one color group.



2

SIM

Investigating Ecosystem
Claims

Investigating Ecosystem Claims



Students read about their assigned ecosystem and use the Sim to gather evidence that either supports or refutes a claim.

Instructional Guide



PURPLE GROUP

1. Direct students to carefully read and annotate the notes about their assigned ecosystem. Circulate and check to see if students need assistance. If students are using the Investigation Notebook, make sure students are referring to the correct page (pages 56–57 for the Purple Group, 59–60 for the Blue Group, and 62–64 for the Green Group), and distribute printed articles.

2. When students are ready, direct them to navigate to the next part of this activity by pressing NEXT, or by moving on to Part 2 in their Investigation Notebooks.

3. Direct students to open the Sim and follow the instructions on their devices, or in their Investigation Notebooks. Remind students to answer the questions on their screens, or in their Investigation Notebooks, as they go.

4. When students are ready, direct them to navigate to the next part of this activity by pressing NEXT or by moving on to Part 3 in their Investigation Notebooks.

5. Direct students to respond to the Econauts' claim in writing. Remind students to mention any evidence they found in the reading and the Sim when they are writing their responses.



BLUE GROUP

- 1. Direct students to carefully read and annotate the notes about their assigned ecosystem.** Circulate and check to see if students need assistance. If students are using the Investigation Notebook, make sure students are referring to the correct page (pages 56–57 for the Purple Group, 59–60 for the Blue Group, and 62–64 for the Green Group), and distribute printed articles.
- 2. When students are ready, direct them to navigate to the next part of this activity by pressing NEXT, or by moving on to Part 2 in their Investigation Notebooks.**
- 3. Direct students to open the Sim and follow the instructions on their devices, or in their Investigation Notebooks.** Remind students to answer the questions on their screens, or in their Investigation Notebooks, as they go.
- 4. When students are ready, direct them to navigate to the next part of this activity by pressing NEXT or by moving on to Part 3 in their Investigation Notebooks.**
- 5. Direct students to respond to the Econauts' claim in writing.** Remind students to mention any evidence they found in the reading and the Sim when they are writing their responses.



GREEN GROUP

- 1. Direct students to carefully read and annotate the notes about their assigned ecosystem.** Circulate and check to see if students need assistance. If students are using the Investigation Notebook, make sure students are referring to the correct page (pages 56–57 for the Purple Group, 59–60 for the Blue Group, and 62–64 for the Green Group), and distribute printed articles.
- 2. When students are ready, direct them to navigate to the next part of this activity by pressing NEXT, or by moving on to Part 2 in their Investigation Notebooks.**
- 3. Direct students to open the Sim and follow the instructions on their devices, or in their Investigation Notebooks.** Remind students to answer the questions on their screens, or in their Investigation Notebooks, as they go.
- 4. When students are ready, direct them to navigate to the next part of this activity by pressing NEXT or by moving on to Part 3 in their Investigation Notebooks.**
- 5. Direct students to respond to the Econauts' claim in writing.** Remind students to mention any evidence they found in the reading and the Sim when they are writing their responses.



Teacher Support

PURPLE GROUP

Instructional Suggestion

Providing More Support: Focusing on the Purple Group

For this differentiated activity, students in the purple group may require the most support when thinking about and investigating a claim. While you are circulating during the text and Sim activities, you will need to check in with students in all three groups, but we suggest that when possible, you provide extra support to the purple group. Students in this group are investigating the claim about the cave ecosystem, and although it is covered in the article, they may need more support in understanding the cave ecosystem. You can use the following prompts if students are having trouble understanding that the fig tree is part of the cave ecosystem, even though it is outside the cave. Without this understanding, students may be confused about the Sim results, which show that an ecosystem cannot survive without sunlight, even though caves can.

1. *Does what happened to the ecosystem in the Sim when there was no sunlight match what happens inside the cave (which does not have light)?* [No, in the Sim, the ecosystem died without sunlight. But, according to the article, a cave ecosystem can flourish without light.]
2. *The Sim represents a closed ecosystem: no resources from outside the ecosystem can come in, and nothing from inside the ecosystem can go out. Is the cave itself a closed ecosystem?* [The cave by itself is not a closed ecosystem, because the bats can leave the cave to get food from the fruit trees.]
3. *The article said that the fig tree is part of the cave ecosystem. How does this information help you think about the claim that populations in cave ecosystems can survive without sunlight?* [Since the fig tree is a producer, it requires sunlight to do photosynthesis. Knowing that the fig tree is part of the cave ecosystem means cave ecosystems also need sunlight to survive. This is because the bats eat the fruit and then bat poop is food for many organisms in the cave. If the trees did not get sunlight, they would die. Then the bats would die, and then lots of other organisms would not have food, and they would die too.]

BLUE GROUP

Instructional Suggestion

Technology Note: Limitations of the Sim Ecosystem

The blue group investigates the claim that an ecosystem can survive with only producers. The results that students observe in the Sim—that it takes a long time for all the producers to die out—are not completely accurate, because the Sim focuses primarily on carbon and does not represent the role that nutrients play in an ecosystem. In reality, an ecosystem cannot survive with only producers. Decomposers are essential for another reason—as they break down dead matter, they release nutrients, such as nitrogen and potassium, into the soil. Plants use these nutrients to build critical molecules, such as proteins and DNA.



GREEN GROUP

Possible Responses



PURPLE GROUP

Part 1: Sunlight

2. b. producers.
3. Energy storage molecules are made by combining **water** and **carbon** from **carbon dioxide** using energy from the sun.
4. After they are produced, energy storage molecules are turned into **water** and **carbon dioxide** during the process of releasing energy in the mitochondrion. The **carbon dioxide** *then moves into the air (abiotic matter).

Part 2: Without Sunlight

3. Producers do not make energy storage molecules in the chloroplast, but they still use them in the mitochondrion.
4. Without sunlight, the energy storage molecules in the organisms decreased and everything in the ecosystem started to die. This happened because producers can't make energy storage molecules without sunlight, and producers make all the energy storage molecules for an ecosystem. The organisms did not have enough energy storage molecules to survive.

What students should/might do: Students should first run the Sim with sunlight ON, and then press VIEW CELL to see where and how energy storage molecules are produced. After that, they should then turn sunlight OFF and observe what happens to the energy storage molecules in producers and consumers.

What students should notice: Students should notice that producers need sunlight to make energy storage molecules through photosynthesis. Once there is no sunlight, the producers stop making energy storage molecules and the amount of energy storage molecules in producers and consumers decreases. Students should observe that if they run the Sim for 100 time units, all living things in the ecosystem die. Decomposers are the last organisms to die, since they get energy storage molecules from dead matter. It takes a long time for all the organisms to die, but eventually they do.

Write a short message to Keith and explain whether you agree with his claim or not. Be sure to use evidence from the article and the Sim in your explanation. Remember, the Econauts do not know as much about ecosystems as you do, so you should explain your ideas fully and clearly.

Keith, I've investigated and your claim is not supported. Even though there is no sunlight in the cave, the article I read told me that bats get energy storage molecules from fig trees (producers) outside the cave, and fig trees use energy from the sun to make energy storage molecules. I ran some tests in the Sim, and they confirmed this—producers are



the only ones that can make energy storage molecules and they need sunlight. When I turned sunlight off, the producers stopped making energy storage molecules and everything eventually died. This shows that without sunlight, an ecosystem cannot survive.



BLUE GROUP

Part 1: With Producers, Consumers, and Decomposers

2. After they are produced, energy storage molecules are turned into **water** and **carbon dioxide** during the process of releasing energy in the mitochondrion. The **carbon dioxide** *then moves into the air (abiotic matter).
3. b. They do cellular respiration.
4. The carbon in energy storage molecules is turned into **carbon dioxide**. When it leaves producers, consumers, and decomposers, it goes to **abiotic matter**.

Part 2: Only Producers

4. **Explain what happened to the producer population over time.** At first, the producer population increased because there were no consumers to eat them. It later began decreasing, and continued decreasing for the rest of the run.

Explain why having an ecosystem without any consumers or decomposers caused the producer population to change.

At first, the population of producers increased because they were not being eaten by primary consumers. Then, the population of producers decreased because they did not have enough carbon dioxide. The carbon dioxide in abiotic matter decreased because no consumers or decomposers are adding carbon dioxide through cellular respiration. Plants do cellular respiration for a while, but start to die off because there is not enough carbon dioxide for them to continue making energy storage molecules. The carbon is stuck in dead plants, and there's no way for the carbon from the dead matter to get back to the air without decomposers.

What students should/might do: Students should first run the Sim with the default settings and observe what is happening to the energy storage molecules in the ecosystem, both in Sim View and Cell View. Then, students should restart the ecosystem and set the amounts for primary consumers, secondary consumers, and decomposers to zero. They should investigate what happens to the number of producers, and observe what is happening to the amount of carbon dioxide over time. They should run the Sim for 250 time units.

What students should notice: Some students may argue that the ecosystem can survive with only producers since producers both take in and give off carbon dioxide. Other students will notice that Carbon Dioxide in Abiotic decreases without consumers or decomposers, which causes the producer population to decrease. Without decomposers, the carbon from dead plants remains trapped in dead matter and the carbon dioxide in the air will slowly decrease. This will cause the ecosystem to very slowly collapse, but it takes a long time to see in the Sim.



Respond to Econaut Tess Ames by explaining whether or not the evidence you found will support her claim. Be sure to include evidence from the article, the Sim, and anything else you learned in the unit. Remember, the Econauts do not know as much about ecosystems as you do, so you should explain your ideas fully and clearly.

Two possible responses are provided. For reasons explained in the Teacher Support note and because it may take too long for students to see the entire ecosystem collapse, some students may conclude the claim is supported, although in reality, a producers- only ecosystem could not survive.

Claim IS NOT supported:

Tess, I could not find evidence to support your claim. First, the article I read said that even though a prairie ecosystem might look like it is only plants, there are lots of consumers and decomposers in the ecosystem—grasshoppers, gophers, and worms, for example. This means there are a lot of organisms performing cellular respiration, so energy storage molecules from producers and dead matter would get broken down and release energy, giving off carbon dioxide to the atmosphere. This is important, because plants need carbon dioxide from the atmosphere (abiotic matter) to produce energy storage molecules. In the Sim, when there only producers, the amount of carbon dioxide in the atmosphere decreases. Producers do cellular respiration and release carbon dioxide, but without consumers and decomposers also releasing carbon dioxide to the atmosphere, the amount of carbon dioxide in the atmosphere decreases. After a while, there was not enough carbon dioxide for producers to make more energy storage molecules, and they started dying. This evidence shows there cannot be any ecosystem with only producers.

Claim IS supported:

Tess, I found evidence to support your claim. Producers need carbon dioxide to survive and carbon dioxide is given off when all organisms use energy storage molecules for energy. An ecosystem with producers gives off carbon dioxide because producers are the ones that give off carbon dioxide, so a producer ecosystem will survive.



GREEN GROUP

Part 1: Without Sunlight

3. Can the ecosystem survive without light? Why or why not?

The ecosystem can survive for a little while without light, but eventually the populations start to die because without light, producers can't do photosynthesis. Producers' energy storage molecules run out and they die. This also means there will not be enough energy storage molecules for consumers, which eat producers. Eventually, even the decomposers run out of energy storage molecules.

Part 2: Represent a Deep-Sea Vent Ecosystem in the Sim

1. Features of the Sim Ecosystem: (left)

- photosynthesis



- uses energy from sunlight

Features of Both Ecosystems: (middle)

- has producers
- has consumers
- has decomposers
- organisms need energy storage molecules
- producers use carbon dioxide

Features of the Deep-Sea Vent Ecosystem: (right)

- chemosynthesis
- uses energy from hydrogen sulfide

2. Descriptions will vary. Students could note that there would be less, or no, sunlight (#2); that abiotic matter (#1) would be water instead of air; and that producers (#3) would make energy storage molecules using energy from chemosynthesis. They might also describe the different consumers (#4 and #5) and decomposers (#6) in the ecosystem.

What students should/might do:

Students run the ecosystem with sunlight OFF, and observe what happens to this ecosystem. They compare the ecosystem in the Sim to the deep-sea vent ecosystem. Then, they describe the changes they would make to the Sim so it represents a deep-sea ecosystem.

What students should notice:

Students should notice that in the Sim, producers need sunlight to make energy storage molecules. Once there is no sunlight, the producers stop making energy storage molecules, and the amount of energy storage molecules in producers and consumers decreases. This Sim does not include chemosynthesis as a method for producing energy storage molecules. In their redesign, students should note that the Sim needs to include chemosynthesis in order to represent a deep-sea vent ecosystem.

Use what you learned to write a short message to Econaut Kate Jones and explain whether you found evidence to support her claim or not. Be sure to include evidence from the article, the Sim, and any other information from the unit in your explanation. Remember, the Econauts do not know as much about ecosystems as you do, so you should explain your ideas fully and clearly.

Kate, I've investigated and the claim that populations in the deep-sea vent ecosystem can survive without sunlight is correct. Most producers use energy from the sun to make energy storage molecules, but at the bottom of the ocean



there is no sun. Instead, there are bacteria that make energy storage molecules using energy from hydrogen sulfide. This is different from photosynthesis and it is called chemosynthesis. All ecosystems need a source of energy to make energy storage molecules, but if there is no energy from sunlight, then some organisms can use energy from hydrogen sulfide.



3

STUDENT-TO-STUDENT
DISCUSSIONWord Relationships
Routine

Word Relationships Routine



Students use the Word Relationships routine to share what they have learned with students who read about a different ecosystem

Instructional Guide

1. Project the instructions and review the Word Relationships routine. Collapse the instructional guide and project the student screen, or have students turn to page 65 in their Investigation Notebooks. Explain that students who investigated different ecosystems should form groups of three. Each group will be comprised of one representative from each of the three ecosystems: cave, producers, and deep-sea vent. Students will take turns sharing what they learned about the ecosystem they investigated. Remind them about using the Word Relationships cards to construct sentences.

2. Distribute sets of Word Relationships cards and instruct students to begin the activity. Each group of three students gets one set of cards. Circulate and offer assistance as students construct their sentences. Allow at least 10 minutes for students to share with their groups. Collect card sets at the end of the activity so they will be ready for your next class.

3. Point out the homework assignment to students (Activity 4 or page 66 in the Investigation Notebook). If students do not have access to Amplify Science at home, provide them with copies of page 66 from the Investigation Notebook and copies of the “Glacier Mice: Living Arctic Tumbleweeds” article. If students did not get a chance to finish writing to the Econauts, they should do so for homework. Explain that students will also read a short article to learn about another, very different ecosystem for homework.

4. Optional: Point out the Self-Assessment (Activity 5 or page 67 in the Investigation Notebook). If students do not have access to Amplify Science at home, provide them with copies of page 67 from the Investigation Notebook. Remind students that in order to reflect on their own learning, they will revisit these questions at the end of every chapter. Some of the questions are based on learning that will come later in the unit, so it's fine if students select NOT YET for some of their responses.



4

HOMEWORK
Homework

Homework

Students finish writing to the Econauts and edit their messages, then read an article about a tiny ecosystem in the Arctic.

Instructional Guide

- 1. If needed, make additional time to explain the homework.** If students do not have access to Amplify Science at home, provide them with copies of page 66 from the Investigation Notebook and copies of the “Glacier Mice: Living Arctic Tumbleweeds” article.
- 2. If needed, make additional time to explain the second part of the homework.** If students do not have access to Amplify Science at home, provide them with copies of page 66 from the Investigation Notebook and copies of the “Glacier Mice: Living Arctic Tumbleweeds” article.

Teacher Support

Rationale

Pedagogical Goals: Reading About Another Ecosystem

In this unit, students learn that in a closed ecosystem, what happens in one part of a system can affect other parts of the system. Not all ecosystems, however, are closed ecosystems, and sometimes defining the boundaries of an ecosystem is difficult. In order to support the NGSS Performance Expectation MS-LS 2-3 (Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem), students read the “Glacier Mice: Living Arctic Tumbleweeds” article for homework. This article discusses how ecosystems come in all different forms and the importance of defining the boundaries of an ecosystem when scientists study them.

Assessment

Additional Assessment Opportunity: Student Understanding of the Boundaries of Ecosystems

This activity can be used to assess whether students understand that ecosystems are complete systems with boundaries that can be defined, but which can also affect and be affected by surrounding ecosystems. Look for whether students can explain that glacier mice are complete ecosystems because they are complete systems of living and nonliving things that are separate from the surrounding ecosystem. Also look for whether students can name a way that the surrounding ecosystem can influence the glacier mouse ecosystem, such as when tiny animals move into or out of the glacier mouse. Finally, look for whether students can explain that the “boundary” of an ecosystem is where



one ecosystem stops and another begins. If students have difficulty explaining these concepts, consider spending some time in class reviewing the idea of ecosystem boundaries and how energy can flow across these boundaries. You might use a larger-scale and more familiar example. For instance, you might show students images of ecosystems in water and on land, and ask them to describe where the boundary between these ecosystems is [the edge of the water] and why [because the animals on land can't live in the water, and the animals in the water can't live on land]. Then ask students to explain how energy might sometimes move across the boundaries of ecosystems [a land animal might eat a fish; a fish might eat an insect from the air]. Images of different ecosystems and the boundaries between them can be found using the search terms “ecosystem boundaries examples.”

Possible Responses

Describe how glacier mice are complete ecosystems, even though they are tiny.

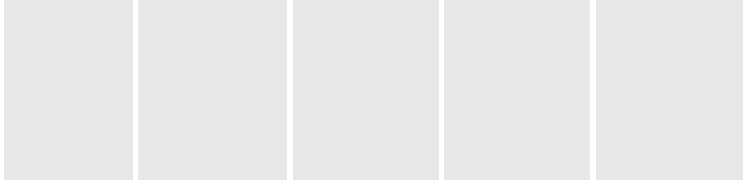
Glacier mice are complete ecosystems because they are complete systems of living and nonliving things, with a boundary that is the outside of the glacier mouse. In their case, the living things are just tiny organisms.

What does it mean to define the “boundaries” of an ecosystem?

Defining the boundaries of an ecosystem means deciding where one ecosystem stops and another begins.

What is one way that the surrounding ecosystem can affect the glacier mouse ecosystem?

Animals can move into and out of the glacier mouse ecosystem from the surrounding ecosystem. Sunlight can shine on the moss, causing energy to flow into the glacier mouse ecosystem.



5

HOMEWORK

Self-Assessment
(Optional)



Self-Assessment (Optional)

This optional homework provides a chance for students to reflect on their learning so far.

Instructional Guide

1. If needed, make additional time to explain this optional homework assignment. If students do not have access to Amplify Science at home, provide them with copies of page 67 from the Investigation Notebook.

Teacher Support

Assessment

Student Self-Assessment: Reflecting on the Unit

This is the second of four self-assessments (one at the end of every chapter), which invites students to reflect on their progress in the unit. To gain insight into students' thinking at this point in the unit, review their responses and questions.

Possible Responses

Answers will vary. This is a self-reflection.



Chapter 3

Carbon Movement in Ecosystems



Chapter Overview

Chapter Question

What happened to the carbon that used to be in the air (abiotic matter) of the biodome?

Investigation Questions

- If the amount of carbon changed in one part of a closed ecosystem, what happened to the carbon in the rest of the ecosystem? (3.1, 3.2)

Key Concepts

- Since carbon cannot be produced or used up, the total amount of carbon in a closed ecosystem does not change. (3.3) ?
- If the amount of carbon increased in abiotic matter, then it also decreased in biotic matter. If the amount of carbon decreased in abiotic matter, then it also increased in biotic matter. (3.3)



Chapter 3 Activities

Lesson 3.1: "Carbon in the Global Ecosystem"

1	Warm-Up	WARM-UP	
2	Focusing on Carbon	TEACHER-LED DISCUSSION	
3	Active Reading: "Carbon in the Global Ecosystem"	READING	
4	Discussing Annotations	STUDENT-TO-STUDENT DISCUSSION	
5	Homework	HOMEWORK	

Lesson 3.2: Total Carbon in an Ecosystem

1	Warm-Up	WARM-UP	
2	Reread "Carbon in the Global Ecosystem"	READING	
3	The Carbon Game	HANDS-ON	
4	Homework	HOMEWORK	

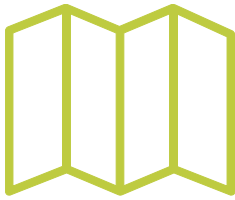
Lesson 3.3: Looking for the Missing Carbon

1	Warm-Up	WARM-UP	
2	Finding the Missing Carbon	SIM	
3	Researching the Biodome Files	READING	
4	Homework	HOMEWORK	

Lesson 3.4: Explaining What Happened in the Biodome

1	Warm-Up	WARM-UP	
2	Cause and Effect in the Biodome	SORTING TOOL	
3	Biodome Model	MODELING TOOL	
T	What's New at Biosphere 2	TEACHER	
4	Homework	HOMEWORK	
5	Family Homework Experience (Optional)	HOMEWORK	
6	Self-Assessment (Optional)	HOMEWORK	





Lesson 3.1

"Carbon in the Global Ecosystem"



Lesson at a Glance

ACTIVITY

1

Warm-Up (5 min)

Students are primed for the upcoming investigation by thinking individually about the Chapter 3 Question.



WARM-UP

2

Focusing on Carbon (5 min)

The teacher prepares students to begin their final investigation by making connections to the content from Chapters 1 and 2.

TEACHER-LED
DISCUSSION

3

Active Reading: "Carbon in the Global Ecosystem" (25 min)

Students read about the accumulation of carbon in one part of the Earth system and its effect on the whole ecosystem. The teacher uses this opportunity as another On-the-Fly Assessment of students' ability to engage with scientific texts and summarize main ideas.



READING

4

Discussing Annotations (10 min)

Students have time to discuss their thinking about the reading they did in order to share important insights and/or correct alternate conceptions. Students' annotations provide an opportunity for an On-the-Fly Assessment of students' annotation skills, reading comprehension, and content understanding.

STUDENT-TO-
STUDENT
DISCUSSION

5

Homework

In the Sim, students explore how moving carbon into one part of an ecosystem necessarily removes it from another part of the ecosystem.



HOMEWORK



DIGITAL RESOURCES

Carbon in the Global Ecosystem

Printable article: "Carbon in the Global Ecosystem"

Annotation Tracker Instructions

Annotation Tracker

Annotation Summary Sheet

Example Annotation Trackers and Summary Sheet

Matter and Energy in Ecosystems Investigation Notebook, pages 69–72

Matter and Energy in Ecosystems Glossary

Matter and Energy in Ecosystems Multi-Language Glossary



1

WARM-UP
Warm-Up



Warm-Up



Dr. Corry introduces students to their final investigation, and students offer their initial ideas.

Instructional Guide

1. Project Warm-Up; students work independently. Collapse the instructional guide and project the student screen, or have students turn to page 70 in their Investigation Notebooks. Allow a few minutes for students to individually respond to the Warm-Up.

Possible Responses

What do you think happened to the carbon that used to be in the air of the biodome?

Answers will vary. Possible ideas include the carbon disappearing, saying it left the biodome, got used up, went to another part of the ecosystem, or became dead matter.



2

TEACHER-LED DISCUSSION

Focusing on Carbon



Focusing on Carbon



The teacher leads a brief discussion that connects the work students have done so far to the new Chapter Question.

Instructional Guide

- 1. Introduce new Chapter Question.** Collapse the instructional guide and project the student screen. Read the Chapter Question aloud and point out where it's posted on the classroom wall. Leave the student screen projected to discuss further.
- 2. Reestablish the importance of carbon.** Using the posted key concepts, emphasize that carbon is an important part of the two ecosystem processes students have studied so far—photosynthesis and cellular respiration. Chapter 1 was about the process of creating energy storage molecules, which contain carbon, and Chapter 2 was about the process of cellular respiration where carbon is given off.
- 3. Connect the Chapter Question to what students already know about carbon in the biodome.** Use the images on the projected student screen to remind students that the amount of carbon in the air (as carbon dioxide) and in living things (as energy storage molecules) decreased after the biodome experiment began.
- 4. Provide a rationale for why the Econauts want to learn what happened to the carbon in the air.** Explain that this information will be helpful to the Econauts as they plan their next biodome because carbon is an essential part of energy storage molecules, which all organisms need to survive, and they need to know this to help them make their next biodome a success.
- 5. Lead a brief class discussion of the Warm-Up.** Invite students to share their ideas about what might have happened to the carbon in the biodome. You could also invite students to speculate about whether the missing carbon could be related to the decrease in decomposers that they discovered in Chapter 2.



3

READING

Active Reading: "Carbon in the Global Ecosystem"



Active Reading: "Carbon in the Global Ecosystem"



Students are introduced to and read, "Carbon in the Global Ecosystem."

Instructional Guide

1. Introduce the Investigation Question. Point to the Investigation Question on the board and read it aloud. Connect this question to the crosscutting concept of systems by drawing attention to the key concept you posted in Lesson 1.5, *If one part of a system changes, this affects the rest of the system.*



When scientists study systems, like ecosystems, they look at how the different parts affect each other, but they also look at how one change can affect the entire system.

2. Project and introduce the "Carbon in the Global Ecosystem", or project the printed article using a document camera. Explain that they will read an article that will help them think about how carbon moves through a system.



We have been thinking about carbon in one type of closed ecosystem—the biodome—but this article focuses on how carbon moves through the whole Earth system. In the biodome, you found that the amount of carbon dioxide was *decreasing*. In the Earth system, scientists have actually noticed that carbon dioxide in the atmosphere is *increasing*. Reading about carbon in the whole Earth system will help us figure out what happened to carbon in the biodome.

3. Model Active Reading with a special emphasis on summarizing. Explain that you will think aloud as the class reads the first two paragraphs together. Remind students that today's reading has one goal in addition to the other reading strategies they have been using and practicing this year: summarizing their thinking as they read. The outline that follows is one suggestion for modeling this; you may adapt it to your own process.

- **Read the title and first sentence; make a connection and ask a question.**

Say: "Here it says that the amount of carbon dioxide in Earth's atmosphere is increasing, which is the opposite of what happened in the biodome. In the biodome, we learned that this was caused by a decrease in cellular respiration as the population of decomposers decreased. Could this increase be caused by an increase in cellular respiration?"

- Open a note and near the first sentence type, "Is this caused by more cellular respiration?"



- **Read the rest of the first paragraph; make a summary statement.**

Say: "This paragraph has some important information about carbon, so this is a good place to write a short summary. Then I can go back and read just my summary and it will remind me what this paragraph was about."

- Open a note near the last sentence of the first paragraph and type, "Carbon dioxide in atmosphere increasing, threatening life. Carbon from underground."

- **Read second paragraph; answer question from first sentence.**

Say: "I had wondered if the increase in carbon dioxide was because of more cellular respiration, but now I see that the increase in carbon dioxide is caused by burning fossil fuels. So cellular respiration is not the only way carbon dioxide gets into the atmosphere."

- Open a note near the last sentence of the first paragraph and type, "The increase in carbon dioxide is caused by burning fossil fuels."

4. Discuss when to summarize. Remind students that not every paragraph needs a summary. Sometimes two or more paragraphs together will make up an important idea that needs to be summarized. It is a personal choice based on when there is an especially important idea they want to note. Let students know that you won't require them to summarize every paragraph, but you would like to have them try to use this strategy at least one or two times while reading today. They should also continue to use the other strategies they have been practicing this year.

5. Prompt students to read and annotate while you circulate with the Annotation Tracker. If students are using the Investigation Notebook, have them turn to page 71 to see instructions and the Active Reading Guidelines. Use the Annotation Tracker to keep track of annotations that you would like to invite students to share during the class discussion. Especially take note of student summaries, since you will return to the idea of summarizing during the end-of-class discussion.

6. On-the-Fly Assessment: Progress with Summarizing Main Ideas in Text. For further suggestions on how to support students as they annotate, press the hummingbird icon and select ON-THE-FLY ASSESSMENT 8.



Embedded Formative Assessment

On-the-Fly Assessment 8: Progress with Summarizing Main Ideas in Text

Look for: This reading lesson is an opportunity to check on students' progress with summarizing main ideas as modeled in Lesson 1.3 and in the beginning of this lesson. As with all reading lessons, students should be encouraged to annotate in the unique ways that are helpful to their own learning and personal style. Look for students to be actively engaged in the reading and annotation process. They may be making a wide range of annotations that reflect their varying levels of science understanding, and that is okay. Have the following questions in mind as you check student annotations:

- Are students attempting to summarize multiple paragraphs in the text?
- Do these summaries capture the main ideas or do they include peripheral ideas?
- Are they attempting to use simpler phrases rather than just copying entire chunks of text?

Now what? This reading experience is intended to be a space for students to have a personal conversation with the text, but some students may need support identifying and summarizing the main ideas from the article. Consider periodically reading an exemplary annotation aloud. Provide positive, encouraging feedback about why this particular annotation is a good example of Active Reading. You can also offer general prompts to support deeper engagement:

- "What questions do you have about this [illustration, paragraph, photograph]?"
- "Were there any words or phrases that were confusing to you?"
- "Was there something in this text that caused you to wonder or have a question? If so, what?"

To support students as they identify and summarize main ideas, you may want to prompt them with questions such as, "Which parts of this paragraph seem the most important to you?" or "Is there a simpler way you can express this idea?" If students who are more familiar with annotating and summarizing during reading are copying long, complex sentences directly from the text instead of writing concise summarizing statements, challenge them to write a summary without looking back at the text. You may also challenge them to try summarizing a paragraph in the fewest words possible, which may motivate students to use their own words rather than copying directly from the text.

Teacher Support

Background

Science Note: Fossil Fuels

If your students already completed the Amplify Science units, *Earth's Changing Climate* or *Earth's Changing Climate Engineering Internship*, they may remember the term *fuels*, which refers to the coal, oil, and gas that humans burn to power our homes, businesses, and cars. It was beyond the scope of these units to explain how fuels are formed and why



they are usually called *fossil* fuels, so we simplified and called them *fuels*. In the *Matter and Energy in Ecosystems* unit, we now refer to coal, oil and gas as *fossil fuels*. For this unit, the fact that these fuels were formed from dead organisms buried underground millions of years ago is related to the biodome problem that students are investigating.



4

STUDENT-TO-STUDENT
DISCUSSION

Discussing Annotations

Discussing Annotations



Students share their annotations and discuss the article.

Instructional Guide

1. Project annotation discussion directions. Collapse the instructional guide and project the student screen. Prompt students to choose one or two annotations they'd like to share with a partner. Explain that students could share summaries, but they probably wouldn't spark much student-to-student discussion; choosing a question or connection is better, and you'll come back to the summaries later.

2. Partners discuss annotations. Have partners share and discuss. After a few minutes, ask students to choose an annotation they would like to share or get help with from the rest of the class. Circulate and listen for annotations that would be nice to discuss as a class.

3. Hold a class discussion for several student annotations. Try to have students share questions or ideas that are helpful for supporting deeper content learning or surfacing alternative conceptions about the content.

4. Discuss summarizing. If you noticed a particular student summary that you would like to acknowledge, use this opportunity to share that student's work. Ask her to explain how she created the summary and what kinds of thoughts went into making it. If you didn't choose one in advance, ask for student volunteers to share what they did, and follow the same procedure.

5. Reflect on utility of summarizing while reading. Ask students whether or not they thought this was a useful strategy and how or why it was (or was not) useful. Acknowledge that summarizing can slow you down and interfere with the flow of reading in some ways, but for difficult texts, such as science texts, it is often very helpful to employ this strategy.

6. Highlight energy driving the cycling of matter. We read about how the movement of carbon is driven by energy, for example energy from the sun for photosynthesis. This concept of energy causing matter to move is one that many scientists use to analyze systems. For example, a weather scientist might consider the energy from the sun that drives the water cycle, and an engineer might consider the energy needed to move parts of a machine.

Ask students to press NEXT (or to turn to page 71 in the Investigation Notebook).



7. Prompt students to review annotations on their digital devices and submit annotated articles. Individual students' annotations for "Carbon in the Global Ecosystem" should be visible on their student screens. Have students submit their annotated articles by pressing HAND IN.

8. On-the-Fly Assessment: Insight from Student Annotations. For further suggestions about reviewing students' annotations, press the hummingbird icon and select ON-THE-FLY ASSESSMENT.

9. Point out the homework assignment (Activity 4 or page 72 in the Investigation Notebook). If students do not have access to Amplify Science at home, adjust your schedule to make time to complete the Sim activity in class. Explain that students will be using the Sim to model events in the global ecosystem after they have increased the amount of carbon dioxide in the air as much as possible.



Embedded Formative Assessment

On-the-Fly Assessment 9: Insight from Student Annotations

Look for: Review submitted student annotations after class. You can use these annotations to assess students' annotation skills, reading comprehension, and content understanding. Use the Annotation Tracker and Annotation Tracker Instructions for guidance.

Now what? See the Annotation Tracker Instructions for suggestions on how to further support students.

Teacher Support

Rationale

Science Reading: Why Discuss Annotations?

Discussing annotations with a partner is an important step in Active Reading. It capitalizes on students' desires to engage with their peers socially and builds in a measure of accountability. An important aspect of these peer discussions is having students go back into the text to try to answer questions or clear up confusion. Discussing the text with a partner creates a reason to revisit the text and reread more carefully than students may have if reading on their own.

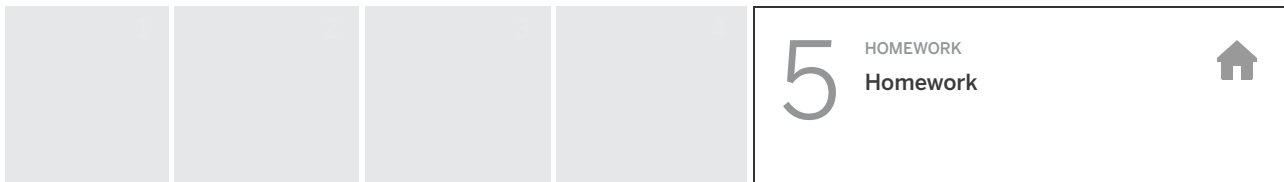
Instructional Suggestion

Literacy Note: Discussing Student Summaries

Students respond well to examples of successful strategies provided by their peers. This is especially true for student examples of connections, questions, and difficult vocabulary in the text, but can be less true for examples of summaries. Questions, connections, and difficult vocabulary bring in a personal tie, and that makes them more interesting, while summaries ask students to restate the text in a simpler way, which isn't as exciting. However, if your goal is to more deeply engage students in thinking about how to come up with better summaries, it is often better to use student examples than it might be to show a predetermined, manufactured summary from an unknown author. If you want to engage students in discussions about how to make decisions about what to include in a summary, the



purposes of written summaries, and what a good summary might look like for a particular piece of text, you may want to take time to examine today's student summaries and ask students if you could share their exemplary work. As they share, students can explain their goals and what they were thinking as they created their summaries. Student modeled think-alouds can be extremely helpful exemplars for their peers.



Homework

Students try to maximize the amount of carbon in the atmosphere, observing how this affects the rest of the Sim ecosystem.

Instructional Guide

1. If needed, make additional time to explain the homework. If students do not have access to Amplify Science at home, adjust your schedule to make time to complete the Sim activity in class.

Possible Responses

What students should/might do:

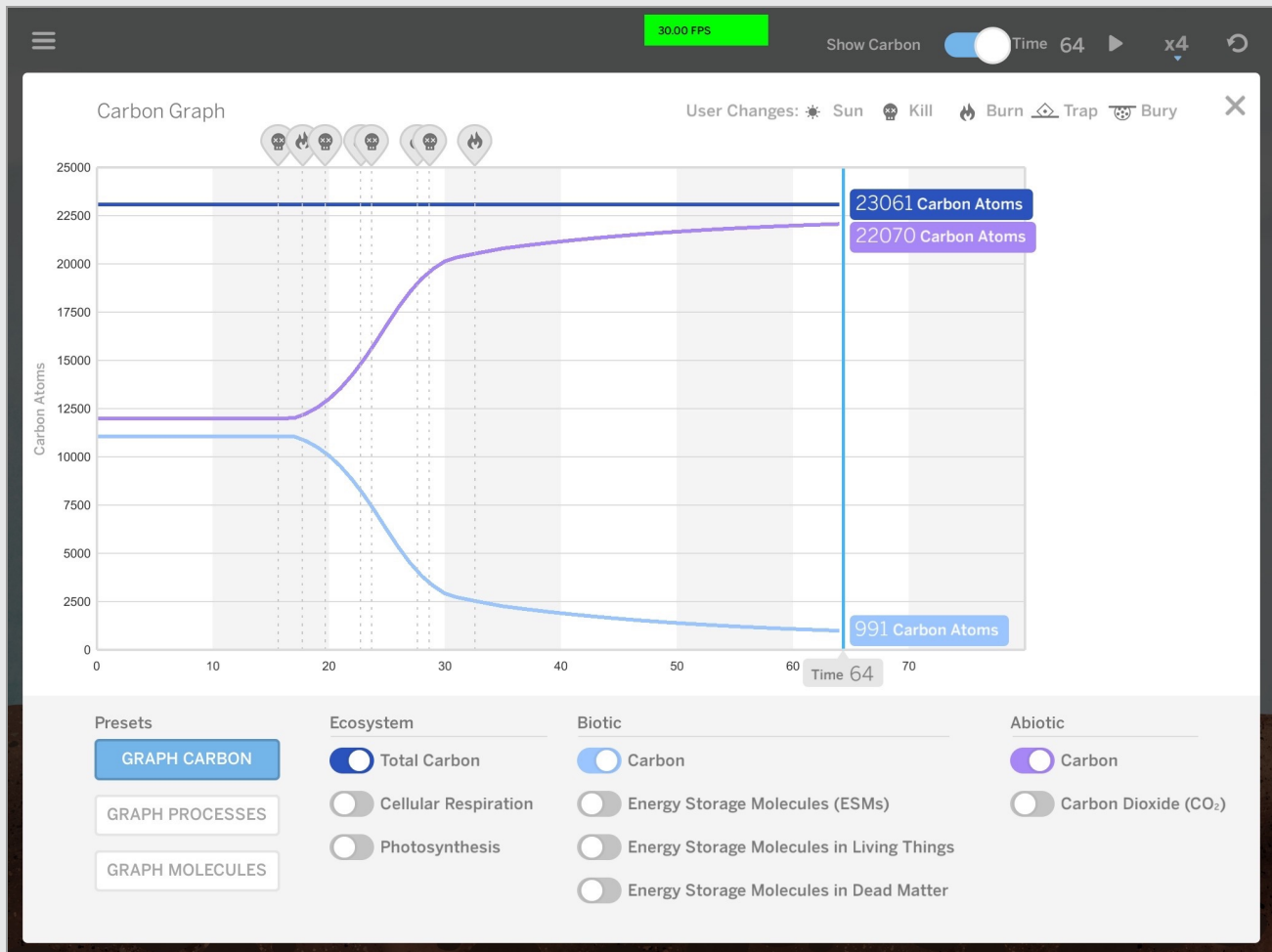
In order to increase carbon dioxide in abiotic matter, students might burn dead matter. Students might kill producers so they cannot use carbon dioxide to make energy storage molecules. Students might also trap carbon dioxide, making it inaccessible to producers.

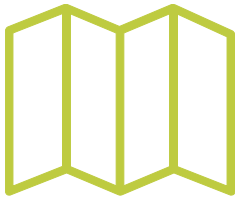
What students should notice:

Students should notice that as they increase the amount of carbon dioxide in abiotic matter, the amount of carbon in other parts of the Sim decreases. The total amount of carbon in the Sim is fixed, since the Sim is a closed ecosystem.

As you increased the amount of carbon dioxide in the air, what happened to the amount of carbon in other parts of the ecosystem? Explain your answer.

The amount of carbon in other parts of the ecosystem (biotic matter) decreased as the amount of carbon dioxide in the air increased.





Lesson 3.2

Total Carbon in an Ecosystem



Lesson at a Glance

ACTIVITY

1

Warm-Up (5 min)

Students consider a claim that the total amount of carbon on Earth is increasing in order to activate their thinking about how amounts of carbon on Earth might change over time.



WARM-UP

2

Reread "Carbon in the Global Ecosystem" (15 min)

Students revisit the "Carbon in the Global Ecosystem" article in order to learn that the total amount of carbon in a closed ecosystem doesn't change. The teacher uses this opportunity as an On-the-Fly Assessment of students' understanding that matter cannot be produced or used up.



READING

3

The Carbon Game (25 min)

Students play a game to help them deepen their knowledge about the movement of carbon between the abiotic and biotic parts of an ecosystem.



HANDS-ON

4

Homework

Students reflect on what they have learned in order to make connections to another science topic.



HOMEWORK



DIGITAL RESOURCES

Carbon in the Global Ecosystem

Printable article: "Carbon in the Global Ecosystem"

Carbon Game Instructions
copymaster

Matter and Energy in Ecosystems
Investigation Notebook, pages
73–78

Matter and Energy in Ecosystems
Glossary

Matter and Energy in Ecosystems
Multi-Language Glossary



1

WARM-UP
Warm-Up



Warm-Up



Students respond to a claim about the amount of carbon on Earth and whether it could be increasing.

Instructional Guide

1. Project Warm-Up; students work independently. Collapse the instructional guide and project the student screen, or have students turn to page 74 in their Investigation Notebooks. Allow a few minutes for students to individually respond to the Warm-Up.

Possible Responses

Do you agree or disagree with Gabriela's statement?

Disagree

Explain your answer.

According to the article we read, the carbon in the atmosphere is coming from somewhere else on Earth, not from outer space since Earth is a closed ecosystem. There must be the same amount of total carbon on Earth, no matter how much is in the atmosphere.



2

READING

Reread "Carbon in the
Global Ecosystem"

Reread "Carbon in the Global Ecosystem"



Students reread part of "Carbon in the Global Ecosystem" to search for evidence that will help them answer the Investigation Question.

Instructional Guide

1. Review Investigation Question and connect to previous and upcoming activities.

- **Connect to article from previous lesson.** Point out that carbon moves constantly through different parts of an ecosystem. The previous lesson's article discussed how this happens.
- **Connect to Warm-Up.** Point out that in the Warm-Up, students thought about whether an increase in one part of the ecosystem meant there would be an increase in the total amount of carbon in an ecosystem.
- **Point out how cause-and-effect relationships help make predictions.** Ask students to think about the cause-and-effect relationships they have discovered related to ecosystems and carbon. These ideas may have helped students predict how increasing carbon in the atmosphere would affect the total amount of carbon on Earth.
- **Let students know that they will continue to focus on the Investigation Question in today's lesson.**
- **Connect to reports for Econauts.** As part of being student ecologists, it's their job to learn as much as they can before making their reports to the Econauts about what went wrong with the biodome.

2. Introduce second read activity. To help students get more evidence to answer the Investigation Question, let them know that they will revisit part of the "Carbon in the Global Ecosystem" article. Remind them of the importance of reading like a scientist and making annotations while reading.

3. Share selected annotations from last lesson. From the analysis you did with the Annotation Tracker, review and discuss any alternate conceptions that were revealed in students' annotations. You may also want to share exemplary annotations that demonstrate thoughtfulness or creativity.

4. Review instructions for second read. Collapse the instructional guide and project the student screen, or have students turn to page 75 in their Investigation Notebooks. Review the instructions.



5. Students read and highlight text. Circulate and assist students as needed.

6. Student discuss text with a partner. Have students choose one or two ideas they highlighted in the text that help them answer the Investigation Question: *If the amount of carbon changed in one part of a closed ecosystem, what happened to the carbon in the rest of the ecosystem?*

7. On-the-Fly Assessment: Accounting for Global Carbon. For further suggestions on how to support students' understanding that matter cannot be produced or used up, press the hummingbird icon and select ON-THE-FLY ASSESSMENT 10.



Embedded Formative Assessment

On-the-Fly Assessment 10: Accounting for Global Carbon

Look for: As students discuss the Investigation Question, listen for them to apply content from the article indicating that carbon is not produced or used up. Students should be concluding that if carbon is increasing in one part of the ecosystem (the atmosphere in the article), it must be decreasing in another part.

Now what? Students will continue to explore the Investigation Question during the Carbon Game activity that follows and during the Sim activity in 3.3. For students who are struggling now, you could ask them to review the article again and look for evidence that explains what happens to carbon in the rest of an ecosystem if the amount in one part changes. You could work with a small group to identify and discuss that evidence in the article. Students struggling with this activity will benefit from guidance and coaching during the Sim Activity in Lesson 3.3.

Possible Responses

Use evidence you found in the article to answer the Investigation Question: *If the amount of carbon changed in one part of a closed ecosystem, what happened to the carbon in the rest of the ecosystem?*

According to the article, Earth is a closed system. Very little carbon enters the Earth system and almost none escapes. This means that if carbon increases in one part of the system, it must have come from somewhere else on Earth. When humans burn fuels (which are made from dead matter), carbon that used to be buried in the ground is given off to the atmosphere. So carbon has increased in the atmosphere (abiotic matter) but decreased in dead matter (biotic matter). According to the article, carbon moves naturally through the system through the processes of photosynthesis, which transfers carbon from abiotic to biotic, and cellular respiration, which transfers carbon from biotic to abiotic.



3

HANDS-ON

The Carbon Game



The Carbon Game



Students play a game that simulates how carbon moves through an ecosystem and observe that the total amount of carbon in the system stays the same.

Instructional Guide

1. Review Investigation Question. Point to the Investigation Question on the board and read it aloud.



From the article, we learned that carbon moves from one part of Earth's ecosystem to another. Remember that the processes of photosynthesis and cellular respiration transfer carbon between biotic and abiotic parts of the system.

2. Review previous learning and introduce Carbon Game. If you think it is useful, review the following information: Carbon in abiotic matter is found in molecules like carbon dioxide, while carbon in biotic matter is found in the molecules that make up organisms, including the energy storage molecules they use to survive.



We're going to play a game that will help us actually see the way carbon moves through an ecosystem. In this game, you and your partner will have to pay close attention to the amount of carbon in each part of your ecosystem. To win, you and your partner will need to make sure the organisms in your ecosystem have enough carbon to survive.



3. Project and narrate the series of images that illustrate how to play the Carbon Game.

- **The Game Board.** Point out that the game board shows the different parts of the ecosystem. Explain that students should start with six carbon tokens in each part of the ecosystem. Each player will take one Action card. This Action card is placed faceup, and will not be used until later in the turn.

Before the Game

1. Place six tokens in each region of the ecosystem.
2. Shuffle both sets of cards (Action and Event), and place the decks facedown near the board.
3. Draw an Action card and place the card faceup in front of you (both players—two cards are faceup).



- **Game Instructions Sheet.** Explain that students will get a copy of these instructions, or refer to page 76 in their Investigation Notebooks. Game instructions are on the left and specific instructions for effects are on the right: Effects of High or Low Carbon. At the start of each round, they'll need to check the ecosystem game board to see if carbon is high or low in any part, and then follow the instructions for carrying out the effects. If there are multiple effects, they should be carried out from the top of the ecosystem to the bottom, and from the left side (producers) to the right side. For example, you would carry out effects in this order: atmosphere, producers, consumers, decomposers, and dead matter.

Playing the Game (each round)

1. **Effects:** Follow the Effects of High and Low Carbon instructions for each part of the ecosystem.

If more than one effect applies, go in order from the top of the board to the bottom, and then from left to right within each row.

The Carbon Game Instructions

Goal: Work with your partner to keep producers, consumers, and decomposers in the ecosystem from carrying out 6 carbon for as many rounds as possible.

Materials (teams of two players)

- 1 Action card game board
- 20 carbon tokens
- 20 Event cards (random events that affect the ecosystem)
- 20 Action cards (ways YOU change the ecosystem)

Before the Game

1. Shuffle the Action cards.
2. Place six tokens in each region of the ecosystem (Producers, Consumers, Decomposers, and Dead Matter).

During the Game

1. ACTION ON YOUR STUDENT SCREEN BEFORE CONTINUING.

1. Shuffle both sets of cards (Action and Event), and place the decks facedown near the board.
2. Each player should draw an Action card and place it faceup in front of both players.

Playing the Game (each round)

1. Effects: Follow the Effects of High and Low Carbon instructions for each part of the ecosystem. If more than one effect applies, go in order from the top of the board to the bottom, and then from left to right within each row.
2. Events: Draw an Event card and place it faceup near the board. Follow the instructions on the card. Start at the beginning of the next round to apply any effects.
3. Action: Choose one of the faceup Action cards and follow the instructions. If the instructions on the faceup Action card, after you follow the instructions on discard, draw a new card, turn it faceup, and wait till the next round to play your new Action card. This round is now over.

Winning and Losing

If any decomposer survives, you win! If any organisms (producers, consumers, or decomposers) run out of carbon, you lose.

Effects of High and Low Carbon

Air (Abiotic Matter)

High carbon (more than 6) Producers have more carbon than other parts to perform more photosynthesis. • Move 1 carbon from air to producers.	Low carbon (fewer than 6) Producers do not have enough carbon from other parts to make enough energy to make ATP. • Move 1 carbon from producers to dead matter.
---	---

Producers

High carbon (more than 6) Producers provide extra food for consumers. • Move 1 carbon from producers to consumers.	Low carbon (fewer than 6) Consumers do not have enough food to survive. • Move 1 carbon from consumers to dead matter.
---	---

Consumers

High carbon (more than 6) More consumers eat extra food from producers and perform cellular respiration. • Move 1 carbon from producers to consumers. • Move 1 carbon from consumers to air.	Low carbon (fewer than 6) More carbon from consumers to air.
--	--

Decomposers

High carbon (more than 6) More decomposers eat dead matter and perform cellular respiration. • Move 1 carbon from dead matter to decomposers. • Move 1 carbon from decomposers to air.	Low carbon (fewer than 6) Decomposers do not have enough carbon from dead matter to survive. • Move 1 carbon from decomposers to dead matter.
--	--

Dead Matter

High carbon (more than 6) Dead matter has too much carbon. • Move 1 carbon from dead matter to decomposers.	Low carbon (fewer than 6) Decomposers do not have enough carbon from dead matter to survive. • Move 1 carbon from decomposers to dead matter.
--	--



- **Carbon Game Effects.**
 - No effects in first round, but check the ecosystem at the start of each subsequent round. Note that image shows the ecosystem after a few rounds of play.
 - Model how to check the ecosystem. Look for high carbon (more than 8) or low carbon (fewer than 4) in any part of the ecosystem. If students find an area of high or low carbon, they should carry out the effects explained on the instruction sheet.
 - Model carrying out effects. The image shows high carbon in producers. The effect would be to move one carbon to consumers. Point out that there is also low carbon in dead matter and the effect would be to move one carbon from decomposers to dead matter.
 - Emphasize the order for carrying out effects: Start in the atmosphere, move down to the living things (from left to right), and last, carry out the effects for dead matter.

Playing the Game

1. Effects: Follow the Effects of High and Low Carbon instructions for each part of the ecosystem. If more than one effect applies, go in order from the top of the board to the bottom, and then from left to right within each row.

EXAMPLES:

More than 8 carbons in producers: Move 1 carbon from producers to consumers.

Fewer than 4 carbons in dead matter: Move 1 carbon from decomposers to dead matter.



- **Events.** Next, students draw an Event Card. Emphasize that these cards describe naturally occurring events that happen in the ecosystem. Read the event on the projection and point out how you would follow the instructions.

Playing the Game

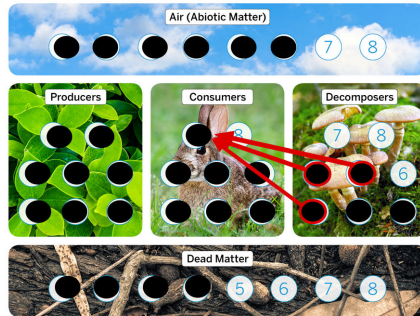
2. **Events:** Draw an Event card and place it faceup next to the board. Follow the instructions on the card. Wait till the beginning of the next round to apply any ecosystem effects.

Animals Munch Mushrooms



Consumers eat decomposers.

Move 3 carbon
Decomposers → Consumers

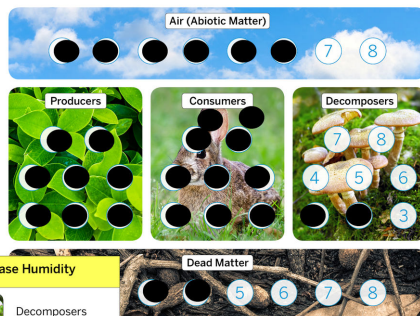


- **Action.** Next, students play or discard an Action card. Emphasize that these cards describe human actions that can affect the carbon in the ecosystem. Remind students that the goal is to keep any one part of the ecosystem from running out of carbon, so they will need to discuss which players' Action card will be best for the ecosystem. Talk through how you would choose between the cards on the image.

Playing the Game

3. **Action:** Choose one of the faceup Action cards and follow the instructions **OR** discard one of the faceup Action cards. After you follow the instructions or discard, draw a new card, turn it faceup, and wait till the next round to play your new Action card. *This round is now over.*

Turn On Grow Lamps  Producers do more photosynthesis. Move 2 carbon Air → Producers	Increase Humidity  Decomposers eat more and reproduce. Move 3 carbon Dead matter → Decomposers
--	---



We wouldn't want to move carbon from the atmosphere to producers because we already have many carbons there. Our dead matter is low and adding a carbon would bring up the amount of carbon there, so I think that is the best choice.



After using an Action card, that player draws a new one. Point out that instead of playing one of the existing Action cards, students can discard an Action card and draw a new one. But that means they may not play another Action card until the next round.

4. Review the goals and conditions for winning and losing the game. Remind students that the goal is to keep living things in the ecosystem from running out of carbon. If the living things can survive all the Event cards, then they win. If any of the living things run out of carbon, they lose.

Ask students to press NEXT (or to turn to page 77 in the Investigation Notebook).

5. Distribute game materials and instruct students to begin setting up the game. Instruct students to refer to their game instruction sheets or page 76 in their Investigation Notebooks. Tell them not to begin yet. Circulate and assist with setup as needed.

6. Prompt students to count carbon. Collapse the instructional guide and project the student screen, or have students turn to page 77 in their Investigation Notebooks. Before students begin to play, let them know that they should count the total carbon in the ecosystem, as well as the amounts of carbon in both abiotic and biotic parts of the ecosystem. Have them record the numbers on their screens or in their Investigation Notebooks.

7. Students play the game. As students are playing, walk around the room and observe the choices that students are making with their ecosystems. Answer any questions.

8. Prompt students to finish their last round and count carbon. When there are about 7 minutes of class time remaining, have students record the amount of total carbon, carbon in biotic, and carbon in abiotic matter, and then clean up their materials. Remind students about the partner discussion question at the bottom of their screens.

9. Debrief the game with a short class discussion. After pairs have finished discussing, begin a whole-class discussion. The following are suggestions to guide your discussion.

- During the game, did the amount of carbon in biotic matter change? What about abiotic matter? [Yes to both. Sometimes carbon came into biotic from the atmosphere, or transferred out of biotic to the atmosphere.]
- Did the total amount of carbon in your ecosystem change? [No. There were 30 total carbon at the beginning and 30 total carbon at the end.]
- After playing the game and reading the article, what did you learn that can help you answer the Investigation Question: *If the amount of carbon changed in one part of a closed ecosystem, what has happened to the carbon in the rest of the ecosystem?* If students need more prompting:
 - If the amount of carbon in abiotic matter increases, what is also happening to the amount of carbon in biotic matter? [If abiotic carbon increases, then biotic carbon decreases.]
 - If the amount of carbon in abiotic matter decreases, what is also happening to the amount of carbon in the organisms? [If abiotic carbon decreases, then biotic carbon increases.]
- Make a connection to the crosscutting concept of systems. Review the key concept on the classroom wall: *If one part of a system changes, this affects the rest of the system.*



In the game, you saw that carbon moves from abiotic to biotic, through various biotic parts of the system, and then from biotic to abiotic. This continuous movement of carbon through an ecosystem is often called the carbon cycle. If something happens that stops carbon from moving through one part of the system, the rest of the system is affected. Since the total amount of carbon in a closed ecosystem doesn't change, when carbon increases in one part of the system, it has to decrease in the rest of the system.

10. Point out the homework. (Activity 4 or page 78 in the Investigation Notebook). If students do not have access to Amplify Science at home, provide them with copies of page 78 from the Investigation Notebook. Explain that for homework students will write about one way the ideas they are exploring in this unit might connect to another science topic that they studied earlier.

11. Give an example of a connection between science units. Select a topic that your class studied earlier in the year or a topic that most students studied in a previous year, and describe its connection to how energy storage molecules are made and used, or how carbon moves through ecosystems. You might use the following example:



We have been investigating the processes of photosynthesis and cellular respiration and how they help move carbon around ecosystems. This is connected to what you might have learned in the *Earth's Changing Climate* unit. For example, you might remember from *Earth's Changing Climate* that the temperature of Earth's surface is increasing because carbon dioxide in the air is increasing. We know that photosynthesis and cellular respiration also affect the amount of carbon dioxide in the air.

12. Encourage students to think creatively. Challenge students to think of ways to connect science topics that might seem quite different from *Matter and Energy in Ecosystems*.

Possible Responses

Before the Game:

- Total carbon = 30
- Biotic carbon = 24
- Abiotic carbon = 6

At the End of the Game:

- Total carbon = 30
- Biotic carbon = varies
- Abiotic carbon = varies



Based on the game, discuss with your partner what you have learned that can help you answer the Investigation Question: *If the amount of carbon changed in one part of a closed ecosystem, what happened to the carbon in the rest of the ecosystem?*

The game showed that the total amount of carbon in the ecosystem stays the same, no matter what happens. It's just that the carbon moves around to different parts of the ecosystem when organisms die, or eat others, or when things happen in the environment like fires, rain, sunlight, or disease. When there is more carbon in the abiotic part of the system, there is less carbon in the biotic part of the system, and vice versa.



4

HOMEWORK

Homework



Homework

Students reflect on what they have learned and make connections between science topics.

Instructional Guide

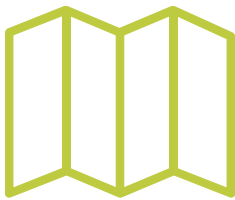
1. If needed, make additional time to explain the homework. If students do not have access to Amplify Science at home, provide them with copies of page 78 from the Investigation Notebook.

Teacher Support

Rationale

Pedagogical Goals: Reasons for Connections Homework

The purpose of this homework activity is to encourage students to think creatively about how their current learning (energy and carbon movement in ecosystems) connects to other science topics they have studied. Making connections between science ideas is an important element of many scientists' work and will also help students reinforce their long-term understanding of science concepts. This activity is intentionally open-ended, so expect a wide variety of student responses, with some more detailed or thoughtful than others. This type of homework is included in many Amplify Science middle school units so students will have other opportunities to practice making these kinds of connections. You can help students improve their thinking by reading aloud some especially detailed or interesting responses in a subsequent lesson.



Lesson 3.3

Looking for the Missing Carbon



Lesson at a Glance

ACTIVITY

1

Warm-Up (5 min)

Students reflect on what they've learned so far by choosing a claim in response to the Chapter 3 Question.



WARM-UP

2

Finding the Missing Carbon (20 min)

Students use the Sim in order to gather evidence about what happened to the carbon that used to be in the abiotic matter of the biodome.



SIM

3

Researching the Biodome Files (15 min)

Students read through the article set, *Biodome Files*, to get evidence about what caused the decomposer population in the biodome to decrease.



READING

4

Homework

Students use the Sorting Tool to label a diagram and summarize what they've learned about why the amount of carbon in the air of the biodome changed.



HOMEWORK



DIGITAL RESOURCES

Biodome File 1: News Stories

Biodome File 2: Econaut
Biographies & Job Descriptions

Biodome File 3: List of
Recommended Organisms to
Include in the Biodome

Biodome File 4: Biodome Water
System Diagram

Biodome File 5: Goatherd's Journal

Printable article: "Biodome File 1:
News Stories"

Printable article: "Biodome File 2:
Econaut Biographies & Job
Descriptions"

Printable article: "Biodome File 3:
List of Recommended Organisms to
Include in the Biodome"

Printable article: "Biodome File 4:
Biodome Water System Diagram"

Printable article: "Biodome File 5:
Goatherd's Journal"

Matter and Energy in Ecosystems
Investigation Notebook, pages
79–84

Matter and Energy in Ecosystems
Glossary

Matter and Energy in Ecosystems
Multi-Language Glossary



1

WARM-UP
Warm-Up



Warm-Up



Students choose and defend a claim about what happened to the carbon that used to be in the air of the biodome.

Instructional Guide

1. Project Warm-Up; students work independently. Collapse the instructional guide and project the student screen, or have students turn to page 80 in their Investigation Notebooks. Allow a few minutes for students to individually respond to the Warm-Up.

Possible Responses

Based on what you learned about carbon movement in ecosystems, which claim best answers the Chapter 3 Question?

Claim 2

Briefly explain your claim choice.

I choose Claim 2 because from the Carbon Game and the article, I learned that the total amount carbon in a closed ecosystem stays the same. Since the biodome is a closed ecosystem, the total carbon can't decrease.



2

SIM

Finding the Missing
Carbon

Finding the Missing Carbon



Students use the Sim to get evidence for where the carbon that used to be in abiotic matter of the biodome went.

Instructional Guide

1. Briefly review students' claims from the Warm-Up. Survey the class to see which claim they chose. Ask several volunteers to share their choices and their reasons for choosing that particular claim. Most students should have picked Claim 2: The carbon that used to be in the air (abiotic matter) is now in another part of the ecosystem, so total carbon stayed the same.

2. Make a connection to previous activities and narrow down the claims. The following suggestions can guide your discussion:

- Ask students to think back to the Carbon Game and the article they read in the previous lessons.
- Ask students if, in a closed ecosystem (like the biodome or the ecosystem in the game), the total amount of carbon can change. [No, the total amount of carbon stays the same. For example, in the game there were 30 carbon tokens at the beginning and 30 carbon tokens at the end, even though the amounts of carbon in the different parts of the ecosystem changed.]
- Remind students that the article also stated that in a closed ecosystem, carbon can't be produced or used up, only moved around to different parts of the system.
- Eliminate Claim 1: The carbon that used to be in the air (abiotic matter) is no longer in the biodome, so the total carbon decreased. This claim can be eliminated because it is not supported by what they learned in the previous lesson.

3. Introduce the Sim activity. Collapse the instructional guide and project the student screen, or have students turn to pages 81–82 in their Investigation Notebooks. Let students know that they will use the Sim to help them figure out what happened to the carbon that used to be in the air of the biodome. Read the instructions aloud.

4. Have students make predictions. Instruct students to predict where they think the carbon went by answering the question on their screens or in their Investigation Notebooks.



5. Students gather evidence in the Sim. Briefly review the Sim instructions and then have students begin the Sim activity. Circulate and assist students as needed. Remind students that energy storage molecules contain carbon, so if they are looking for where the carbon went, they can look for the place where energy storage molecules are increasing. Students may look at this in info view or by looking at the graphs and using the “Graph Molecules” preset.

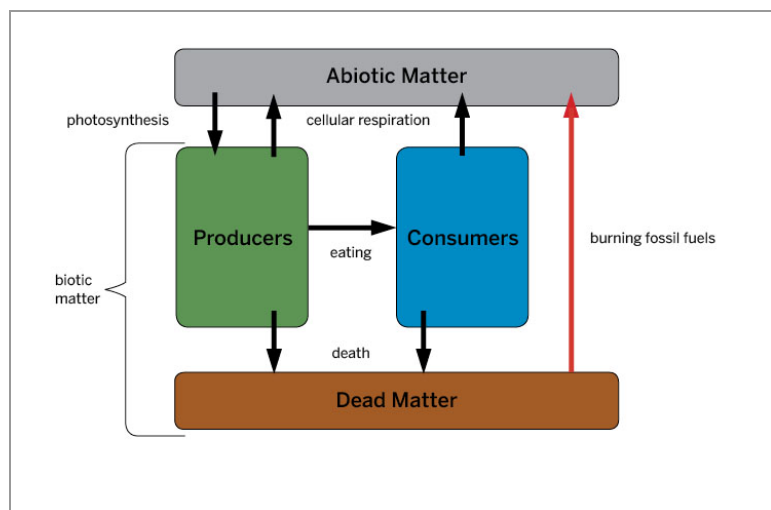
6. Students upload a screenshot or record evidence in their Investigation Notebooks. Ask students to upload a screenshot of the info view or a graph from the Sim that indicates what happened to the carbon that used to be in abiotic matter. If students are using the Investigation Notebook, have them write or draw evidence from the Sim about what happened to the carbon.

7. Debrief the Sim activity.

- Have students share whether their predictions were correct or not and why.
- Ask a volunteer to summarize the evidence gathered. [Carbon dioxide decreased AND energy storage molecules in living things decreased while energy storage molecules in dead matter increased.]
- Point out that without decomposers, the carbon that is stuck in dead matter can’t be transferred back to the abiotic part of the ecosystem. This is because decomposers get energy storage molecules from consuming dead matter, and return the carbon to the air when they do cellular respiration.

If students are using digital devices, ask them to press NEXT.

9. Project the Carbon Cycle diagram. Connect this diagram to the key concepts. Remind students that they saw this diagram in the article, “Carbon in the Global Ecosystem.” Explain that because the total carbon in an ecosystem doesn’t change, it moves between the biotic and abiotic parts of the ecosystem in a continuous and consistent pattern called *the carbon cycle*.



10. Review how the key concepts are related to the biodome problem.



After our activities today and from previous lessons, we know that the total carbon in an ecosystem doesn't change, but it does move from one part of the ecosystem to another. If the amount of carbon in abiotic matter changed, then the amount of carbon in biotic matter must have also changed because the total carbon is shared between the abiotic and biotic parts of the system. In the biodome, we know that the carbon in abiotic matter decreased. Now we know that this means that the carbon in biotic matter must have increased as well. As we just observed in the Sim, this increase in carbon took place in dead matter.

11. See the "See the "Going Further: Linear and Nonlinear Relationships in Sim Data" note in the Teacher Support tab. This note provides guidance for conducting an activity in which students analyze displays of data from the Sim to identify linear and nonlinear relationships.

Teacher Support

Instructional Suggestion

Student Thinking: Clarifying the Sim Activity's Purpose

This Sim activity models what happens in an ecosystem when all the decomposers die, and it's a way to get students to make connections to the biodome problem in which carbon dioxide in the air decreased when the decomposer population decreased. Through the Sim, students will see that when there are no decomposers, the energy storage molecules get stuck in dead matter and without decomposers to break down the dead matter, there is no way that carbon can be returned to the air. Eventually the producers run out of carbon dioxide to do photosynthesis and start to die, leaving no food for the consumers, and they also start to die. When students start to think about the biodome problem, some of them may wonder, "If all the energy storage molecules ended up in dead matter because the decomposers died, then why did the decomposers die? Having a lot of energy storage molecules in dead matter is good for decomposers!" Confirm for students that this is a good line of inquiry. Although the Sim activity provided evidence about what happened to the energy storage molecules in the ecosystem after the decrease in decomposers, it did not explain why the decomposers began to die in the first place. Let students know that in the next activity in this lesson, they will revisit the *Biodome Files* to see if they can find the cause of the decreasing decomposer population.

Instructional Suggestion

Providing More Experience: Looking at the Sim as a Whole-Class Activity

If your students are having trouble figuring out where the carbon that used to be in the abiotic part of the ecosystem went, project the Sim and trace the carbon as a whole class. Run the Sim for 20 time units, then pause the Sim and kill all the decomposers. Play the Sim for an additional 100 time units. The following are some suggestions for highlighting different aspects of this activity:

- In the graph, use the carbon preset to verify that, while total carbon in the ecosystem did not change, the carbon that used to be in abiotic matter is now in biotic matter.
- Close the graph and trace the carbon in energy storage molecules as it moves through consumers, then to dead matter, then decomposers, and then back to the air. Point out that the carbon from the abiotic matter is taken in by producers and made into energy storage molecules.
- After killing all the decomposers, help students notice that the amount of carbon in abiotic matter is decreasing because producers are still taking in carbon dioxide, but there are no decomposers returning carbon dioxide to the air (even though the other organisms are still returning carbon dioxide to the air).



- Eventually, as organisms continue to die, less and less carbon is returned to the air through cellular respiration, and the carbon becomes trapped in dead matter because there are no decomposers to complete the cycling of carbon.
- Switch to the molecules preset in the graph. Explain that this preset can help you track carbon in the ecosystem because it tracks carbon dioxide in abiotic matter and energy storage molecules in biotic matter—both of which are molecules that contain carbon. Point out that carbon dioxide in abiotic matter decreased AND that energy storage molecules in living things decreased while energy storage molecules in dead matter increased.

Instructional Suggestion

Going Further: Linear and Nonlinear Relationships in Sim Data

Students can conduct further analyses of data from the Simulation in order to practice identifying linear and nonlinear relationships and to discover more about the factors related to carbon cycling in ecosystems. Have each pair of students select two variables shown in the Sim's graph that they think might be related to each other (i.e., one variable affects the other). For example, students might choose cellular respiration and carbon dioxide, or biotic carbon and abiotic carbon. Have students use graph paper to set up a new graph with one of their chosen variables as the x-axis and the other as the y-axis. Have them make one change to the populations in the Sim (introducing a change to the simulated ecosystem will produce data that shows the relationship better), and then run the Sim for 50 time units. Finally, have students translate data from the Sim graphs to their own graphs. Guide them to analyze whether their graphs show a linear or nonlinear relationship.

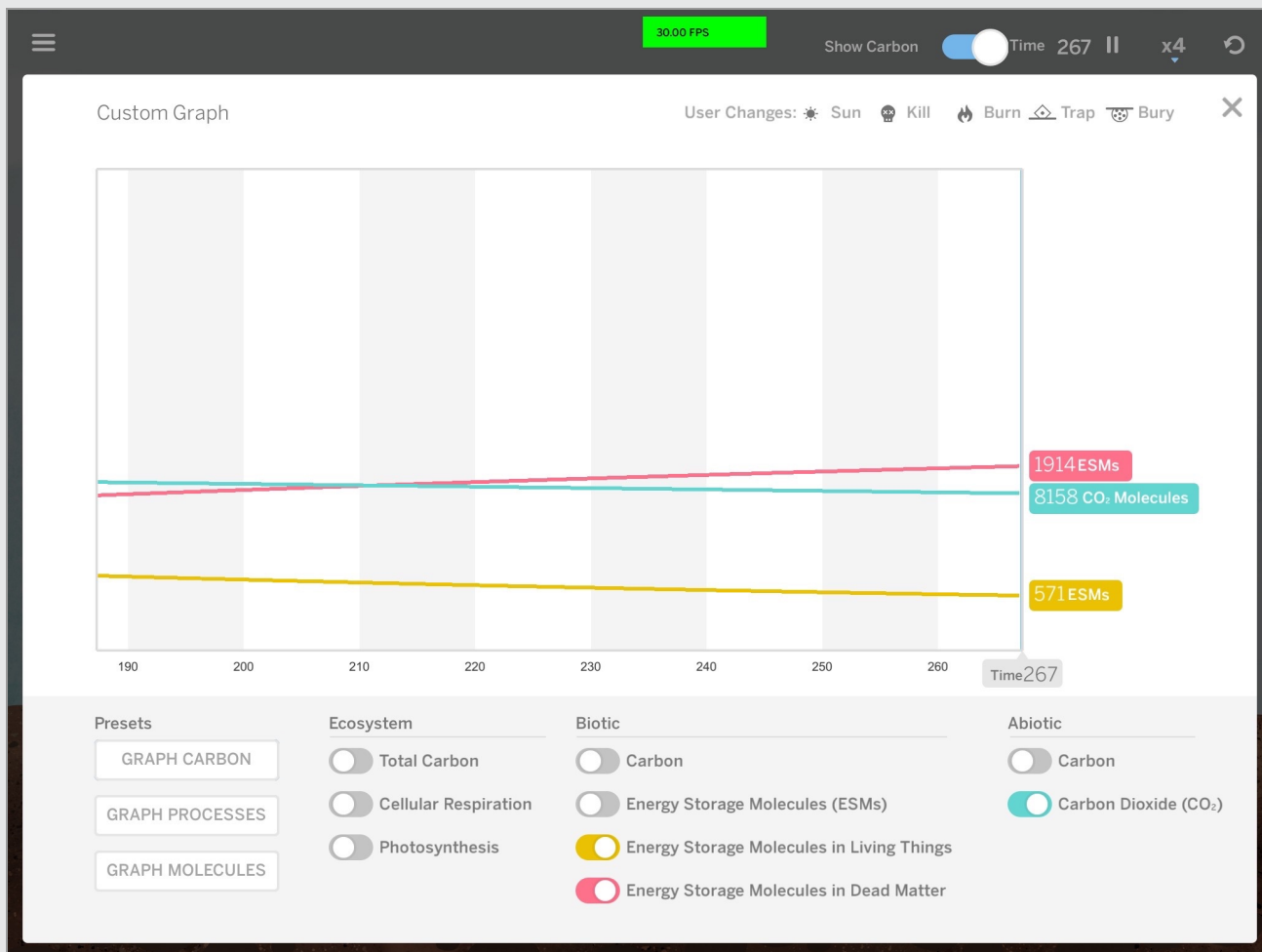
Possible Responses

Was your prediction correct? Explain why or why not.

Answers will vary about whether predictions are right or wrong. The correct prediction is that the carbon is now in the dead matter of the ecosystem.

What students should/might do:

Students should kill all decomposers after running the Sim for 20 time units. Students should then observe where the carbon that used to be in abiotic matter ends up. Students might look in Info view for evidence of where the carbon went. In this view, they should see the number of energy storage molecules in dead matter is increasing and there are fewer energy storage molecules in other parts of the ecosystem. Students might also use the graph to find out where the carbon went. They should use the "Graph Molecules" preset. They should see that energy storage molecules in dead matter increased, while energy storage molecules in living things and carbon dioxide in biotic matter both decreased.

**What students should notice:**

Students should notice that the total amount of carbon in the ecosystem did not change as a result of killing decomposers. They should also notice that the amount of carbon in abiotic matter decreased, while the amount of carbon in biotic matter increased. They should find that this increase in biotic carbon is entirely due to an increase in energy storage molecules in dead matter, and that energy storage molecules in living things actually decreased during this run.



3

READING

Researching the Biodome Files



Researching the Biodome Files



Students use *The Biodome Files* to find evidence for why the decomposer population declined in the biodome.

Instructional Guide

1. Introduce purpose of revisiting the *Biodome Files*. Collapse the instructional guide and project the student screen, or have students turn to page 83 in their Investigation Notebooks. Read the message from Dr. Corry aloud and then review the instructions for the activity.

 As we saw in the Sim, when the population of decomposers decreased, the amount of energy storage molecules in dead matter increased. This evidence suggests that the carbon in the biodome may have ended up in dead matter, where producers couldn't use it to make energy storage molecules, but this doesn't explain why the decomposers died in the first place. Dr. Corry wants us to review the *Biodome Files* to see if we can find a possible explanation.

2. Students review the *Biodome Files* and discuss the evidence. Circulate and assist students as needed. If students need more guidance as to how to manage this large set of texts, the following are some things you can suggest to them:

- **Start by looking at the files where Dr. Corry left notes.** They can discuss the notes with their partners, and decide which ideas are helpful for understanding what happened to the decomposers. From there, they can read those files in more depth and annotate any evidence they find.
- **Split up the chapters of the *Biodome Files* and divide the work.** When they finish looking at their parts, share what they found with their partners.

3. Have students write a claim. After they have read and discussed the *Biodome Files* with their partners, remind students to make a claim and describe their evidence on their screens or in their Investigation Notebooks.

4. Have a whole-class discussion. Ask volunteers to share claims about what happened to decomposers. Some students may mention that no worms in the biodome meant decomposers could not break down dead matter. Others may focus on dead matter being buried too deep, so decomposers could not access it. Both causes would result in death of decomposers due to them not being able to get enough energy storage molecules. Either response is acceptable, and discussing and making connections between these ideas will benefit all students. If time permits, also make connections back to the carbon in the ecosystem and the problem with energy storage molecules in the biodome.



5. Highlight stability and change, and the effect of a small change. Point out that what might seem like a fairly small change to the ecosystem had a huge effect causing the whole ecosystem to become unstable.

6. Point out the homework (Activity 4 or page 84 in the Investigation Notebook). Explain that for homework students will use the Sorting Tool to reflect on what they've learned about carbon in an ecosystem. If students do not have access to Amplify Science at home, adjust your schedule to make time to complete the Sorting Tool activity in class.

Teacher Support

Background

Science Note: The Importance of Worms as Decomposers

Worms and other small animals (e.g., pill bugs, dung flies, and millipedes) are special types of decomposers, known as physical decomposers or detritivores. Detritivores must ingest dead matter and break it down into smaller pieces in order to get nutrients and energy. This process also makes the dead matter more accessible to other types of decomposers, such as bacteria and fungi, which can break down cells of other organisms using biochemical reactions without need for internal digestion. The *Biodome Files* refer to a lack of worms included with the original organisms. Without worms and other physical decomposers, the dead matter is too hard for the bacterial and fungal decomposers to break down. The lack of worms, in conjunction with the burying of the dead matter (making it inaccessible) both contributed to the decrease in the decomposer population. Some students read about worms or bugs in the *A Feast for Decomposers* article set, but all students will not have read this. You may wish to plan a little extra time to clarify this with students or suggest that they revisit this article for more information.

Possible Responses

A. The decomposer population could have decreased for two reasons. First, the dead matter was buried too deep for decomposers to access, and second, there were no worms in the biodome to break down dead matter so it could be accessible to other decomposers.

B. My evidence includes information from one of the sticky notes that states that bacteria need worms to break dead matter into smaller pieces so bacteria can feed on it. One of the sticky notes also states that dead matter and garbage were buried, but many decomposer bacteria can't survive below six feet. The job assignment duties say that dead matter was buried in sealed trash bags, which makes it difficult for decomposers to get to their food.



4

HOMEWORK

Homework



Homework

Students use the Sorting Tool to help them reflect on what they've learned about carbon in an ecosystem.

Instructional Guide

1. If needed, make additional time to introduce the homework. If students do not have access to Amplify Science at home, adjust your schedule to make time to complete the Sorting Tool activity in class.

Possible Responses

Modeling Tool Response

A possible proficient response is shown below. Since the total amount of carbon in a closed ecosystem does not change, and the amount of carbon in abiotic matter and living organisms decreased, then the amount of carbon in dead matter would have increased.

Explain why you think this diagram shows what happened to the carbon in the biodome.

The diagram started with a decrease in carbon in the atmosphere and a decrease in carbon in living things. Since I learned today that the total amount of carbon in an ecosystem stays the same, this means that carbon in the biodome must have increased somewhere else. Based on this diagram, the only place for the carbon to go is into dead matter. While the amount of carbon in abiotic matter and carbon in living things decreased, the amount of carbon in dead matter in the biodome must have increased.



Hand In

Instructions

Reset

Undo

Redo

Show what happened to the amount of carbon in different parts of the biodome ecosystem.

total carbon in ecosystem

carbon in abiotic matter

carbon in living things

producers

primary consumers

secondary consumers

decomposers

carbon in dead matter

↑
increased

↓
decreased

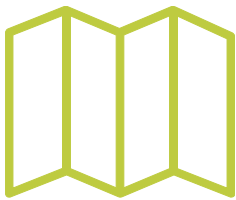
=
stayed the same

↓
decreased

↑
increased

=
stayed the same





Lesson 3.4

Explaining What Happened in the Biodome



Lesson at a Glance

ACTIVITY

1

Warm-Up (5 min)

The Warm-Up activates students' prior knowledge and promotes thinking about cause-and-effect relationships.



WARM-UP

2

Cause and Effect in the Biodome (20 min)

Students practice causal thinking as they review the evidence about the biodome in preparation for making a model that will depict their final explanation.



SORTING TOOL

3

Biodome Model (15 min)

Students demonstrate their understanding of the key concepts by applying them to their explanations of the biodome problem. The teacher uses this opportunity as another On-the-Fly Assessment of students' understanding of how carbon moves through an ecosystem.

MODELING
TOOL

T

What's New at Biosphere 2 (5 min)

Students watch a video about the current research on ecosystems happening at Biosphere 2.



TEACHER

4

Homework

Students get a chance to reflect on the unit by making a recommendation to the Econauts about how to plan their next biodome experiment.



HOMEWORK

5

Family Homework Experience (Optional)

Explaining biodomes to a member of their household supports student learning through shared experiences with family.



HOMEWORK



6

Self-Assessment (Optional)

Students check their understanding of key content in the unit, and are given a chance to reflect on additional questions they have about ecosystems.



HOMEWORK

**DIGITAL RESOURCES**

Video: New Research at the Biosphere

Matter and Energy in Ecosystems Investigation Notebook, pages 85–90

Biodome File 1: News Stories

Printable article: "Biodome Files 1: News Stories"

Family Homework Experience: Explaining Biodomes at Home
copymaster

Hands-On Flexextension lesson guide: Biodome Design Challenge

Hands-On Flexextension copymaster: Biodome Design Challenge

Matter and Energy in Ecosystems Glossary

Matter and Energy in Ecosystems Multi-Language Glossary



1

WARM-UP
Warm-Up

Warm-Up



Students activate their prior knowledge of cause and effect by thinking through an everyday example.

Instructional Guide

1. Project Warm-Up; students work independently. Collapse the instructional guide and project the student screen, or have students turn to page 86 in their Investigation Notebooks. Allow a few minutes for students to individually respond to the Warm-Up.

2. If using digital devices, remind students to press HAND IN when they finish working. By pressing HAND IN and reloading their screens, students can see their completed models.

Possible Responses

Left to right:

1. Quincy stayed up late, so . . .
2. Quincy overslept, so . . .
3. Quincy missed the bus, so . . .
4. Quincy was late to first period.



2

SORTING TOOL

Cause and Effect in the
Biodome



Cause and Effect in the Biodome



Students complete a cause-and-effect card sort with a partner while explaining how one thing led to another in the biodome.

Instructional Guide

1. Lead a brief discussion of the Warm-Up. Invite students to share their ideas about what caused Quincy to be late to his first period class. Emphasize that a cause may have more than one effect and that an effect may have more than one cause. Point out that some things can be considered to be both a cause and an effect.

2. Introduce another Sorting Tool activity. Relate the Warm-Up to the biodome by explaining that students will work in pairs to complete a cause-and-effect analysis for the Econauts.



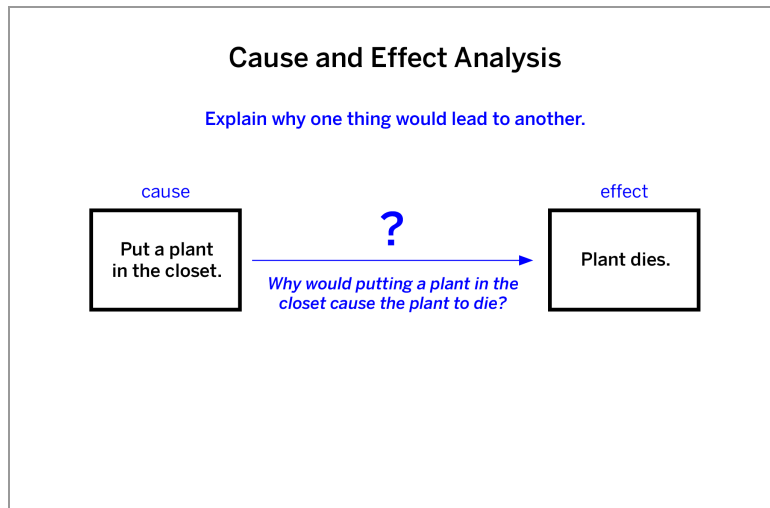
Today you're going to explain to the Econauts how events in the biodome caused the plants and animals to not have enough energy storage molecules.



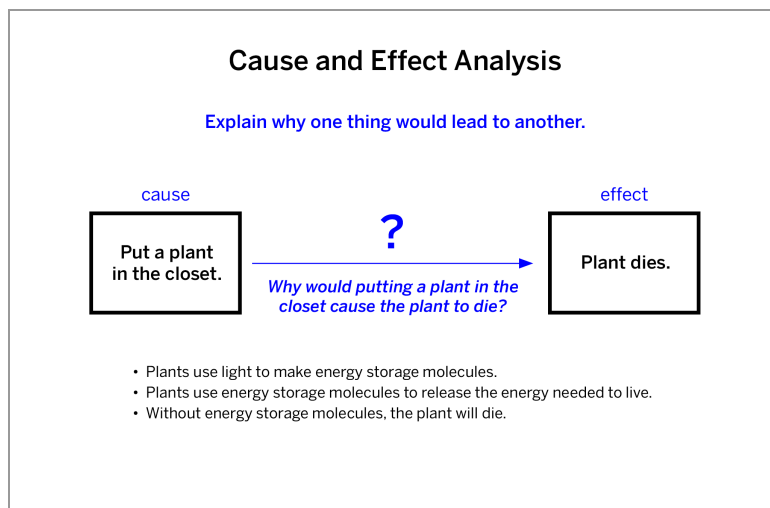
The causes and effects you will think about involve interactions among organisms and between organisms and the abiotic environment. Although the species involved vary across ecosystems, the patterns of interactions are the same. Consider what you've learned about these interactions from the sim, the articles you have read, and other sources to order events and show which things you think caused other things to happen in the biodome.



3. Project and discuss cause-and-effect example. Ask student pairs to briefly discuss what ideas would help someone understand why putting a plant in the closet would cause the plant to die. Ask a few students to share their ideas with the class.



4. Project and discuss cause-and-effect example explained. Point out the key ideas that help explain why putting a plant in the closet will cause it to die.



5. Project *Matter and Energy in Ecosystems* Sorting Tool activity: **Cause and Effect in the Biodome.** Explain that different events in the biodome are displayed on different cards. In pairs, students should decide the order of these causes and effects by placing them next to each other. Prepare students to successfully complete this activity with the following suggestions:

**The first cause and last effect are given.**

We know that Econauts buried the dead matter and we know that the biodome experiment had to end early because the plants and animals were not getting enough energy storage molecules. Our job is to help the Econauts understand the cause-and-effect relationship between these events.

**Begin with a cause and work forward to the effect.**

One strategy is to start with the first cause. In that case, I might say to my partner, “The Econauts buried dead matter, what did that cause?” We could get started by discussing the role that dead matter plays in an ecosystem. My next step might be to rule out the cards that don’t have anything to do with burying dead matter. For instance, I don’t think burying dead matter has anything to do with a decrease in photosynthesis, so I can rule that card out.

**Begin with an effect and work back to the cause.**

Another strategy is to start with the last effect. In that case, I might say to my partner, “Why did the plants and animals not have enough energy storage molecules?” Remember, that this is the question we started with in Chapter 1, so my partner and I will want to retrace our steps. The questions and key concepts posted on the wall might be a good guide to use if I work back from the last effect.

**Emphasize importance of discussion.**

Whether you are working forward or backward, it will be helpful to talk with your partner about why one thing caused another thing to happen. Even if you think you know the order of these causes and effects, talking about why something happened is a good way to check your ideas.

6. Collapse the instructional guide and project student screen, or have students turn to page 87 in their Investigation Notebooks, and draw attention to Word Bank. Encourage students to use these words as they discuss with their partners. Explain that these words will be projected during the activity so students can refer to them. Remind students that these words are also posted on the classroom wall.

7. Students complete card sort in pairs. Circulate and offer assistance as needed. Make sure that students are talking through their answers with their partners.

8. If using digital devices, remind students to press HAND IN and to reload their Amplify Science screens to see the screenshot of their completed models.

Teacher Support

Rationale

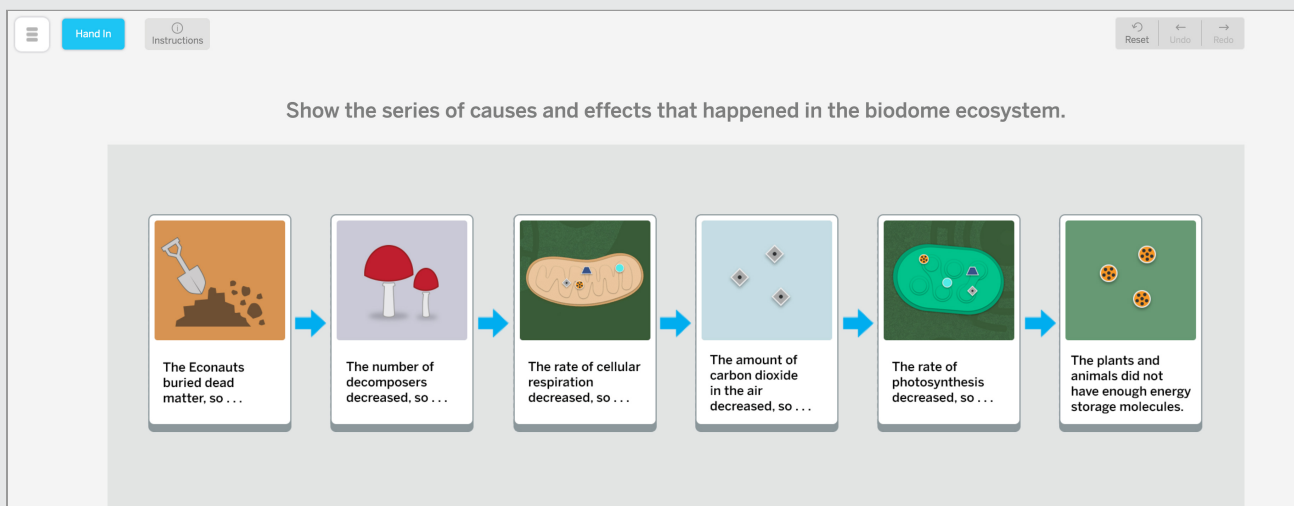
Pedagogical Goals: Omitting a Cause—Absence of Worms in the Biodome

Students may have identified the absence of worms in the biodome as a potential cause of the decrease in the decomposer population when reading the *Biodome Files* in Lesson 3.3. However, for simplicity in this lesson, the lack of worms has been omitted from the Cause and Effect Sorting Tool. For students with developing causal thinking skills, it is easier to reason through a causal chain that begins with a single cause, rather than distributed causation. If students



bring up that this cause is missing from the activity, confirm that the absence of worms may have also contributed to the collapse of the biodome, but suggest that they focus on buried dead matter as the main cause for the purposes of this cause-and-effect analysis.

Possible Responses





3

MODELING TOOL
Biodome Model

Biodome Model



Students create a model of the biodome ecosystem that shows how carbon moves from one part of the ecosystem to another.

Instructional Guide

1. Introduce the Modeling Tool activity: Biodome Model. Collapse the instructional guide and project the student screen, or have students turn to page 88 in their Investigation Notebooks. Explain that students will be making a model of the entire biodome ecosystem in order to show the Econauts what happened to the carbon that used to be in the air.

2. Connect previous activity, Cause and Effect in the Biodome, to upcoming Biodome Model activity. Establish that both of these are important pieces of students' final explanation for the Econauts.



In the last activity, you connected causes and effects to show the way one thing led to another in the biodome. However, in order for the Econauts to understand how these causes and effects can happen, they need to see how the movement of carbon connects the different parts of an ecosystem.

3. Review instructions as a class. Make sure students know that they should include the processes as part of their models. If necessary, project the Modeling Tool and provide a quick demonstration to remind students how to use the process editor.

4. Students work individually to construct their models. Circulate and offer assistance as needed.

5. On-the-Fly Assessment: Modeling Carbon in an Ecosystem. For further suggestions on how to support student understanding of how carbon moves in an ecosystem, press the hummingbird icon and select ON-THE-FLY ASSESSMENT 11.



Embedded Formative Assessment

On-the-Fly Assessment 11: Modeling Carbon in an Ecosystem

Look for: In students' final models for this unit, look for submissions that comprehensively depict how carbon moves through the different parts of an ecosystem. Students should show that the abiotic and biotic parts of an ecosystem are connected by the continual movement of matter between levels. They can show this with carbon dioxide arrows moving into producers and out of all trophic levels. Additionally, students should use the process editor to show how carbon dioxide is used to make energy storage molecules through photosynthesis and how energy storage molecules are used to make carbon dioxide through cellular respiration. Students should also show how carbon (in energy storage molecules) moves within the biotic part of an ecosystem as organisms eat each other or die and become dead matter. By evaluating students' work for this level of understanding, you can get a sense of students' comfort level and ability to track the flow of matter through an ecosystem. An example of a proficient model can be found under the Possible Responses tab.

Now what? As the final, cumulative model of the unit, this is a good opportunity to identify gaps in understanding that can be reviewed prior to the End-of-Unit Assessment. Depending on the identified concepts targeted for review, different materials from the unit can be useful tools. You can use the visual representation of photosynthesis from Chapter 1 to review how carbon is brought into biotic matter through photosynthesis, producing energy storage molecules. The *Snail and Elodea* video from Chapter 2 will help you review that all organisms give off carbon dioxide, even in the dark. The Sim offers a rich environment for exploring and testing relationships about specific interactions, including the relationships between trophic levels and the factors that affect the direction and rate of carbon movement in an ecosystem. The graphs in the Sim can be particularly useful for demonstrating that carbon is never produced or used up, even though its relative abundance in different parts of the ecosystem can change.

Teacher Support

Instructional Suggestion

Going Further: Developing Models

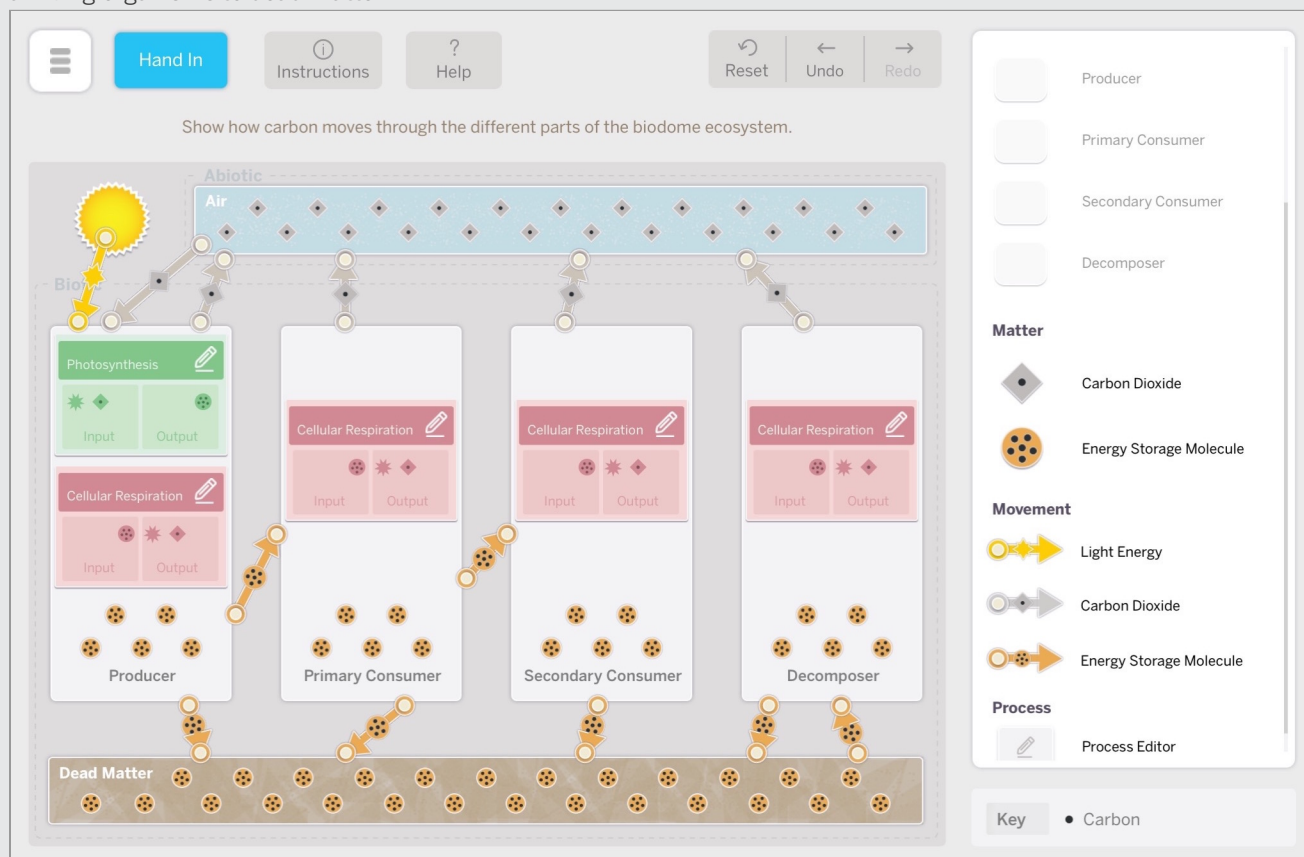
A biodome is a model of an ecosystem. Give students the opportunity to imagine making their own physical models of an ecosystem in order to learn more about matter and energy in an ecosystem. Ask them to describe the model ecosystem that they imagine: What would it be made of? What would it include? How would it be different from and similar to a real ecosystem? Ask them to describe what kind of data they might gather from their models.

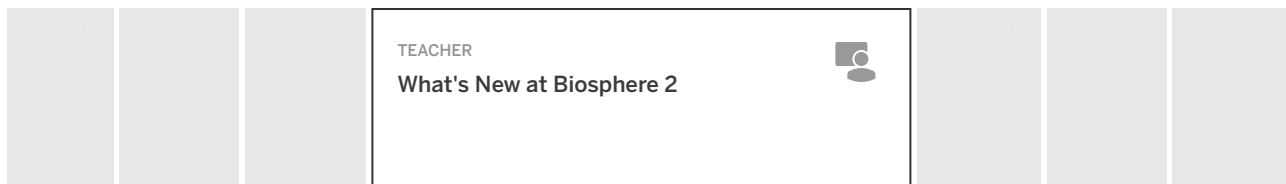


Possible Responses

Modeling Tool Response

A possible proficient model is shown below. The model shows that abiotic matter contains carbon dioxide and that biotic matter (both living organisms and dead matter) contains energy storage molecules. The model shows that producers make energy storage molecules during photosynthesis, using energy from the sun, and that all living organisms give off carbon dioxide during cellular respiration. Energy storage molecules transfer from producers to primary consumers, from primary consumers to secondary consumers, from dead matter to decomposers, and from all living organisms to dead matter.





What's New at Biosphere 2



The teacher plays a short video about current research on ecosystems at Biosphere 2.

Instructional Guide

1. Introduce the video. Remind students that they watched a video about Biosphere 2 at the beginning of the unit. Explain that they will now watch a video about research that is currently taking place at Biosphere 2.

 Remember that the biodome we have been investigating is based on a real biodome experiment called Biosphere 2. That biodome still exists and many scientists take advantage of its closed environment to do experiments. You will now watch a video that highlights some of this current research.

2. Play the video. Collapse the instructional guide and project the video, using the play button at the bottom of the screen.

3. Lead a brief class discussion of the video. Invite students to share their reactions to the video.

4. Point out the homework assignment (Activity 4 or page 89 in the Investigation Notebook). If students do not have access to Amplify Science at home, provide them with copies of page 89 from the Investigation Notebook. Inform students that they will make a recommendation to the Econauts about how their plans for their next biodome should be different. Encourage students to refer to their cause-and-effect analyses and to their models of carbon in the biodome as they write.

 As you write your recommendations, use the cause-and-effect analysis to think about what the Econauts could have done differently to prevent the last biodome experiment from running into problems. Refer to your model of carbon in the biodome to help the Econauts understand how your recommendation will help prevent these same problems from happening again in the next biodome.

5. Optional: Point out the Family Homework Experience to students (Activity 5). Let students know that they will explain biodomes to a family member. If students do not have access to Amplify Science at home, provide each of them with a copy of the Family Homework Experience: Explaining Biodomes at Home student sheet and a copy of the article "Biodome File 1: News Stories."



6. Optional: Point out the Self-Assessment (Activity 6 or page 90 in the Investigation Notebook). If students do not have access to Amplify Science at home, provide them with copies of page 90 from the Investigation Notebook. Remind students that in order to reflect on their own learning, they will revisit these questions at the end of every chapter.

Teacher Support

Rationale

Pedagogical Goals: Understanding the Nature of Science

One goal set forth by the Next Generation Science Standards (NGSS) is for students to understand the nature of science as a discipline and how scientific knowledge develops over time. The NGSS calls out eight understandings about the nature of science, which are woven throughout the Amplify Science curriculum. This activity gives students an opportunity to experience the understanding that Scientific Investigations Use a Variety of Methods. Specifically, the video, *New Research at the Biosphere*, illustrates the idea that science investigations use a variety of methods and tools to make measurements and observations.



4

HOMEWORK
Homework

Homework

Students write a recommendation to the Econauts about what should be different in their next biodome experiment.

Instructional Guide

1. If needed, make additional time to explain the homework. If students do not have access to Amplify Science at home, provide them with copies of page 89 from the Investigation Notebook.

Teacher Support

Instructional Suggestion

Homework: Writing Explanations in Class

Although this lesson does not provide time for students to write their recommendations to the Econauts in class, you may wish to set aside some time for writing at the beginning of the next lesson. This writing assignment is potentially challenging because it involves applying the key concepts from across the unit and interpreting the cause-and-effect analysis and the model of the biodome in order to make a suggestion. Since this is the final opportunity for students to apply the content of this unit in the familiar context of the biodome before switching to a new and different context in the Science Seminar, it may be worthwhile to provide extra time for students to do this writing in the supportive environment of the classroom.

Possible Responses

Explain to the Econauts how their plans for the next biodome should be different.

The Econauts should not bury the dead matter in their next biodome. Burying dead matter causes problems for an ecosystem because it makes it impossible for decomposers to get energy storage molecules from dead matter. When decomposers cannot get energy storage molecules, they die off, and this reduces the amount of carbon dioxide given off by cellular respiration. A decrease in carbon dioxide in the air (part of the abiotic matter in the ecosystem) will cause a decrease in photosynthesis, because the carbon in carbon dioxide is required for producers to make energy storage



molecules. This means there will be less carbon in the biotic matter of the ecosystem. Once producers start making fewer energy storage molecules, the organisms in the ecosystem will not have enough energy storage molecules, so they will stop growing and reproducing. This is what happened in the last biodome. This outcome can be avoided in the next biodome if the Econauts let the dead matter get broken down by decomposers. The biodome's problems are an example of how all the parts of an ecosystem are connected and changes to one part of the system affect all the other parts.



5

HOMEWORK

Family Homework
Experience (Optional)

Family Homework Experience (Optional)

Students have a chance to explain biodomes to a member of their household.

Instructional Guide

1. If needed, make additional time to explain the optional Family Homework Experience. If students do not have access to Amplify Science at home, provide each of them with a copy of the Family Homework Experience: Explaining Biodomes at Home student sheet and a copy of the article “Biodome File 1: News Stories.”

Teacher Support

Rationale

Pedagogical Goals: Purpose of the Family Homework Experience

This homework activity is designed to give students the opportunity to explain to a member of their household what they have learned during the unit. This activity can encourage interaction and discussion between students and their families around science concepts—this has been found to be beneficial for student learning.

Possible Responses

1. Record one question they asked you:

Answers will vary.

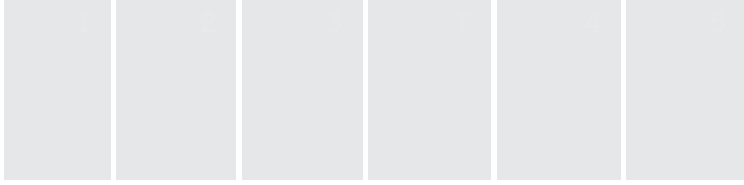
2. Record your answer to their question:



Answers will vary.

3. Have the family member write a few sentences summarizing what they understood from your explanation.

Answers will vary.



6

HOMEWORK

Self-Assessment
(Optional)

Self-Assessment (Optional)

This optional homework provides a chance for students to reflect on their learning so far.

Instructional Guide

1. If needed, make time to introduce this optional homework assignment. If students do not have access to Amplify Science at home, provide them with copies of page 90 from the Investigation Notebook.

Teacher Support

Assessment

Student Self-Assessment: Reflecting on the Unit

This is the third of four student self-assessments (one at the end of every chapter), which invites students to reflect on their progress in the unit. To gain insight into students' thinking at this point in the unit, review their responses and questions.

Possible Responses

Answers will vary. This is a self-reflection.





Chapter 4

Science Seminar



Chapter Overview

Chapter Question

Why does deforestation lead to increased carbon dioxide in the air?



Chapter 4 Activities

Lesson 4.1: Analyzing Claims and Evidence

1 Warm-Up	WARM-UP	
2 Discussing Claims	STUDENT-TO-STUDENT DISCUSSION	
3 Analyzing Evidence	READING	
4 Sorting Evidence	STUDENT-TO-STUDENT DISCUSSION	
5 Homework	HOMEWORK	

Lesson 4.2: Science Seminar

1 Warm-Up	WARM-UP	
2 Preparing for the Science Seminar	STUDENT-TO-STUDENT DISCUSSION	
T Introducing the Science Seminar	TEACHER	
3 Participating in the Science Seminar	STUDENT-TO-STUDENT DISCUSSION	
4 Homework	HOMEWORK	

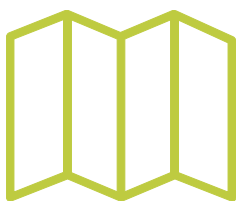
Lesson 4.3: Writing a Scientific Argument

1 Warm-Up	WARM-UP	
2 Using the Reasoning Tool	STUDENT-TO-STUDENT DISCUSSION	
3 Organizing Ideas in the Reasoning Tool	TEACHER-LED DISCUSSION	
4 Writing a Scientific Argument	WRITING	
5 Homework	HOMEWORK	
6 Self-Assessment (Optional)	HOMEWORK	

Lesson 4.4: End-of-Unit Assessment

1 Multiple-Choice Questions	CLASS	
2 Written-Response Question #1	CLASS	
3 Written-Response Question #2	CLASS	





Lesson 4.1

Analyzing Claims and Evidence



Lesson at a Glance

ACTIVITY

1

Warm-Up (5 min)

After students are introduced to the term *deforestation*, they activate prior knowledge by thinking of reasons that people might need to clear trees from land.



WARM-UP

2

Discussing Claims (10 min)

As students prepare to understand the available evidence, they first discuss the two claims about deforestation leading to increased carbon dioxide.

STUDENT-TO-
STUDENT
DISCUSSION

3

Analyzing Evidence (10 min)

Students do a deep dive with the evidence cards—read, annotate, and discuss—in order to come to full understanding.



READING

4

Sorting Evidence (20 min)

Students sort, coordinate, and discuss pieces of evidence in order to decide how the evidence relates to the claims.

STUDENT-TO-
STUDENT
DISCUSSION

5

Homework

Students reflect on the evidence analysis by choosing the claim they think is best supported by evidence.



HOMEWORK



DIGITAL RESOURCES

Video: Activity: Science Seminar

Science Seminar Claims
copymaster

Science Seminar Evidence Cards
A–D Copymaster

Matter and Energy in Ecosystems
Investigation Notebook, pages
92–97

Matter and Energy in Ecosystems
Glossary

Matter and Energy in Ecosystems
Multi-Language Glossary



1

WARM-UP
Warm-Up



Warm-Up

Students are introduced to the term *deforestation* and think of reasons that people might need to clear trees off land.



Instructional Guide

1. Project Warm-Up; students work independently. Collapse the instructional guide and project the student screen, or have students turn to page 93 in their Investigation Notebooks. Allow a few minutes for students to individually respond to the Warm-Up.

Possible Responses

Why might people want to remove all the trees from an area of land? List two or three reasons.

Answers will vary, but could include things like making room for crops, livestock, or building houses.



2

STUDENT-TO-STUDENT
DISCUSSION

Discussing Claims



Discussing Claims

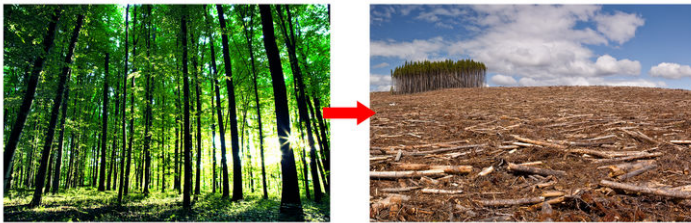
The teacher introduces the claims and question for the Science Seminar.



Instructional Guide

1. **Have students share ideas about why land would be cleared of trees.** Call on student volunteers to share their ideas from the Warm-Up.
2. **Project *Deforestation* and review its definition aloud.** Deforestation is when all the trees in an area are cut down or burned.

Deforestation



Deforestation happens all over the globe. Like burning fossil fuels, it can create an increase in carbon dioxide in the air, which we know can affect all the ecosystems on Earth. Deforestation occurs to create space for farmland and expanding cities, while the trees are used for building and fuel.



3. Project and read aloud the message from Dr. Corry. Make a connection between the new problem and what students have been learning about carbon and energy in ecosystems.



To: Student Ecologists
From: Dr. Bryan Corry
Subject: A New Problem

Thanks to your hard work, the mystery of the biodome has been solved. The Econauts are very happy with the results of your investigation.

Now I need your help with a new problem. I was contacted by a group of farmers who are trying to understand how cutting down the trees in their area—deforestation—has increased carbon dioxide in the air. They know that increased carbon dioxide and global climate change are related, and they want to understand more about this so they can take steps to fix the problem. I've sent some claims and evidence for you to look through. I look forward to hearing your ideas.

Bryan
Dr. Bryan Corry, Head Ecologist
Biodome Investigation Team

 Dr. Corry has sent you a new problem, along with some evidence and claims, to investigate. You've been learning about how energy storage molecules are made and used through the two processes—photosynthesis and cellular respiration—as well as how carbon moves through different parts of an ecosystem. As you look at the evidence Dr. Corry sent, it's important to keep in mind all that you have learned throughout the unit.

4. Review the goal for today. In order to figure out exactly how the carbon dioxide is increasing in the atmosphere, let students know that they will spend the class time today looking at the claims and evidence. In upcoming lessons, they will then discuss their ideas (the Science Seminar) and write scientific arguments.

5. Introduce the Science Seminar Question and each claim. Point to the question and claims written on the board. Call on student volunteers to read the question and each claim.

6. Direct students to work in pairs to discuss Claim 1. Collapse the instructional guide and project the student screen, or have students turn to page 94 in their Investigation Notebooks. Explain that it's important to understand what each claim is stating before they look at evidence. Have students read Claim 1, look at the diagram, and then discuss the prompt with their partners. Circulate and assist students. Remind students to refer to the key concepts posted on the classroom wall, as needed.

7. Direct students to work in pairs to discuss Claim 2. After a few minutes discussing Claim 1, remind students to move on and discuss Claim 2.



Teacher Support

Instructional Suggestion

Environmental Principles and Concepts: Deforestation

To help students understand how the process of making decisions about resources and natural systems and how the assessment of social, economic, political, and environmental factors has changed over time, have students complete a research project about deforestation. You may wish to focus students on a particular region, for example, how forestry regulations have changed in the state of California. Students could research how cutting down trees in California has changed from the 1800s to present day and create a timeline. You may choose to have students research how political decisions (e.g., the Clean Air and Clean Water Acts, Endangered Species Act, or the Forest Practice Act of 1973) have changed forest protection. Then, as a class, students can discuss what may have influenced the decisions made a long time ago, which caused problems in the ecosystems—and why people decided to restore the ecosystems more recently. You may also want to discuss how social, economic, political, and environmental factors continue to play a role in managing ecosystems and could point to other examples where social, economic, or political concerns still outweigh environmental concerns. Furthermore, consider discussing a local environmental issue, and how social, economic, political, and environmental factors are at play in making decisions about it.

Possible Responses

Partner discussions will vary.



3

READING

Analyzing Evidence



Analyzing Evidence



Students read the evidence and annotate the cards so they understand each before determining how the information relates to the claims.

Instructional Guide

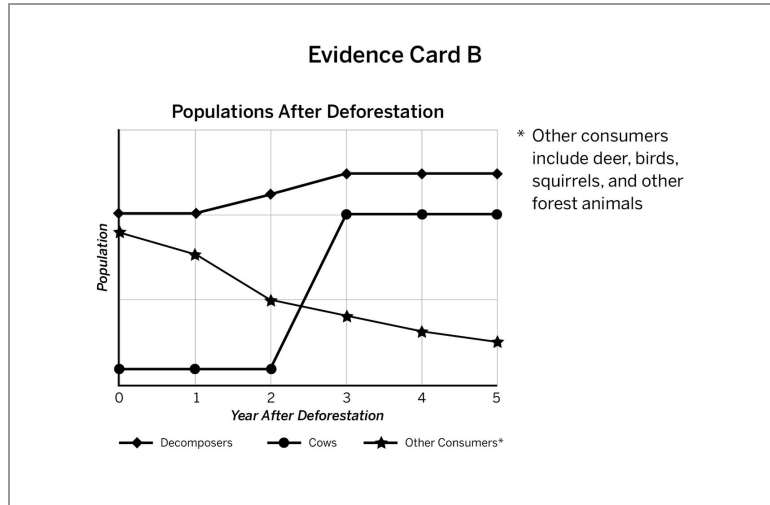
1. Introduce the evidence-analysis activity. Explain that in a moment, students will be given evidence about what happened after the trees were cut down. Students should review each piece of evidence thoroughly, making annotations on each card that will help them think about why deforestation causes carbon dioxide to increase. Let students know that they should consider the following while annotating the evidence cards:

- questions about the evidence itself
- how the evidence is connected to carbon, photosynthesis, cellular respiration, and energy storage molecules in ecosystems
- how the evidence helps explain deforestation

Point out that students have these instructions on their screens or on page 95 in their Investigation Notebooks.



2. Project Evidence Card B and demonstrate how to annotate a card.



Looking at Evidence Card B, I see it's giving me data about populations. I can see that the cow population increased over time, I see that other types of consumers decreased a lot and decomposers increased slowly over time. That seems curious to me. Why would decomposers increase? I am not really sure at this point, so I am going to write that question on this card.

3. Distribute one set of evidence cards to each student. Hold the question and claims sheet for now. Let students know that they will get a chance to sort the evidence based on which claim they go with at a later time.

4. Students read and annotate cards independently. Let them know that they will have time to discuss the cards with a partner in a few minutes, but that right now they just be trying to understand the evidence cards on their own.

5. Project discussion questions and have pairs discuss evidence cards. Collapse the instructional guide and project the student screen, or have students refer to the partner discussion questions in their Investigation Notebooks. The discussion questions will help students in reviewing the evidence. Circulate and assist pairs as needed.



4

STUDENT-TO-STUDENT
DISCUSSION

Sorting Evidence

Sorting Evidence



Pairs consider how each piece of evidence connects to the claims.

Instructional Guide

1. Explain the purpose of sorting evidence. Tell students that in a few moments they will work with a partner to consider how the evidence cards connect to the claims and then decide which claim is best supported by the evidence.

2. Distribute one question and claims sheet to each student. Explain that partners will be discussing their ideas, but each student will sort their own evidence cards under their own Science Seminar Question and Claims sheet. Briefly review the claims.

3. Project the student screen, or have students turn to page 96 in their Investigation Notebooks, and read the instructions. Highlight the following important points:

- Place each evidence card under the claim it supports or goes against.
 - If the evidence supports a claim, write "Supports Claim [1 or 2]" on that card.
 - If the evidence refutes a claim, write "Goes Against Claim [1 or 2]" on that card.
 - If the evidence connects with another evidence card, write "Connects with Evidence Card [A, B, C, or D]" on that card.
- As pairs sort the cards, remind them to discuss their reasons for the placement of each card.
- Students don't have to agree about the placement of the evidence cards, as long as they discuss their reasoning.

4. Pairs sort evidence cards. Direct partners to discuss each piece of evidence, and then decide if it supports or goes against any of the claims.

5. Distribute an envelope with two paper clips to each student. Instruct students to clip the evidence cards to the claims sheet and place everything inside the envelope.

6. Class discussion. Have several students briefly share which evidence supports each claim. Are there any pieces of evidence that go together? Students don't need to state which claim they support at this time.



7. Collect students' envelopes. These will need to be reused for the upcoming two lessons in the Science Seminar sequence.

8. Point out the homework assignment to students (Activity 5 or page 97 in the Investigation Notebook). If students do not have access to Amplify Science at home, provide them with copies of page 97 from the Investigation Notebook.

Teacher Support

Rationale

Argumentation: Discussing the Evidence

After students discuss and sort the evidence cards, there is a brief whole-class discussion about which pieces of evidence support or go against each claim. It is important to avoid discussing which claim is best supported by the evidence; instead, focus on how the evidence cards relate to the claims and whether multiple cards can be used together to support or go against a claim. For homework, students will select a claim, and then discuss their choices with the class during the next lesson. We've found that having students share their claim choices ahead of the Science Seminar can sometimes skew that discussion, as some students prematurely switch claims after learning what others have chosen.

Background

Argumentation: Supporting the Evidence Sort

The following descriptions for each evidence card indicate how that evidence might be used to support the claims. Suggestions for supporting student thinking around claims and evidence are included. Note that much of the evidence was designed to promote student discussion and is open to interpretation.

Evidence Card A:

- Supports Claim 1 because it shows the tree population drastically decreased.
- Combined with Card C (one tree makes more energy storage molecules in one year than one grass plant), one can infer that since the tree population decreased, the amount of photosynthesis decreased even though the grass population increased, because one tree does more photosynthesis than one grass plant. This would cause an overall increase in carbon dioxide since photosynthesis removes carbon dioxide from the air.



- On the other hand, students could use this card in support of Claim 2 because it shows that the population of trees decreased. Since trees do cellular respiration, they might infer that trees do more respiration than grass, so the rate of cellular respiration went down because there were fewer trees.

Support students' thinking with the following prompts:

- Do you think photosynthesis or cellular respiration would be more affected by the population changes you see in the graph? Why?
- How would the decrease in tree population affect photosynthesis (or cellular respiration)?
- How would the increase in grass population affect photosynthesis (or cellular respiration)?
- How would the amount of carbon dioxide in the air be affected?
- How can this card be connected to another evidence card to better support the claim?
- What more might you want to know about this evidence to help you connect it to a claim?

Evidence Card B:

- Supports Claim 2 because it shows that although the populations of other consumers decreased, the population of cows increased, as did the population of decomposers. Some students may infer that the amount of cellular respiration increased, since all organisms do cellular respiration. Other students may infer that the average amount of cellular respiration stayed the same because some populations increased, while others decreased.
- Combined with Card A, this card supports Claim 1. This is because, if cellular respiration stayed the same but photosynthesis decreased, then the increase in carbon dioxide is because less photosynthesis occurred in the ecosystem.

Support students' thinking with the following prompts:

- Do you think photosynthesis or cellular respiration would be more affected by the population changes you see in the graph? Why?
- How would the changes in each population affect the amount of cellular respiration being done?
- How would the amount of carbon dioxide in the air be affected?
- How can this card be connected to another evidence card to better support the claim?
- What more might you want to know about this evidence to help you connect it to a claim?

Evidence Card C:

- Supports Claim 1 because it indicates that trees do more photosynthesis than grass does.



- Combined with Card A (tree population decrease while grass population increased), students can use these cards to infer that photosynthesis decreased, slowing the removal of carbon dioxide from the air.

Support students' thinking with the following prompts:

- This card talks about the production of energy storage molecules. Is that related to photosynthesis or cellular respiration? Why? How?
- How does this information help you think about the claims?
- How can this card be connected to another evidence card to better support the claim?
- What more might you want to know about this evidence to help you connect it to a claim?

Evidence Card D:

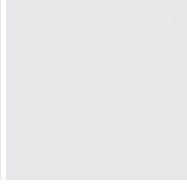
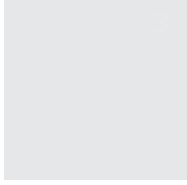
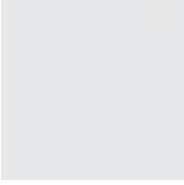
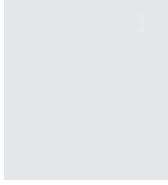
- Supports Claim 2 because decomposers could use the dead trees to get energy storage molecules, and thus will do more cellular respiration. Students could then infer that they would use these energy storage molecules to do cellular respiration, giving off carbon dioxide in the process.
- Combined with Card B, which shows that the population of decomposers increased, this would indicate that increased cellular respiration could be the cause of the increase in carbon dioxide.

Support students' thinking with the following prompts:

- This card talks about how decomposers get energy storage molecules. Is that related to photosynthesis or cellular respiration? Why? How?
- How does this information help you think about the claims?
- How can this card be connected to another evidence card to better support the claim?
- What more might you want to know about this evidence to help you connect it to a claim?

Possible Responses

Student responses will vary. For examples of supports to help students discuss the evidence cards, see the Teacher Support tab.



5

HOMEWORK

Homework



Homework

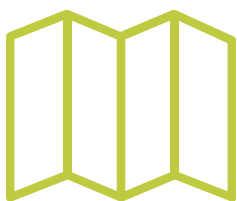
Students select a claim and explain their choices.

Instructional Guide

1. If needed, make additional time to explain the homework. If students do not have access to Amplify Science at home, provide them with copies of page 97 from the Investigation Notebook.

Possible Responses

Answers will vary.



Lesson 4.2

Science Seminar



Lesson at a Glance

ACTIVITY

1

Warm-Up (5 min)

Students choose a piece of evidence that supports their preferred claim in order to organize their thinking for the upcoming Science Seminar discussion.



WARM-UP

2

Preparing for the Science Seminar (15 min)

Prior to engaging in the all-class discussion, students rehearse their arguments in a low-stakes environment by sharing ideas with a partner about the claims and evidence.

STUDENT-TO-
STUDENT
DISCUSSION

T

Introducing the Science Seminar (5 min)

The teacher prepares the class for a productive discussion by introducing them to the procedures and expectations of the Science Seminar.



TEACHER

3

Participating in the Science Seminar (20 min)

Students practice scientific argumentation and demonstrate their knowledge of matter and energy in ecosystems through a collaborative group discussion.

STUDENT-TO-
STUDENT
DISCUSSION

4

Homework

Students reflect on how the Science Seminar changed their thinking in order to better understand how discussion can stimulate new ideas in science.



HOMEWORK



DIGITAL RESOURCES

Video: Strategy: Stepping Back
During Science Seminars

Science Seminar Observations
copymaster

Matter and Energy in Ecosystems
Investigation Notebook, pages
98–102

Matter and Energy in Ecosystems
Glossary

Matter and Energy in Ecosystems
Multi-Language Glossary



1

WARM-UP
Warm-Up

Warm-Up



Students organize their thoughts and prepare to discuss by selecting one preferred claim and one piece of supporting evidence.

Instructional Guide

- 1. Distribute envelopes containing students' annotated evidence cards.** Students will need these cards in order to complete the Warm-Up.
- 2. Project Warm-Up; students work independently.** Collapse the instructional guide and project the student screen, or have students turn to page 99 in their Investigation Notebooks. Allow a few minutes for students to individually respond to the Warm-Up.

Possible Responses

Accept either claim selection for the poll.

Students' reasons will vary, depending on the claim and piece(s) of evidence they chose. Some examples follow:

- Evidence Card C** is the piece of evidence that **best supports Claim 1**. This evidence card shows that trees produce more energy storage molecules than grass plants, which means trees do more photosynthesis than grass plants. Since deforestation replaces trees with grass plants, it is likely the deforestation results in less photosynthesis, which would increase the amount of carbon dioxide in the air.
- Evidence Card B** is the piece of evidence that **best supports Claim 2**. This evidence card shows that the population of cows and the population of decomposers both increased after the trees were cut down. Although this card shows a decrease in the other consumer populations, this decrease is smaller than the increase in the population of cows and decomposers. The populations of organisms in the ecosystem seem to have increased more than they decreased after deforestation, and since all organisms do cellular respiration, there was probably more cellular respiration after deforestation, which would increase the amount of carbon dioxide in the air.



2

STUDENT-TO-STUDENT
DISCUSSIONPreparing for the Science
Seminar

Preparing for the Science Seminar



Students pairs practice making an oral argument by discussing their preferred claim and the evidence that supports it.

Instructional Guide

1. Look ahead to today's Science Seminar. Let the class know that they will be participating in a student-led, whole-class discussion called a Science Seminar. Explain that they will share their claims and evidence as they work together to try and answer the Science Seminar (Chapter 4) Question.

2. Project the Scientific Argumentation Sentence Starters. Let students know that as they discuss their claims and evidence, they should use phrases such as the ones on the screen. When scientists are speaking, they use these types of questions and statements to help them explain their thinking, make their arguments more convincing, and respectfully agree and disagree. Point out that the sentence starters are also posted on the Scientific Argumentation wall.

Scientific Argumentation Sentence Starters

Describing evidence:

The evidence that supports my claim is ...
My first piece of evidence is ...
Another piece of evidence is ...
This evidence shows ...

Describing how evidence supports a claim:

If _____, then ...
This is important because ...
Since ...
Based on the evidence, I conclude that ...

Addressing an alternate claim:

Claim X is stronger than Claim Y because ...
Claim Y is not as strong because ...
Some people think Claim Y is stronger, but I disagree because ...



3. Discuss changing your mind. Point out that as students discuss, they might be convinced by their partners, and they might feel the need to change their minds about which claim is the most convincing. Assure students that this is fine—scientists often do this, too.

4. Provide instructions for Partner Share. Have students refer to the instructions on their screens, or have them turn to page 100 in their Investigation Notebooks. Explain that students will prepare to share their ideas with the whole class by first sharing their ideas with a partner. Point out that each student will have a turn to share their ideas, and then listen to their partner's ideas.

5. Partner Share. Ask pairs to decide which student will share first and begin. Encourage partners to respond to each other's ideas, using the Scientific Argumentation Sentence Starters.



TEACHER

Introducing the Science
Seminar

Introducing the Science Seminar



The teacher explains how and why students will engage in the Science Seminar discussion.

Instructional Guide

1. Project and discuss Science Seminar Expectations. Read the guidelines aloud and ask if students have any questions about the expectations for their participation in today's Seminar.

Science Seminar Expectations

Students are expected to

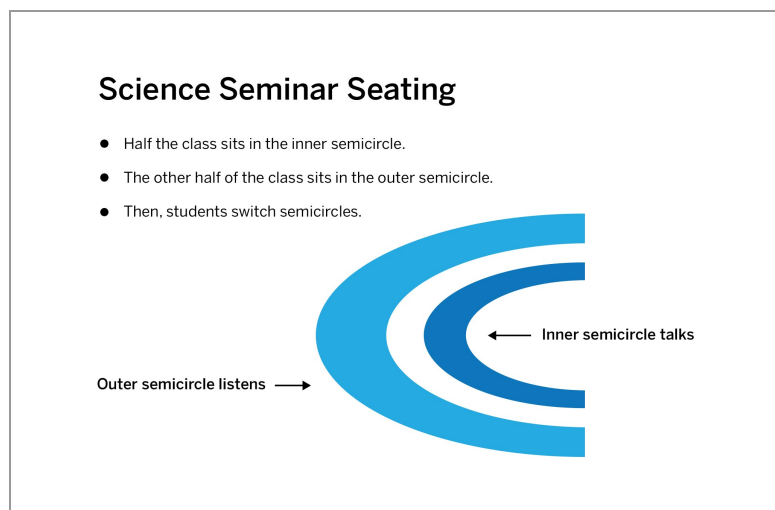
- run the conversation.
- use evidence to support ideas.
- explain their thinking.
- listen to one another.
- respond to one another.
- be open to changing their minds.



A Science Seminar is a scientific discussion in which students share their ideas and questions and challenge each other. The purpose of the Seminar is to use everyone's knowledge to come to a deeper understanding of something. Today's Seminar is specifically about coming to a better understanding of how the available evidence supports different explanations for why deforestation leads to increased carbon in the air.



2. Project Science Seminar Seating, and explain the two parts of the Science Seminar. Explain that students in the outer semicircle will listen and take notes. Students in the inner semicircle will share and discuss their ideas about the evidence. Halfway through, students will switch positions and switch roles. Students that were in the outer semicircle will now be in the inner semicircle, sharing and discussing.



3. Distribute Science Seminar Observation sheets, or have students turn to page 101 in their Investigation

Notebooks. Give one copy to each student. You can also distribute clipboards at this time, if you choose. Explain that when students are sitting in the outer semicircle they will use this sheet to take notes while they are listening. Quickly go over the instructions and expectations involved with this sheet.

4. Reinforce your role in the Seminar.



I'll start the conversation and offer prompts when needed, but otherwise I'll just be observing and taking notes. As much as possible, I want you to run the discussion. It's okay if things are quiet for a few minutes while we think about our ideas. This is your time to come together as a team of student ecologists and build the best explanation for why deforestation leads to increased carbon dioxide in the air.

Teacher Support

Rationale

Supporting Discussions: Your Role as Note Taker

When a teacher takes notes during the Science Seminar, students seem to respond more seriously to the ongoing discussion. Simply taking notes may cause more students to engage purposefully in the Seminar. It isn't necessary to tell students that they will get participation points, unless this is an expectation in your class.



3

STUDENT-TO-STUDENT
DISCUSSIONParticipating in the
Science Seminar

Participating in the Science Seminar



Students discuss the evidence to determine which claim best explains why deforestation leads to increased carbon dioxide in the air.

Instructional Guide

1. Introduce the Science Seminar. Point out the Science Seminar Question and claims that are written on the board. Suggest that students close their devices during the Seminar so they can pay attention to whomever is speaking. Remind students that they are responsible for presenting their ideas and opinions to the group, discussing the ideas and evidence that are presented, and asking questions of one another.

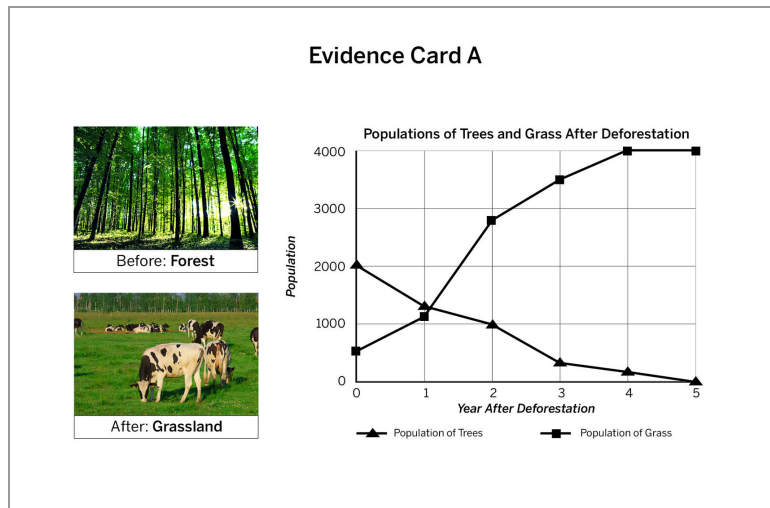


The planet's systems interact over scales that range from microscopic (for example carbon molecules) to global in size, and over a wide range of time scales. This science seminar gives you another chance to think about these interactions at several scales.

2. Students sit in assigned semicircles. Divide students into the two groups you determined before the lesson. Have students help you set up the room, if you haven't done this already. Students should bring their Science Seminar Evidence Cards and Claims, Science Seminar Observations sheets, and a pencil or pen (as well as a clipboard, if those are available).

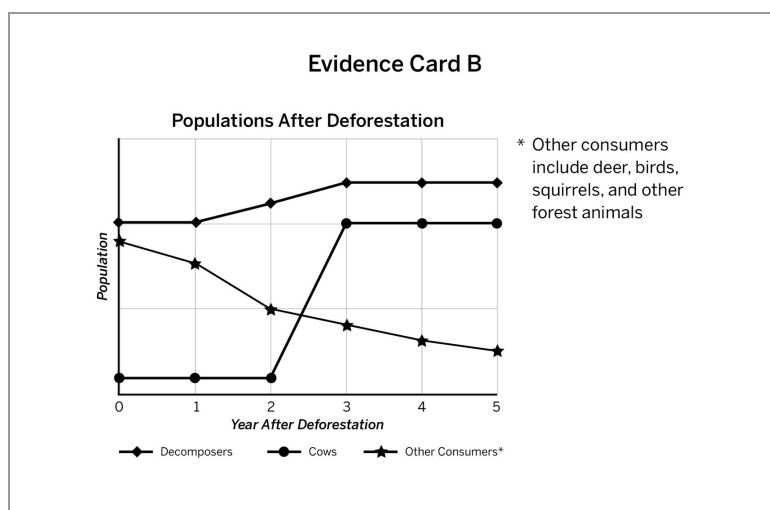


3. Start the Seminar by projecting Evidence Card A. Ask students in the first group what this evidence card shows and why this evidence matters. Prompt students to look back at their evidence card sorts to see which claim Evidence Card A supports. As the discussion continues, project other evidence cards as needed. See the note in the Teacher Support tab for suggested questions if your students are having difficulty starting or maintaining the discussion. Allow about 8 minutes for the first group discussion.



4. Groups switch roles. Bring the first discussion to a close. Highlight one or two important points that you heard during the first discussion. You can record these claims and important pieces of evidence on the board. Ask groups to switch seats.

5. Prompt the second group's conversation by projecting Evidence Card B. Ask students what this evidence can tell them about increased carbon dioxide in the air. Allow the inner semicircle to discuss for 8 minutes.





6. If time permits, invite both groups to discuss how deforestation leads to increased carbon dioxide. Open the discussion to all students, and encourage them to share ideas for a few minutes.

7. Conclude the Science Seminar. Congratulate students on their work. Point out that participating in the Science Seminar will help them build a more complete explanation for the farmers.



Like scientists, we did not all agree on the claims presented in the Science Seminar. Yet, listening to each other's ideas about the evidence that supports the claims helped us deepen our understanding. Disagreements help us explain our thinking and consider new ideas. This kind of discussion helps us to construct better explanations for scientific questions.

8. Point out the homework assignment to students (Activity 4 or page 102 in the Investigation Notebook). If students do not have access to Amplify Science at home, provide them with copies of page 102 from the Investigation Notebook. Instruct students to reflect on how the Science Seminar affected their thinking about the claims.

Teacher Support

Rationale

Argumentation: Purpose of the Science Seminar

A primary goal of the Science Seminar is to turn over as much of the conversation as possible to students. This provides opportunities for students to develop skills in building knowledge collaboratively and disagreeing productively.

Instructional Suggestion

Science Seminar: Asking About Specific Evidence Cards

If you notice that your students are having a difficult time engaging in the discussion, consider asking about a specific evidence card, using one of the questions below:

Evidence Card A:

- Do you think photosynthesis or cellular respiration would be more affected by the population changes you see in the graph? Why?
- How would the decrease in tree population affect photosynthesis (or cellular respiration)?
- How would the increase in grass population affect photosynthesis (or cellular respiration)?
- Based on the graph, what parts of the ecosystem changed after deforestation and how did it affect the rest of the system?

Evidence Card B:

- Do you think photosynthesis or cellular respiration would be more affected by the population changes you see in the graph? Why?
- How would the changes in each population affect the amount of cellular respiration being done?



- How would the amount of carbon dioxide in the air be affected?
- Based on the graph, what parts of the ecosystem changed after deforestation and how did it affect the rest of the system?

Evidence Card C:

- This card talks about the production of energy storage molecules. Is that related to photosynthesis or cellular respiration? Why? How?
- How does this information help you think about the claims?
- What more might you want to know about this evidence to help you connect it to a claim?

Evidence Card D:

- This card talks about how decomposers get energy storage molecules. Is that related to photosynthesis or cellular respiration? Why? How?
- How does this information help you think about the claims?
- What more might you want to know about this evidence to help you connect it to a claim?
- How did this change (decomposing wood in the field) affect the system?

Instructional Suggestion

Science Seminar: Helping the Second Group Contribute When the First Group Reaches Consensus

If it seems that the first group has reached agreement about the Seminar Question, you might ask one of the following challenge questions during the second group's discussion:

- Is there anyone who could make an argument in favor of the other claim?
- Could both claims be true? Why do you think that is possible or impossible?
- Is there any missing evidence? If so, what?
- What evidence could make this argument stronger?
- What evidence could make this argument weaker?

Assessment

4

HOMework
Homework



Homework

Students reflect on how the Science Seminar affected their thinking.

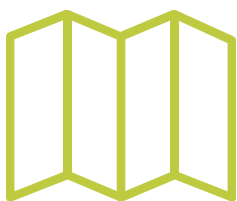
Instructional Guide

1. If needed, make additional time to explain the homework. If students do not have access to Amplify Science at home, provide them with copies of page 102 from the Investigation Notebook.

Possible Responses

Answers will vary.





Lesson 4.3

Writing a Scientific Argument



Lesson at a Glance

ACTIVITY

1

Warm-Up (5 min)

Students learn that scientific arguments need to make their reasoning clear by showing how the evidence supports a claim.



WARM-UP

2

Using the Reasoning Tool (15 min)

Students use the Reasoning Tool to make their reasoning clear before constructing their written arguments.

STUDENT-TO-
STUDENT
DISCUSSION

3

Organizing Ideas in the Reasoning Tool (10 min)

As students complete the Reasoning Tool, this activity provides an On-the-Fly Assessment for reasoning about the Science Seminar claims and evidence.

TEACHER-LED
DISCUSSION

4

Writing a Scientific Argument (15 min)

Students apply their knowledge of cellular respiration and photosynthesis as they write a convincing scientific argument about the Science Seminar Question. Student writing represents an opportunity for students to demonstrate understanding through a three-dimensional performance. Student writing can be scored by referencing the provided rubric in the *Matter and Energy in Ecosystems* Rubrics for Final Written Argument (in Digital Resources).



WRITING

5

Homework

Students engage in an important part of the writing process by reviewing and revising their written arguments.



HOMEWORK

6

Self-Assessment (Optional)

Students check their understanding of key content in the unit and reflect on any additional questions they have about ecosystems.



HOMEWORK



DIGITAL RESOURCES

Printable Reasoning Tool

Matter and Energy in Ecosystems
Investigation Notebook, pages
103–110

Matter and Energy in Ecosystems
Rubrics for Final Written Arguments

Matter and Energy in Ecosystems
Glossary

Matter and Energy in Ecosystems
Multi-Language Glossary



1

WARM-UP
Warm-Up

Warm-Up



Students compare two arguments and think about why one argument is more convincing than another.

Instructional Guide

1. Project Warm-Up; students work independently. Collapse the instructional guide and project the student screen, or have students turn to page 104 in their Investigation Notebooks. Allow a few minutes for students to individually respond to the Warm-Up.

Teacher Support

Rationale

Argumentation: Strengthening Arguments by Making Reasoning Explicit

The purpose of this Warm-Up is to demonstrate that arguments are easier to understand when they describe how pieces of evidence are connected to one another and to the claim. In the example, Ahmed's argument is stronger than Yuki's because it explains why the evidence matters. This is meant to prime students for the Reasoning Tool activity that follows.

Possible Responses

What makes one argument more convincing than the other?

Ahmed's argument is more convincing than Yuki's because Ahmed explains the connection between the evidence and the claims. Yuki says that the decrease in decomposers caused a decrease in energy storage molecules in producers and consumers, but she does not explain why this effect happened. So, her argument is not as convincing as Ahmed's argument.



2

STUDENT-TO-STUDENT
DISCUSSION

Using the Reasoning Tool



Using the Reasoning Tool



Students reason about the Science Seminar claims and evidence after they review an example Reasoning Tool and argument.

Instructional Guide

1. Lead a brief class discussion of the Warm-Up. Invite students to share which argument they think is more convincing and why. Help students identify that a convincing argument should make a clear connection between the evidence and the claim by explaining why the evidence matters.

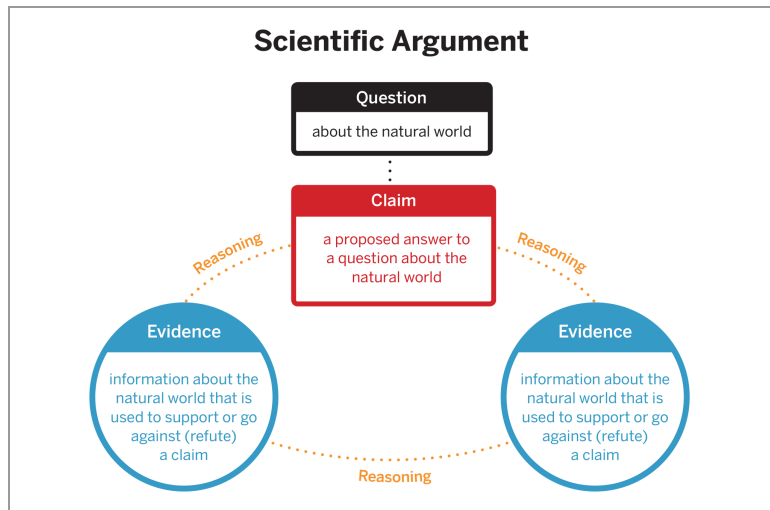
2. Explain the goals for this lesson.



In the last lesson, you discussed the claims and evidence about deforestation adding carbon dioxide to the air. After this discussion, some of you changed your thinking. Today, you are going to develop your own argument that answers this question for the farmers. The farmers know that carbon dioxide in the air increased, but they need you to help them understand why so they can do what it takes to reduce the amount of carbon dioxide in the future.



3. Project and review the different parts of a scientific argument. Point out that convincing arguments include claims, evidence, and statements that make the reasoning process clear by showing how the evidence supports the claim. Point out that this diagram can also be found on the argumentation wall.



4. Review why reasoning is important.



When making an argument, you are trying to explain your thinking in a way that convinces someone else that it is *the* best possible argument. This practice is called reasoning, and it is what your argument for the farmers needs in order to help them understand this problem.

Ask students to press NEXT (or to turn to page 105 in the Investigation Notebook).

5. Project Reasoning Tool. Remind students that they used a digital version of the Reasoning Tool in Chapter 1 of this unit. Inform them that they will be using a paper version of this tool today.

Using the Reasoning Tool to Support Your Claim

1. Record the claim that you think is best supported by the evidence (in the **Therefore**, column). If you prefer, you can also write and record your own claim.
2. Tape the evidence cards that support your claim to the Reasoning Tool (in the **Evidence** column). You do not need to use all the cards, but you can use more than one to support your claim.
3. Use the middle column (**This matters because . . .**) to record how the evidence in the left column connects to the claim in the right column.

Evidence	This matters because . . . (How does this evidence support the claim?)	Therefore, . . . (claim)



6. Review Reasoning Tool's purpose. Highlight how the tool will help them write a convincing argument—it will help them clearly explain their thinking and connect a scientific claim to evidence. Point out that students have instructions for using the tool on their screens, or on page 105 in their Investigation Notebooks.

7. Distribute envelopes and copies of the Reasoning Tool. Students need their annotated Science Seminar Evidence Cards and paper copies of the Reasoning Tool.

8. Direct students to review their annotated evidence cards with a partner. Allow a few minutes for pairs to discuss their evidence cards. Remind them that they are getting ready to choose a claim and should be thinking about which pieces of evidence they will use when arguing for that claim.

9. Instruct students to write the selected claim in the *Therefore* column of the Reasoning Tool. Tell students that may choose one of the two established claims, or write in a claim of their own.

10. Students tape selected cards in *Evidence* column of the Reasoning Tool. Instruct students to choose at least two cards that support their claim and tape or paste them, one per row, in the left-hand column. If students want to use all four evidence cards, they will need to tape at least one of these cards on the reverse side of the Reasoning Tool. Encourage students to talk with their partners as they decide which pieces of evidence to use.

11. Explain the *This matters because . . .* column. Go over recording how each taped piece of evidence supports the claim written in the right-hand column. Remind students that it can be helpful to think about how different pieces of evidence work together. In that case, encourage students to write about how these evidence cards are connected when they complete the middle column.

12. Direct students' attention to the posted key concepts and vocabulary terms. Encourage students to use these concepts and words as they reason about the evidence and claims.

13. Students complete Reasoning Tools. Encourage pairs to discuss their thinking as they individually complete their Reasoning Tools. Circulate to assist students and listen for examples of thoughtful reasoning that you might share with the class later.

Teacher Support

Instructional Suggestion

Supporting Argumentation: Reasoning as a Class

If your students are not yet comfortable with completing the Reasoning Tool on their own, you can support them by modeling how to use the middle column to connect a piece of evidence to a claim. You may want to use Evidence Card A or Evidence Card B to do this modeling since these cards require more interpretive work on the part of the student. To do this, prompt students with a question about why the changes in population shown in these graphs would matter for photosynthesis or cellular respiration. Encourage them to refer to the key concepts as they do their reasoning, and ask them to identify which population changes will affect photosynthesis and which will affect cellular respiration. Once students have generated some of these relationships, record them in the middle column for the class to see.



3

TEACHER-LED DISCUSSION

Organizing Ideas in the
Reasoning Tool



Organizing Ideas in the Reasoning Tool



Prior to writing, students think about how to best organize the ideas recorded in the Reasoning Tool.

Instructional Guide

- 1. Highlight that students have already begun their scientific arguments.** By completing the Reasoning Tool, students have already identified how the evidence they selected supports their claims. Remind students that this is an important step in creating a written argument.
- 2. Describe further steps in organizing student thinking.** Explain that annotating what students have already done in the Reasoning Tool will help them to order and coordinate their ideas, which will help them produce a clearer and more convincing piece of writing.



3. Project annotated Using the Reasoning Tool to Support Your Claim. Have students refer to their screens, or to page 106 in their Investigation Notebooks, to follow along. Go over the three types of annotations and provide students with a rationale for each:

- **Circle your strongest piece of evidence.** Encourage all students to use this annotation.
Say: "Identifying your strongest piece of evidence is a good idea because convincing arguments often start with the strongest piece of evidence."
- **Draw an X over those pieces of evidence that you do not plan to use in your argument.** Students should only use this annotation if there is a weaker piece of evidence that they are not going to use.
Say: "If there is a piece of evidence on your Reasoning Tool that does not support your claim, then drawing an X over it will help you remember to ignore it when you begin writing your argument."
- **Draw an arrow to connect pieces of evidence that go together.** Encourage students to use this annotation if they connected two pieces of evidence when they were recording their reasoning.
Say: "An arrow connecting pieces of evidence that go together will remind you to put these items next to each other as you structure your written argument."

Using the Reasoning Tool to Support Your Claim

- Circle your strongest piece of evidence.
- Draw an X over those pieces of evidence that you do not plan to use in your argument.
- Draw an arrow to connect pieces of evidence that go together.

Example

Evidence	This matters because . . . (How does this evidence support the claim?)	Therefore, . . . (claim)
Sample Evidence Card A	Your ideas about how the evidence supports the claim	Your claim
Sample Evidence Card B	Your ideas about how the evidence supports the claim	
Sample Evidence Card C	Your ideas about how the evidence supports the claim	

Note: In the example, Sample Evidence Card A is circled in green, Sample Evidence Card B is crossed out with a red X, and a red arrow connects Sample Evidence Card A to Sample Evidence Card C.

4. Students work individually to annotate their Reasoning Tools. Circulate and offer assistance as needed.

5. On-the-Fly Assessment: Reasoning About the Science Seminar. For further suggestions on how to support students in reasoning about the Science Seminar, press the hummingbird icon and select ON-THE-FLY ASSESSMENT 12.



Embedded Formative Assessment

On-the-Fly Assessment 12: Reasoning About the Science Seminar

Look for: As students use the Reasoning Tool in preparation for writing their final arguments, they integrate their interpretation of each evidence card with the ideas they heard from their fellow students during the Science Seminar. As students work through and annotate their Reasoning Tools, check to see whether they are able to make clear connections between the evidence and the selected claim. Can they clearly support one claim and explain why their chosen evidence supports this claim? Are they able to coordinate multiple pieces of evidence to support a single claim? A successful example of coordinated evidence might include a connection between Evidence Cards A and C in support of Claim 1 or Evidence Cards B and D in support of Claim 2.

Now what? Consider working individually or in small groups with students who need more support in developing their arguments. To do this, work with students to develop their arguments by talking them through the process of choosing their strongest piece of evidence. You can also focus on helping them make clear connections between the evidence cards and the claims, as well as how multiple pieces of evidence can be combined to support a claim.



4

WRITING

Writing a Scientific
Argument

Writing a Scientific Argument



Students build on the work they have done in the unit by using the Reasoning Tool to write a scientific argument.

Instructional Guide

1. Project Using the Reasoning Tool to Write an Argument. Prompt students to elaborate on the ideas in their Reasoning Tool when they write. Point out that the three colors are keyed to the elements that make up a convincing argument: a claim, specific evidence, and an explanation of how the evidence supports the claim.

Using the Reasoning Tool to Write an Argument

State your claim.

Deforestation causes increased carbon dioxide in the air because . . .

Describe the evidence.

One evidence card shows ... Another evidence card said . . .

Explain how the evidence supports the claim.

Together this evidence shows . . .



Your Reasoning Tools have helped you carefully consider how the evidence supports the claim. You also organized the tool by annotating, and that will help you express your ideas in a more convincing way. Remember to use your Reasoning Tool as you write, but be sure to expand on your ideas and use complete sentences.

2. Review the need to address alternate claims. Remind students that part of convincing an audience that the claim they are supporting is the best is explaining why another possible argument isn't as strong as the one they are choosing to write.



If you choose to support Claim 1, *There is less photosynthesis, so carbon dioxide increases in the air*, you'll want to give at least one reason why you think this is a stronger claim than Claim 2, *There is more cellular respiration, so carbon dioxide increases in the air*. If you choose to support Claim 2, you'll need to provide at least one reason why you think Claim 1 isn't as strong.

Let students know that they will be prompted to address the other claim at the end of the argument they will be writing; they will be asked to give at least one reason why they did not choose an alternative claim. In this section they may want to address any other claims that came up when they were talking with their peers over the last few days.

3. Project Scientific Argumentation Sentence Starters. Point out that these sentence starters might help students connect their ideas and sentences more clearly for the reader.

Scientific Argumentation Sentence Starters	
Describing evidence: The evidence that supports my claim is ... My first piece of evidence is ... Another piece of evidence is ... This evidence shows ...	Describing how evidence supports a claim: If _____, then ... This is important because ... Since ... Based on the evidence, I conclude that ...
Addressing an alternate claim: Claim X is stronger than Claim Y because ... Claim Y is not as strong because ... Some people think Claim Y is stronger, but I disagree because ...	

4. Prompt students to write their arguments. Collapse the instructional guide and project the students screen, or have students turn to page 107 in their Investigation Notebooks. Circulate and offer support as needed. For sample student arguments, see the Possible Responses tab.

5. Share highlights of thoughtful reasoning and convincing arguments that you heard or read while circulating. If appropriate, congratulate students on completing all the lessons in this unit.

6. Point out the homework assignment (Activity 5 or pages 109–110 in the Investigation Notebook). If students do not have access to Amplify Science at home, provide them with copies of pages 109–110 from the Investigation Notebook. Let students know that if they did not have enough time to finish writing their arguments in class, they should finish them for homework. Encourage students to reread their work to ensure that their arguments will be clear and convincing to the farmers. Suggest that students read their arguments aloud or ask another person to read them. Instruct students to rewrite any sections that could be clearer.



7. Optional: Point out the Self-Assessment (Activity 6 or page 111 in the Investigation Notebook). If students do not have access to Amplify Science at home, provide them with copies of page 111 from the Investigation Notebook. Remind students that this activity is a good opportunity for students to think about what they have learned over the course of the unit.

Teacher Support

Assessment

Science Writing: Supporting Students in Writing Their Final Arguments

In the Science Seminar for this unit, students engaged in the same type of work as scientists by using evidence to support a claim about why deforestation increased the amount of carbon dioxide in the air. In order to assess students' written arguments from the Science Seminar, we have provided three rubrics, which can be found in the Rubrics for Final Written Argument document (in Digital Resources). The rubrics are grounded in the principle that ideas in science are based on evidence, and, of equal importance, that students are engaging with science when they are constructing explanations and arguments. Scientists use evidence to justify why a particular explanation is the best one available.

Rationale

Argumentation: Addressing Opposing Claims

In grade 7, we provide students an opportunity during their final written arguments to consider and address an opposing or alternate claim. This meets the grade 7, CCSS Standard CCSS.ELA-LITERACY.W.7.1.A: Introduce claim(s), acknowledge alternate or opposing claims, and organize the reasons and evidence logically, and prepares students for dealing with the concept of refutation in a more deliberate way in grade 8. At this point it is fine for students to say something general to explain their thinking about why one claims is not as strong as the one they've chosen. For example, a student might write something such as, *The other claim is not supported by as many pieces of evidence.* However, you may find that some students can and will go further than this, and provide more detailed refutational thinking in their arguments.

Possible Responses

Write a scientific argument that addresses the question: *Why does deforestation lead to increased carbon dioxide in the air?* State your claim and explain how it could cause carbon dioxide to increase. Then, use evidence to support your claim. For each piece of evidence, explain how the evidence supports your claim.

Claim 1: There is **less photosynthesis** so carbon dioxide increases in the air.

Deforestation leads to increased carbon dioxide because there is less photosynthesis. Less photosynthesis could cause carbon dioxide to increase because producers take in carbon dioxide from the air during photosynthesis to make energy storage molecules. The evidence that supports my claim is that after the forest was cut down, there were fewer



trees and more grass plants in the ecosystem (Evidence Card A). This is important because trees and grass plants are two types of producers and producers are the only organisms that do photosynthesis. One tree produces a lot more energy storage molecules than one grass plant (Evidence Card C). If one tree produces a lot more energy storage molecules than one grass plant, then one tree must be doing more photosynthesis and taking in more carbon dioxide. Since the population of trees decreases a lot after deforestation and trees take in more carbon dioxide than grass plants, then there must be less carbon dioxide taken in by plants through photosynthesis, and more carbon dioxide stays in the air.

What is another claim that you considered? Explain why you chose not to support this claim.

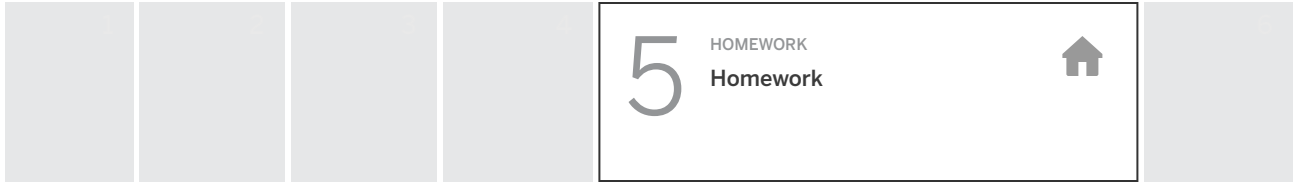
I also considered supporting the claim that there is more cellular respiration so carbon dioxide increases in the air. I didn't think this claim was as strong because many of the organisms that used to live there had left so I don't think there was as enough cellular respiration happening to cause this change.

Claim 2: There is **more cellular respiration** so carbon dioxide increases in the air.

My claim is that deforestation leads to increased carbon dioxide because there is more cellular respiration. More cellular respiration could have caused carbon dioxide to increase because organisms use energy storage molecules and make carbon dioxide during cellular respiration. The evidence that supports my claim is that after the forest was cut down, there were more cows and more decomposers and fewer other consumers in the ecosystem (Evidence Card B). Also, after the trees were cut down, some of the dead trees were left in the field to decompose (Evidence Card D). This explains why the population of decomposers increased, since decomposers get energy storage molecules from consuming dead trees. If the population of cows and the population of decomposers both increased and all organisms do cellular respiration, then there is more cellular respiration after deforestation. Since there is more cellular respiration after deforestation, more energy storage molecules are used, so more carbon dioxide molecules are given off to the air by organisms in the ecosystem. Based on the evidence, I conclude that there is more cellular respiration so carbon dioxide increases in the air.

What is another claim that you considered? Explain why you chose not to support this claim.

I also considered supporting the claim that there is less photosynthesis so carbon dioxide increases in the air. I don't think this claim is as strong because the area where the deforestation happened ended up with a lot of grass and other plants producing oxygen through cellular respiration, so I don't think that the plants could change the carbon dioxide in the air. I think that the cows are the reason for there being more CO₂ in the air.

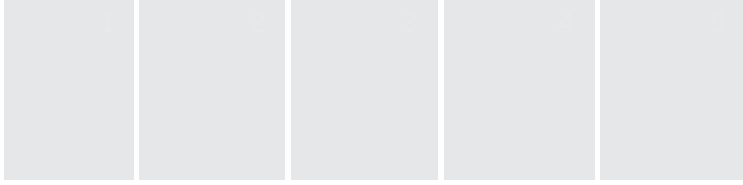


Homework

Students finish their written arguments and revise them to be as clear as possible.

Instructional Guide

1. If needed, make additional time to review the homework. If students do not have access to Amplify Science at home, provide them with copies of pages 109–110 from the Investigation Notebook.



6

HOMEWORK

Self-Assessment
(Optional)



Self-Assessment (Optional)

This optional homework provides a chance for students to reflect on their learning so far.

Instructional Guide

1. If needed, make additional time to explain this optional homework assignment. If students do not have access to Amplify Science at home, provide them with copies of page 111 from the Investigation Notebook.

Teacher Support

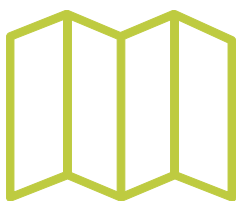
Assessment

Student Self-Assessment: Reflecting on the Unit

This is the final self-assessment, which invites students to reflect on their progress in the unit. Review students' responses and questions to gain insight into their thinking at the conclusion of the unit.

Possible Responses

Answers will vary. This is a self-reflection.



Lesson 4.4

End-of-Unit Assessment



Lesson at a Glance

ACTIVITY

1

Multiple-Choice Questions (25 min)

These multiple-choice questions provide an auto-scored measure of students' placements on the Progress Build.

CLASS

2

Written-Response Question #1 (10 min)

This written-response question provides additional information about students' placements on the Progress Build, including both unit-specific science concepts and crosscutting concepts. This item can be scored by referencing the provided rubrics in the *Matter and Energy in Ecosystems* End-of-Unit Assessment Answer Key and Scoring Guide (in Digital Resources).

CLASS

3

Written-Response Question #2 (10 min)

This written-response question provides additional information about students' placements on the Progress Build, including both unit-specific science concepts and crosscutting concepts. This item can be scored by referencing the provided rubrics in the *Matter and Energy in Ecosystems* End-of-Unit Assessment Answer Key and Scoring Guide (in Digital Resources).



CLASS



DIGITAL RESOURCES

Matter and Energy in Ecosystems
End-of-Unit Assessment
copymaster

Matter and Energy in Ecosystems
End-of-Unit Assessment Answer
Key and Scoring Guide

Matter and Energy in Ecosystems
Glossary

Matter and Energy in Ecosystems
Multi-Language Glossary



1

CLASS

Multiple-Choice Questions



Multiple-Choice Questions



Students complete 18 multiple-choice questions to show their current understanding of the content before beginning this unit.

Instructional Guide

1. Students complete multiple-choice questions. Circulate and assist students with clarifying instructions, as needed.

Teacher Support

Assessment

Pedagogical Goals: Assessing Complex Ideas

The Pre-Unit, Critical Juncture, and End-of-Unit assessments are different from traditional multiple-choice tests. Rather than testing recall of isolated facts, the questions are designed to assess the deep, explanatory understanding called for in NGSS and the Progress Build. Students are required to figure out and explain or make predictions about phenomena and as a result, students should expect to spend more time with each question as they think through the scenarios and work out their answers.

Possible Responses

1. The sun has been up for several hours, and it has been shining on these trees. What can the trees do because they are in sunlight? What does this mean for the number of energy storage molecules in the trees?

The trees can . . .

c. **take in** carbon from the air. The carbon is used to make energy storage molecules.



2. These goats are eating grass on a sunny day. What is happening to the carbon in the air around the living things on the mountain? Is carbon moving into the air, moving out of the air, or both?

b. Carbon is moving into the air **and** out of the air at the same time.

3. Will has an aquarium with water, plants, and fish that eat the plants. It is sealed so no material can get in or out, and has glass sides that allow sunlight to come in. The aquarium can also be covered to prevent light from entering.

The amount of carbon in the aquarium's water started out high. Now, the amount of carbon in the water is decreasing. Is the aquarium now in sunlight or is it covered? What is happening to the number of energy storage molecules in the plants and fish as a result?

a. The aquarium is now in sunlight, and there are **more** energy storage molecules in the plants and fish.

4. Scientists are studying photosynthesis in a forest ecosystem that has plants, animals, and decomposers (which consume dead things). Which group or groups of organisms in the forest carry out photosynthesis?

d. plants

5. A herd of deer lives in a forest where they eat the leaves of trees. The number of energy storage molecules in the trees and in the deer has increased. What has happened to the amount of carbon in the trees and in the deer?

The amount of carbon in the trees and in the deer . . .

a. has increased.

6. This sea grass grows in shallow water. It has had the sun shining on it for most of the day. What has the sunlight caused to happen? What has happened to the number of molecules that store energy in the sea grass?

The sea grass can . . .

b. **take in** carbon from the air. The carbon is used to **make** energy storage molecules.

7. This tortoise is eating cactus on a sunny day. Is carbon moving into the air, moving out of the air, or both?

d. Carbon is moving into the air **and** out of the air at the same time.



8. Lily has an aquarium with water, plants, and fish that eat the plants. The aquarium is sealed so no material can get in or out, and has glass sides that allow light to come in. The aquarium can also be covered to prevent light from entering.

The number of energy storage molecules in the plants and fish started out low, but that number has been increasing over time. Has the aquarium been in sunlight or has it been covered during this time? What has happened to the carbon in the water?

d. The aquarium has been in sunlight, and there is **less** carbon in the water.

9. Scientists are studying cellular respiration in a jungle ecosystem that has plants, animals, and decomposers (which consume dead things). Which group or groups of organisms in the jungle carry out cellular respiration?

c. all organisms in the jungle

10. Giant pandas eat bamboo plants in the mountains of China. The number of energy storage molecules has decreased in both the bamboo and the pandas. What has happened to the amount of carbon in the bamboo and the pandas?

The amount of carbon in the bamboo and pandas . . .

d. has decreased.

11. Giant kelp are plantlike organisms that grow in clear ocean water. Over the last few hours some kelp has been taking in carbon from the water around it. Is the kelp in sunlight? What has happened to the number of energy storage molecules in the kelp?

The kelp . . .

b. is in sunlight, and the number of energy storage molecules in the kelp has **increased**.

12. A rabbit is eating leafy plants on a sunny day. What is happening to the carbon in the plants and in the rabbit?

c. Carbon is moving into and out of the living things at the same time.

13. A scientist set up an experimental ecosystem in a sealed room with no windows. The experimental ecosystem has plants, and animals that eat those plants. The scientist can control whether the room is light or dark with a light switch outside the room.



The amount of carbon in the air of the ecosystem started out low. Then the amount of carbon in the air started to increase. Is the increase because the scientist switched the light *on* or because she switched the light *off*? What happened to the number of energy storage molecules in the living things?

The scientist . . .

a. switched the light **off**, and the number of energy storage molecules in the living things **decreased**.

14. Scientists are studying photosynthesis in a desert ecosystem that has plants, animals, and decomposers (which consume dead things). Which group or groups of organisms in the desert carry out photosynthesis?

a. plants

15. Scientists are studying cellular respiration in a river ecosystem that has plants, animals, and decomposers (which consume dead things). Which group or groups of organisms in the river carry out cellular respiration?

c. all organisms in the river

16. An ivy plant has been taking in carbon from the air for several hours.

Is the ivy in sunlight? What has happened to the number of energy storage molecules in the ivy?

The ivy . . .

b. is **in** sunlight. The number of energy storage molecules in the ivy has **increased**.

17. A group of giraffes feeds on leaves and grasses during the daytime. Right now, it is dark out and the giraffes are *not* eating. Is carbon moving into the living things, moving out of the living things, or both?

c. Carbon is only moving out of the living things; it is not moving into them.

18. Reza has a glass ball filled with water that contains tiny plants and shrimp that eat those plants. No material can get in or out, but light can get through the glass when it is placed in sunlight.

The number of energy storage molecules in the plants and shrimp started out high, but then the glass ball was moved, and the number of energy storage molecules decreased. Was the glass ball moved into the *light* or into the *dark*? What happened to the amount of carbon in the water?

b. The glass ball was moved into the **dark**, and there is **more** carbon in the water.



2

CLASS

Written-Response
Question #1



Written-Response Question #1



Students complete the first written-response question on the End-of-Unit Assessment.

Instructional Guide

1. Students complete the first written-response question. Circulate and assist students with clarifying instructions, as needed.

Possible Responses

This space station has plants growing inside it, and astronauts who eat the fruits and vegetables from those plants. Because it is in space, the station is sealed so no material can get in or out. The space station is in Earth's shadow, so no light is getting into it. The sensors in the space station show that carbon dioxide in the air is increasing.

What is happening to the energy storage molecules in the plants and humans in the space station? Explain your answer as completely as possible.

Level 1: Student indicates that the number of energy storage molecules is not increasing because without light plants cannot perform photosynthesis.

Possible student response: Since there is no light in the space station, the plants are not doing photosynthesis, so they are not making energy storage molecules. This means that the number of energy storage molecules in the plants and animals is not increasing.

Level 2: Student demonstrates an understanding of Level 1 and describes how organisms give off carbon dioxide through cellular respiration (which will be absorbed into the biodome walls).



Possible student response: Since there is no light in the space station, the plants are not doing photosynthesis, so they are not making energy storage molecules. However, the organisms are using up energy storage molecules when they do cellular respiration, and that gives off carbon dioxide to the air, which is why it is increasing. This means that the number of energy storage molecules in the plants and animals is decreasing because they are only using them up.

Level 3: Student demonstrates an understanding of Levels 1 and 2 and explains that increasing carbon dioxide necessitates a decrease in energy storage molecules, because there is a fixed amount of carbon in the space station.

Possible student response: Since there is no light in the space station, the plants are not doing photosynthesis, so they are not making energy storage molecules. However, the organisms are using up energy storage molecules when they do cellular respiration, and that gives off carbon dioxide to the air, which is why it is increasing. Because carbon cannot be produced or used up, and since carbon dioxide in the air increased, that means the number of energy storage molecules in the plants and animals is decreasing.



3

CLASS

Written-Response
Question #2



Written-Response Question #2



Students complete the second written-response question on the End-of-Unit Assessment.

Instructional Guide

1. Students complete the second written-response question. Circulate and assist students with clarifying instructions, as needed.

Possible Responses

A scientist is studying an aquarium ecosystem that contains water, plants, and fish that eat those plants. The aquarium has glass walls so light can get in, but it is sealed so no material can move into or out of the tank. When the scientist turned the aquarium's light on, carbon dioxide in the water started decreasing. How is carbon moving and what is happening to the amount of carbon in the living things inside the aquarium? Explain your thinking as completely as possible.

Level 1: Student indicates carbon is moving into living things and biotic carbon is increasing as plants perform photosynthesis.

Possible student response: Since the aquarium is exposed to light, the plants are performing photosynthesis. This means carbon dioxide from the air is moving into living things so the plants can use the carbon to make energy storage molecules, which is why carbon in the air is decreasing. Because of this, carbon in living things is increasing.

Level 2: Student indicates an understanding of carbon movement from Level 1 and indicates that there is also carbon moving out of living things as organisms give off carbon dioxide produced through cellular respiration.



Possible student response: Since the aquarium is exposed to light, the plants are performing photosynthesis. This means carbon dioxide from the air is moving into living things so the plants can use the carbon to make energy storage molecules, which is why carbon in the air is decreasing. I also know that some carbon is moving out of living things into the air, because the organisms are giving off carbon dioxide as they use up energy storage molecules through cellular respiration. Because carbon is moving into and out of living things, I am not sure how the amount of carbon in living things is changing.

Level 3: Student indicates an understanding of Levels 1 and 2 and indicates that the amount of carbon in living things must be increasing because there is a fixed amount of carbon in the aquarium.

Possible student response: Since the aquarium is exposed to light, the plants are performing photosynthesis. This means carbon dioxide from the air is moving into living things so the plants can use the carbon to make energy storage molecules, which is why carbon in the air is decreasing. Because of this, carbon in living things is increasing. I also know that some carbon is moving out of living things into the air, because the organisms are giving off carbon dioxide as they use up energy storage molecules through cellular respiration. Since the amount of carbon in the air is decreasing, the amount of carbon in living things is increasing. This is because it is a closed ecosystem and there is a set amount of carbon—it can't be produced or used up.



Image Credits

Shutterstock-- JoenStock/Getty Images-- groveb/Getty Images-- Sean Bagshaw/Science Source-- Bryan and Cherry Alexander/Science Source-- William Sherman/Getty Images-- Stephen Muskie/Getty Images-- FrankvandenBergh/Getty Images (Matter and Energy in Ecosystems End-of-Unit Assessment copymaster).