Houghton Mifflin Harcourt

HMH SCIENCE DIMENSIONS™

ENGINEERED *for the* NEXT GENERATION

Biology

Program Overview

GRADES 9–12

Built from the ground up for

NEXT GENERATION SCIENCE STANDARDS

EXPLORE. EXPERIMENT. EXPERIENCE.

Envision a classroom where students ask questions, state claims, test their ideas, and find resolution through reasoning. With increased demand for science proficiency in the workplace, it has become imperative to develop such innovators and problem solvers to fill critical next generation career roles.

This instructional shift is achievable now. With built-in support and a transformed lesson structure, instructors will become facilitators who empower their students to learn through self-directed exploration, analysis, application, and explanation—in short, to think like scientists.

HMH SCIENCE DIMENSIONS™

A **NEW** K–12 solution engineered for success with NGSS

Inspire the next generation of scientists and innovators

- Promote active learning with **investigation-driven activities.**
- Build excitement for **engineering and STEM.**
- Build problem-solving skills with **performance-based assessment.**
- Engage students with motivating **digital resources**, including connections to Google® Expeditions.
- Create **enduring understanding** with integrated Three-Dimensional Learning.
- Develop effective NGSS* approaches with embedded **professional support from HMH.**

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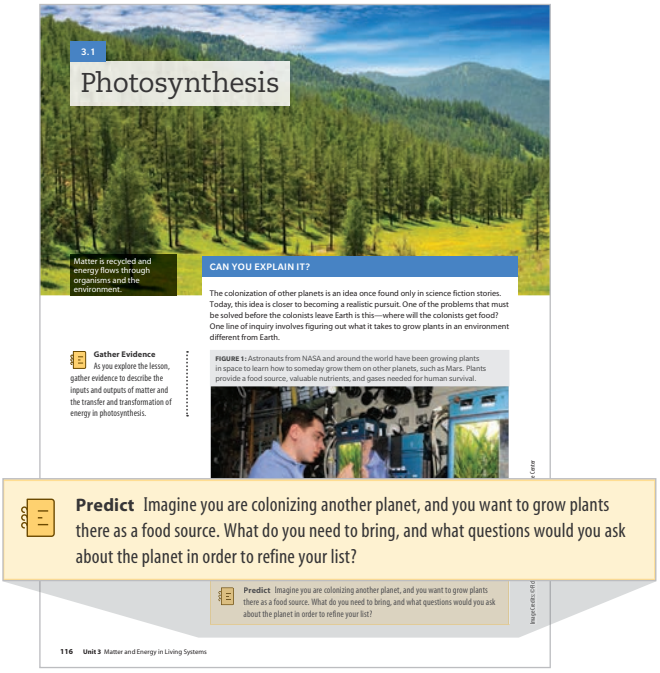
Build Student Confidence with Authentic Investigations

Students are more engaged and learn more meaningfully through investigative inquiry. ***HMH Science Dimensions*** is built on this approach. Your students will learn to conduct hands-on investigations, define questions and objectives, make claims, and identify evidence—in short, to **take charge** and **fully engage** in their learning!



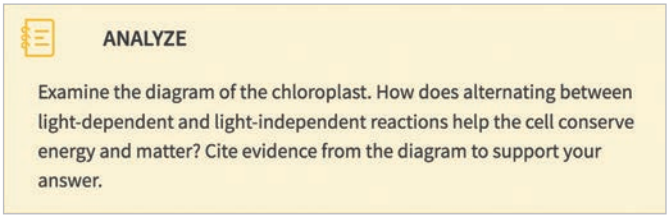
Print Student Edition

Discrepant Phenomena Lead Every Lesson

- Each lesson begins with **Can You Solve It?** or **Can You Explain It?**—a **problem to solve** or **discrepant event to explain**. This feature provides intrinsic motivation to spark curiosity and serves as the context for the three-dimensional learning and hands-on activities throughout the lessons. Students are motivated to think critically and construct explanations of *how* and *why*.
- The program is built around **active learning**. Rather than receive content passively, students are asked to **solve problems** or explain phenomena by stating **claims**, gathering **evidence**, and providing explanations through **reasoning**.

Science Notebooking to Strengthen Writing Skills

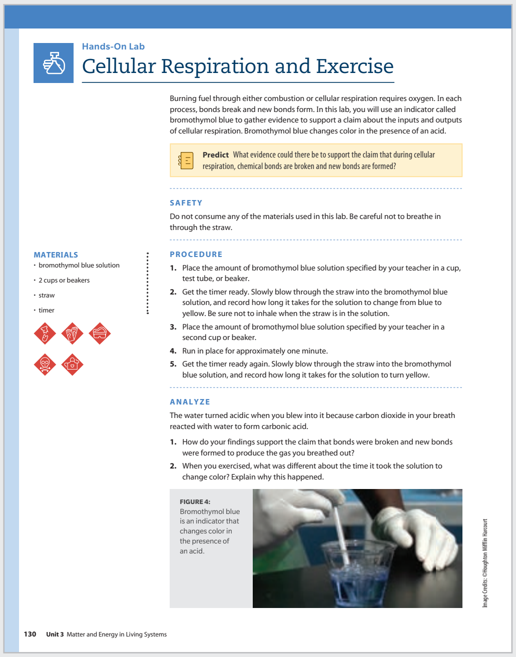
Many of the lessons in ***HMH Science Dimensions*** support the use of **Evidence Notebooks**. **Helpful prompts** have been inserted throughout the lessons to guide students on when to use these notebooks. Students will love creating their own study guides that can be taken into the next grade, and teachers will love the extra writing practice!



Online Student Edition Notebook Prompt

Drive Student Learning with Hands-On Labs

- **Hands-On Labs** are integrated into many of the lessons. These are built with teachers' busy schedules in mind. Each lab uses **easily sourced materials**.
- Many activities, including the **Hands-On Labs**, contribute to a student's evidence gathering in each lesson.
- Students get to actively "do science"; they **think critically** about their observations, practice gathering evidence, and defend their claims.



Hands-On Lab

Cellular Respiration and Exercise

Burning fuel through either combustion or cellular respiration requires oxygen. In each process, bonds break and new bonds form. In this lab, you will use an indicator called bromothymol blue to gather evidence to support a claim about the inputs and outputs of cellular respiration. Bromothymol blue changes color in the presence of an acid.

Predict What evidence could there be to support the claim that during cellular respiration, chemical bonds are broken and new bonds are formed?

SAFETY

Do not consume any of the materials used in this lab. Be careful not to breathe in through the straw.

MATERIALS
- bromothymol blue solution
- 2 cups or beakers
- straw
- timer

PROCEDURE
1. Place the amount of bromothymol blue solution specified by your teacher in a cup, test tube, or beaker.
2. Get the timer ready. Slowly blow through the straw into the bromothymol blue solution, and record how long it takes for the solution to change from blue to yellow. Be sure not to inhale when the straw is in the solution.
3. Place the amount of bromothymol blue solution specified by your teacher in a second cup or beaker.
4. Run in place for approximately one minute.
5. Get the timer ready again. Slowly blow through the straw into the bromothymol blue solution, and record how long it takes for the solution to turn yellow.

ANALYZE

The water turned acidic when you blew into it because carbon dioxide in your breath reacted with water to form carbonic acid.
1. How do your findings support the claim that bonds were broken and new bonds were formed to produce the gas you breathed out?
2. When you exercised, what was different about the time it took the solution to change color? Explain why this happened.

FIGURE 4: Bromothymol blue is an indicator that changes color in the presence of an acid.

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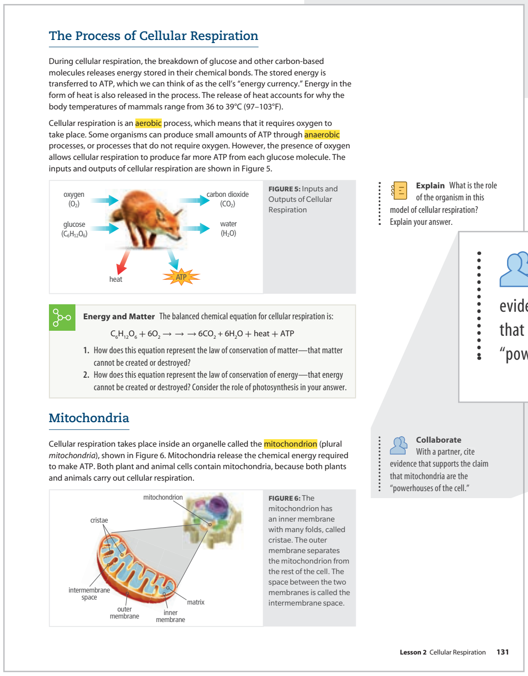
130 **Unit 3** Matter and Energy in Living Systems

Print Student Edition



The Process of Cellular Respiration

During cellular respiration, the breakdown of glucose and other carbon-based molecules releases energy stored in their chemical bonds. The stored energy is transferred to ATP, which we can think of as the cell's "energy currency." Energy in the form of heat is also released in the process. The release of heat accounts for why the body temperatures of mammals range from 36 to 39°C (97–103°F).

Cellular respiration is an aerobic process, which means that it requires oxygen to take place. Some organisms can produce small amounts of ATP through anaerobic processes, or processes that do not require oxygen. However, the presence of oxygen allows cellular respiration to produce far more ATP from each glucose molecule. The inputs and outputs of cellular respiration are shown in Figure 5.

FIGURE 5: Inputs and Outputs of Cellular Respiration

Explain What is the role of the organism in this model of cellular respiration? Explain your answer.

Energy and Matter The balanced chemical equation for cellular respiration is:

$$C_6H_{12}O_6 + 6O_2 \rightarrow \rightarrow \rightarrow 6CO_2 + 6H_2O + \text{heat} + \text{ATP}$$

1. How does this equation represent the law of conservation of matter—that matter cannot be created or destroyed?
2. How does this equation represent the law of conservation of energy—that energy cannot be created or destroyed? Consider the role of photosynthesis in your answer.

Mitochondria

Cellular respiration takes place inside an organelle called the mitochondrion (plural *mitochondria*), shown in Figure 6. Mitochondria release the chemical energy required to make ATP. Both plant and animal cells contain mitochondria, because both plants and animals carry out cellular respiration.

FIGURE 6: The mitochondrion has an inner membrane with many folds, called cristae. The outer membrane separates the mitochondrion from the rest of the cell. The space between the two membranes is called the intermembrane space.

Collaborate With a partner, cite evidence that supports the claim that mitochondria are the "powerhouses of the cell."

Lesson 2 Cellular Respiration 131

Collaborate With a partner, cite evidence that supports the claim that mitochondria are the "powerhouses of the cell."

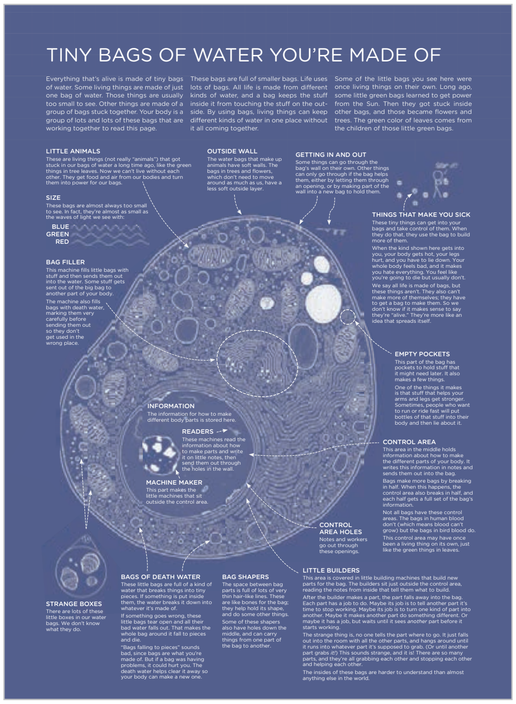
Print Student Edition

Cultivate Collaboration

Working as a team is an essential part of developing **21st-century skills**. ***HMH Science Dimensions*** provides ample opportunities for students to participate in groups to complete activities and partner with their peers to discuss their findings.

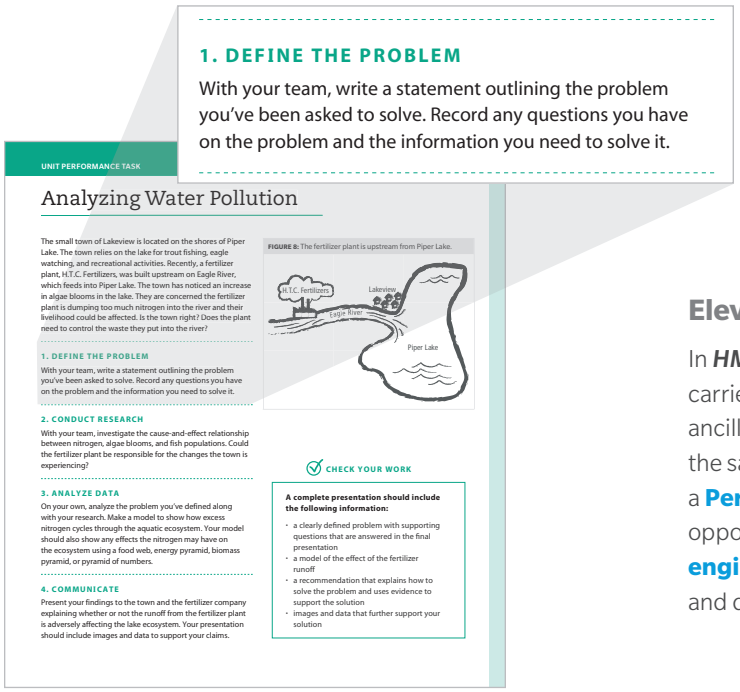
A Unique Approach to Exploring Phenomena

Through an exclusive partnership with author and internet sensation **Randall Munroe**, HMH has incorporated highly engaging and educational material from Randall's latest book, *Thing Explainer*, into our print and digital editions. Randall's webcomic style, as seen on **xkcd.com**, **humorously explains** complex topics in easy-to-understand language.



Today's Students Will Solve the Technology and Engineering Challenges of Tomorrow!

NGSS* has raised the engineering design process to the same level as scientific inquiry. In ***HMH Science Dimensions***, science, technology, engineering, and math are considered **integral** parts of the curriculum. Lessons are designed for students to explore science the same way real-life scientists do. Watch your students' eyes **light up** as they brainstorm solutions, share their ideas, and experiment to find solutions.



1. DEFINE THE PROBLEM

With your team, write a statement outlining the problem you've been asked to solve. Record any questions you have on the problem and the information you need to solve it.

UNIT PERFORMANCE TASK

Analyzing Water Pollution

The small town of Lakeview is located on the shores of Piper Lake. The town relies on the lake for trout fishing, eagle watching, and recreational activities. Recently, a fertilizer plant, H.T.C. Fertilizers, was built upstream on Eagle River, which feeds into Piper Lake. The town has noticed an increase in algae blooms in the lake. They are concerned the fertilizer plant is dumping too much nitrogen into the river and their livelihood could be affected. Is the town right? Does the plant need to control the waste they put into the river?

FIGURE 8: The fertilizer plant is upstream from Piper Lake.

1. DEFINE THE PROBLEM

With your team, write a statement outlining the problem you've been asked to solve. Record any questions you have on the problem and the information you need to solve it.

2. CONDUCT RESEARCH

With your team, investigate the cause-and-effect relationship between nitrogen, algae blooms, and fish populations. Could the fertilizer plant be responsible for the changes the town is experiencing?

3. ANALYZE DATA

On your own, analyze the problem you've defined along with your research. Make a model to show how excess nitrogen cycles through the aquatic ecosystem. Your model should also show any effects the nitrogen may have on the ecosystem using a food web, energy pyramid, biomass pyramid, or pyramid of numbers.

4. COMMUNICATE

Present your findings to the town and the fertilizer company explaining whether or not the runoff from the fertilizer plant is adversely affecting the lake ecosystem. Your presentation should include images and data to support your claims.

CHECK YOUR WORK

A complete presentation should include the following information:

- a clearly defined problem with supporting questions that are answered in the final presentation
- a model of the effect of the fertilizer runoff
- a recommendation that explains how to solve the problem and uses evidence to support the solution
- images and data that further support your solution

Print Student Edition

Elevate Engineering

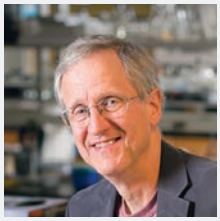
In ***HMH Science Dimensions,*** engineering and STEM are carried throughout every unit and not just treated as an ancillary. This approach elevates engineering design to the same level as scientific literacy. Each unit includes a **Performance Task**, offering students multiple opportunities throughout the program to apply the **engineering design process** by defining a problem and designing a solution.

Provide Extra Support for Students Who Need It

The **Science and Engineering Practices Online Handbook** will help students achieve a higher level of understanding and skill as they build their experience applying the **Science and Engineering Practices** of NGSS.

Education Leaders You Can Trust

Dr. Stephen Nowicki received his doctorate in neurobiology and behavior from Cornell University in 1985. He is now Dean and Vice Provost for Undergraduate Education, as well as Bass Fellow and Professor in the departments of Biology, Psychology, and Neurobiology at Duke University. In 2010, he was elected a Fellow of the American Association for the Advancement of Science.



Dr. Stephen Nowicki

During consulting author **Cary Sneider's** teaching career and nearly three decades at the Lawrence Hall of Science in Berkeley, California, he developed skills in curriculum development and teacher education. He was a writing team leader for the Next Generation Science Standards and has been instrumental in ensuring ***HMH Science Dimensions*** meets the high expectations of the NGSS and provides an effective three-dimensional learning experience for all students.

Dr. Cary Sneider

CONTINUE YOUR EXPLORATION

Careers in Science

Genomics: Studying Genomes

Genomics is a branch of biology that analyzes the DNA sequence of specific organisms and compares it to other organisms, with the hope of gaining information about a gene's particular function. Scientists in this field might study the DNA code of an organism, the length of genes, and numbers of genes, or the locations of genes on chromosomes. They are particularly interested in any similarities and differences in the genome of various organisms.

A career in genomics requires a strong background in molecular biology but also a solid foundation in math and statistics. Genomicists often use computers to aid in the analysis and presentation of vast amounts of data. This use of computer databases to organize and analyze biological data is called bioinformatics. A sharp eye for detail and an underlying curiosity about the world are also essential characteristics in this and other fields of science.

One area of genomics called gene mapping got its start with the mapping of a simple virus in 1977. To date, scientists have mapped the genome of hundreds of animals, including mice, frogs, and chimpanzees. Our own genome was sequenced as part of the Human Genome Project completed in 2003.

Plants also have been studied using gene sequencing. Watermelons, sugar beets, rice, and wheat have all had their genomes mapped. Scientists today often use techniques called Next-Generation Sequencing, which are higher yielding methods than previous techniques, resulting in millions of copies of DNA in a short period. A small flowering plant called *Arabidopsis*, a type of mustard plant, was the first plant to have its genome sequenced in 2000. *Arabidopsis* is still used today as a model organism for research into the processes of all flowering plants. Genomicists and plant biologists are working together to research variant alleles of *Arabidopsis* to improve understanding of other plants, including those used for food. Because the DNA sequence of *Arabidopsis* is already known, scientists can use this information and compare it to other plants. Research on rice and corn genomes is aimed at producing crop varieties that produce higher yields, are less susceptible to disease, or can grow in drought conditions.

FIGURE 16: The field of genomics attempts to understand our genetic code better in order to find out how genes affect our traits, our health, and even our future.

The study of animal genomes gives researchers in many fields of research incredibly valuable information about how our own genes might function and what happens when they do not function properly. Plant genome sequencing provides scientists with information on how to grow crops that are more productive. The insights gained from the field of genomics will undoubtedly have far-reaching effects on industries, such as pharmaceutical research, health care, and agriculture.

Language Arts Connection
Write a brief report answering these questions.

- Do you think you would enjoy a career as a genomicist? Why or why not?
- Which organism would you like to study the DNA of, and why?
- Why do you think studying the genome of other animals might provide valuable information?
- Why might scientists be interested in the genomes of plants?
- In what ways do you think the field of genomics has improved our lives?
- How might changes in technology change the way we study the genomes of organisms?

DISCUSSION: SEQUENCING YOUR OWN GENOME | EVALUATING CLAIMS: EYE COLOR AND OUR ANCESTORS | Go online to choose one of these other paths.

Lesson 2 Mendel and Heredity 325

Image Credits: ©Erik Voinov/Bloomberg Getty Images

Biology Print Student Edition

Inspire Students to Consider STEM Careers

- The Take it Further (Elaborate) section of each unit features **Careers in Science**. These features show students the **real-world applications** of what they're learning and pique their interest in science-based careers.
- Additionally, as part of all our offerings, HMH now includes 29 *On the Job* STEM videos that **profile STEM careers** in today's fastest-growing industries. These videos will **motivate students** to enter emerging STEM fields.

On the Job STEM video

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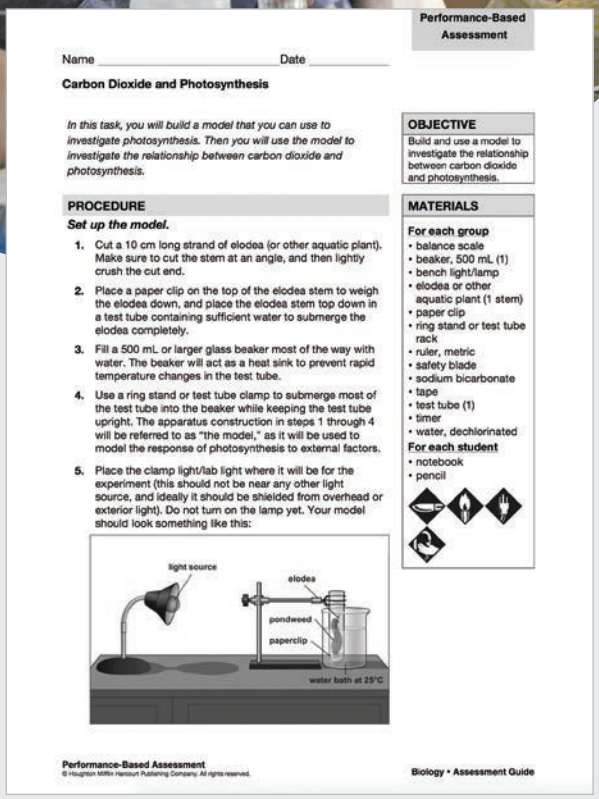
Let Students Show What They Know

For the first time ever, through NGSS,* science standards now include specific **measurable learning outcomes**. These Performance Expectations guide test developers and teachers in understanding how to measure student learning. ***HMH Science Dimensions*** offers flexible assessment tools in a variety of formats to help you assess both formative and summative student learning according to NGSS.



Performance-Based Assessment

Name _____ Date _____

Carbon Dioxide and Photosynthesis

In this task, you will build a model that you can use to investigate photosynthesis. Then you will use the model to investigate the relationship between carbon dioxide and photosynthesis.

OBJECTIVE

Build and use a model to investigate the relationship between carbon dioxide and photosynthesis.

PROCEDURE

Set up the model.

1. Cut a 10 cm long strand of elodea (or other aquatic plant). Make sure to cut the stem at an angle, and then lightly crush the cut end.
2. Place a paper clip on the top of the elodea stem to weigh the elodea down, and place the elodea stem top down in a test tube containing sufficient water to submerge the elodea completely.
3. Fill a 500 mL or larger glass beaker most of the way with water. The beaker will act as a heat sink to prevent rapid temperature changes in the test tube.
4. Use a ring stand or test tube clamp to submerge most of the test tube into the beaker while keeping the test tube upright. The apparatus construction in steps 1 through 4 will be referred to as "the model," as it will be used to model the response of photosynthesis to external factors.
5. Place the clamp light/lab light where it will be for the experiment (this should not be near any other light source, and ideally it should be shielded from overhead or exterior light). Do not turn on the lamp yet. Your model should look something like this:

MATERIALS

For each group
- balance scale
- beaker, 500 mL (1)
- bench light/lamp
- elodea or other aquatic plant (1 stem)
- paper clip
- ring stand or test tube rack
- ruler, metric
- safety blade
- sodium bicarbonate
- tape
- test tube (1)
- timer
- water, dechlorinated

For each student
- notebook
- pencil

Performance-Based Assessment

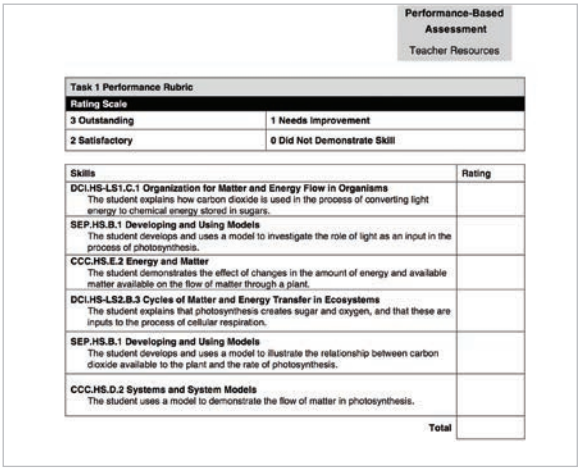
Biology • Assessment Guide

Address Scientific Practices with Authentic Performance Assessments

Performance-Based Assessments help you ensure that your students can perform the science and engineering practices called for by NGSS, and they guide students toward **making connections** across Performance Expectations.

Assess on All Dimensions

- Formal assessment questions **aligned to multiple dimensions** provide you with a complete picture of student understanding.
- A unique **3D Evaluation Rubric** helps you evaluate open-ended student responses and identify the underlying cause of student misunderstanding so that you can target remediation where it's most needed.



Performance-Based Assessment
Teacher Resources

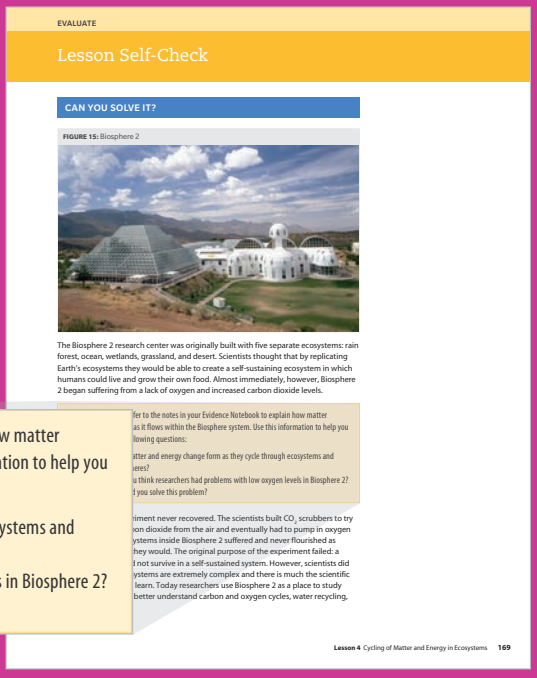
Task 1 Performance Rubric

Rating Scale	
3 Outstanding	1 Needs Improvement
2 Satisfactory	0 Did Not Demonstrate Skill

Skills	Rating
DCI.HS-LS1.C.1 Organization for Matter and Energy Flow in Organisms The student explains how carbon dioxide is used in the process of converting light energy to chemical energy stored in sugars.	
SEP.HS.B.1 Developing and Using Models The student develops and uses a model to investigate the role of light as an input in the process of photosynthesis.	
CCC.HS.E.2 Energy and Matter The student demonstrates the effect of changes in the amount of energy and available matter available on the flow of matter through a plant.	
DCI.HS-LS2.B.3 Cycles of Matter and Energy Transfer in Ecosystems The student explains that photosynthesis creates sugar and oxygen, and that these are inputs to the process of cellular respiration.	
SEP.HS.B.1 Developing and Using Models The student develops and uses a model to illustrate the relationship between carbon dioxide available to the plant and the rate of photosynthesis.	
CCC.HS.D.2 Systems and System Models The student uses a model to demonstrate the flow of matter in photosynthesis.	
Total	

Reflect on Evidence Gathered

At the end of a lesson, the **Lesson Self-Check** encourages students to reflect on the evidence they gathered throughout the lesson. They have another chance to respond to the discrepant phenomenon or central question of the lesson with **open-ended response** questions.



EVALUATE

Lesson Self-Check

CAN YOU SOLVE IT?

FIGURE 15: Biosphere 2

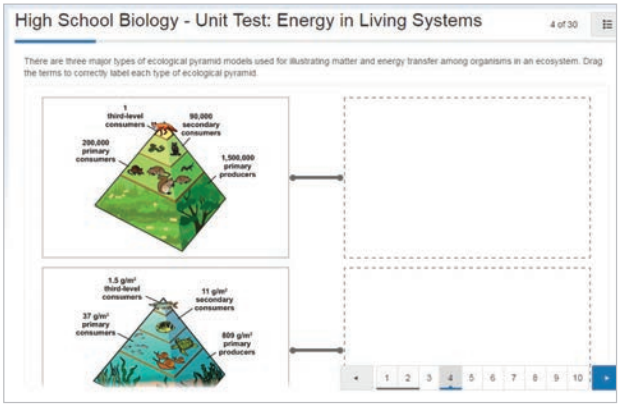
The Biosphere 2 research center was originally built with five separate ecosystems: rain forest, ocean, wetlands, grassland, and desert. Scientists thought that by replicating Earth's ecosystems they would be able to create a self-sustaining ecosystem in which humans could live and grow their own food. Almost immediately, however, Biosphere 2 began suffering from a lack of oxygen and increased carbon dioxide levels.

Explain Refer to the notes in your Evidence Notebook to explain how matter changes form as it flows within the Biosphere system. Use this information to help you answer the following questions:

1. How do matter and energy change form as they cycle through ecosystems and Earth's spheres?
2. Why do you think researchers had problems with low oxygen levels in Biosphere 2?
3. How would you solve this problem?

Lesson 4 Cycling of Matter and Energy in Ecosystems 169

Print Student Edition



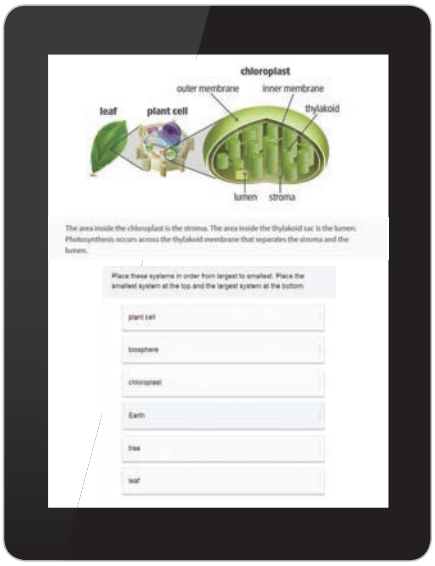
Unit Test

Scaffold to Higher-level Thinking Skills

Formal assessments build in complexity. **Unit Pretests** help you make sure students have the basic knowledge they need to enter the lessons. **Lesson Quizzes** provide a quick check that students are getting the 3D concepts. **Unit Tests** check for understanding and challenge students to apply what they've learned in new contexts. **Mid-Year** and **End-of-Year benchmark tests** help you make sure your students are on track to **achieve the Performance Expectations**. Parallel print assessments ensure that your students are challenged in the same way both on- and offline.

Prepare for High-Stakes Tests

Technology-enhanced assessment items (multi-select, drag and drop, etc.) prepare your students for modern **computer-based high-stakes tests**. Rigorous Mid-Year and End-of-Year benchmarks help you ensure that your students perform at a high depth of knowledge. Leveled benchmark tests help make the assessment accessible for all of your students.



Online Student Edition

Engage with Meaningful Technology

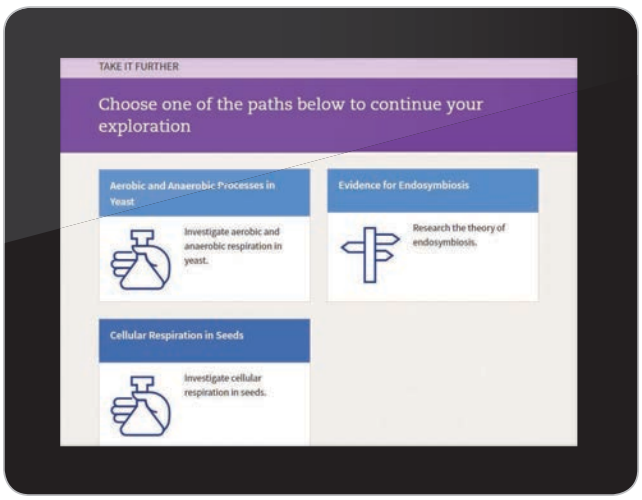
HMH Science Dimensions leverages the advantages of technology while prioritizing a **student-centered learning model**. Students can view videos and animations, interact with instructional images and text, enter responses, pursue their intellectual interests by choosing lesson paths, and enjoy simulation-based learning. All of these features help you maintain an **integrated three-dimensional approach** to learning science.

Immersive Digital Curriculum

Online lessons are enriched above and beyond the print lessons with educational videos, learning interactivities, and places to save student work as **typewritten responses** and **technology-enhanced item choices**. Vocabulary is highlighted and clickable, with point-of-use pop-up definitions.

Maximize Student Choice

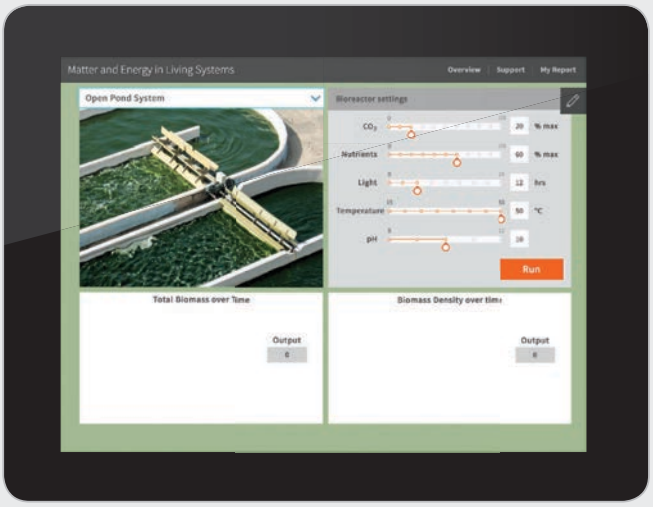
The **Take It Further** feature at the end of each lesson maximizes the opportunity for students to elaborate further on what they have learned so far. By leveraging the power of technology, students can continue to go in depth on **topics of their choice** to learn more and create stronger, more personal links to their learning.



Online Student Edition

Deepen Understanding with Open-Ended Simulations

Unique **You Solve It!** simulations provide completely **open-ended opportunities** for students to demonstrate their ability to problem solve and perform at the level described by the NGSS* Performance Expectations. The program encourages students to explore multiple answers to a problem and learn to develop explanations and defend their answers.



You Solve It!

HMH Field Trips

powered by

Google Expeditions

Explore Immersive Virtual Worlds with Google Expeditions

- As a Google content partner, HMH has developed field trips for Google Expeditions. Using a simple Google Cardboard™ device and a smartphone, students are swept away into **3D, 360-degree experiences** in fascinating locations directly tied to science content!
- An HMH **Teacher Guide** provides ideas for incorporating the Expeditions into your lessons, as well as tips on how to **guide** and **customize** the experience.
- Experience these **HMH Virtual Field Trips** with your students: Big Cypress National Preserve, Florida Everglades, Saturn V Rocket at NASA, Orange Blossom Cannonball Train, Kennedy Space Center, and more!

Learn more at **hmhco.com/fieldtrips**

The Ultimate Online and Offline Program Experience

- Teachers can look forward to accessing ***HMH Science Dimensions*** on **Ed: Your Friend in Learning**. Ed is a new online learning system that combines the best of technology, HMH content, and instruction to personalize the teaching and learning experience for every teacher and student. Ed is designed to be a friend to learners while supporting teachers and simplifying their instructional practice.
- Additionally, program content can be accessed offline through the ***HMH Player***® app. This allows for **maximum compatibility in 1:1** or in **Bring Your Own Device** learning environments and with the wide variety of technology that students have at home.

Ed
your friend in learning

HMHPLAYER®
Making 1:1 Learning a Reality

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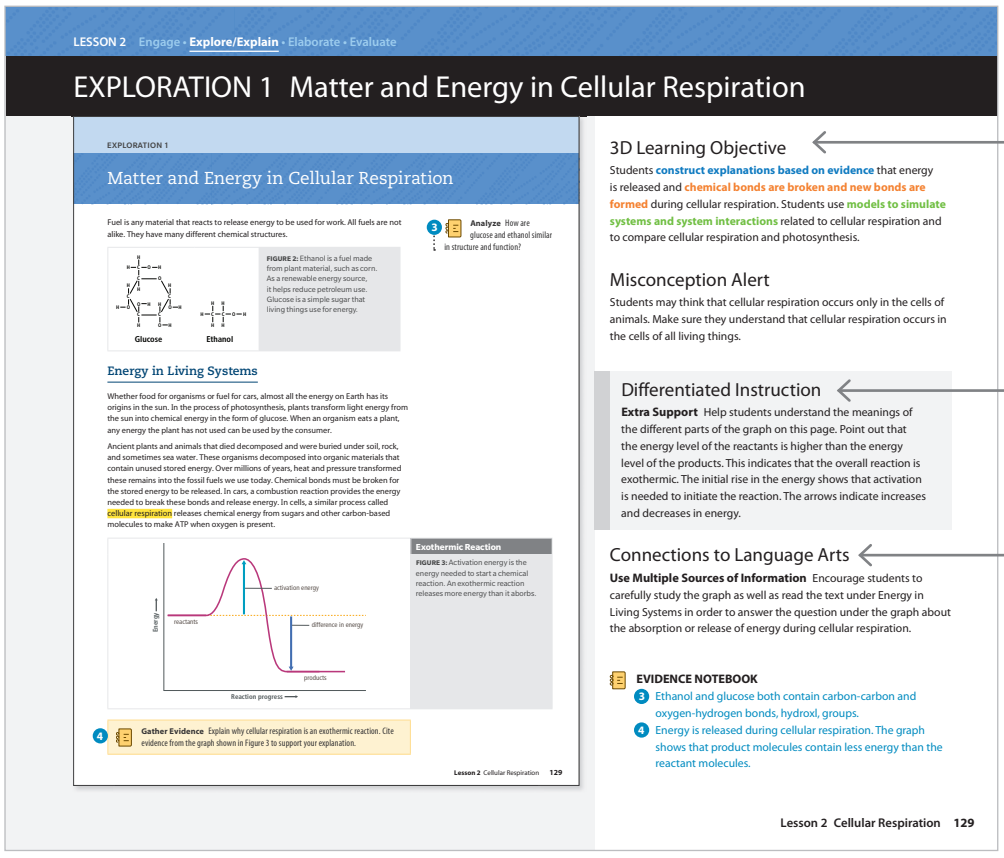
Three-Dimensional Learning Made Simple

HMH Science Dimensions expertly weaves the Three Dimensions of Learning into each lesson in order to meet the Performance Expectations (PEs). This braided approach takes the burden off you while ensuring a **high-quality 3D learning experience** for your students.

3D Learning Objectives

Each lesson has unique interrelated **3D Learning Objectives** that can be found in the Teacher Edition. The objective is generated from the SEPs, CCCs, and DCIs associated with the Performance Expectations correlated to the unit. These **custom stepping-stone objectives** ensure that the lessons cover 100% of the NGSS* material associated with the PEs.



LESSON 2 Engage • **Explore/Explain** • Elaborate • Evaluate

EXPLORATION 1 Matter and Energy in Cellular Respiration

EXPLORATION 1

Matter and Energy in Cellular Respiration

Fuel is any material that reacts to release energy to be used for work. All fuels are not alike. They have many different chemical structures.

FIGURE 2: Ethanol is a fuel made from plant material, such as corn. As a renewable energy source, it helps reduce petroleum use. Glucose is a simple sugar that living things use for energy.

Glucose Ethanol

3 **Analyze** How are glucose and ethanol similar in structure and function?

Energy in Living Systems

Whether food for organisms or fuel for cars, almost all the energy on Earth has its origins in the sun. In the process of photosynthesis, plants transform light energy from the sun into chemical energy in the form of glucose. When an organism eats a plant, any energy the plant has not used can be used by the consumer.

Ancient plants and animals that died decomposed and were buried under soil, rock, and sometimes sea water. These organisms decomposed into organic materials that contain unused stored energy. Over millions of years, heat and pressure transformed these remains into the fossil fuels we use today. Chemical bonds must be broken for the stored energy to be released. In cars, a combustion reaction provides the energy needed to break these bonds and release energy. In cells, a similar process called cellular respiration releases chemical energy from sugars and other carbon-based molecules to make ATP when oxygen is present.

Exothermic Reaction

FIGURE 3: Activation energy is the energy needed to start a chemical reaction. An exothermic reaction releases more energy than it absorbs.

activation energy
reactants
difference in energy
products
Energy
Reaction progress

4 **Gather Evidence** Explain why cellular respiration is an exothermic reaction. Cite evidence from the graph shown in Figure 3 to support your explanation.

Lesson 2 Cellular Respiration 129

3D Learning Objective

Students **construct explanations based on evidence** that energy is released and **chemical bonds are broken and new bonds are formed** during cellular respiration. Students use **models to simulate systems and system interactions** related to cellular respiration and to compare cellular respiration and photosynthesis.

Misconception Alert

Students may think that cellular respiration occurs only in the cells of animals. Make sure they understand that cellular respiration occurs in the cells of all living things.

Differentiated Instruction

Extra Support Help students understand the meanings of the different parts of the graph on this page. Point out that the energy level of the reactants is higher than the energy level of the products. This indicates that the overall reaction is exothermic. The initial rise in the energy shows that activation is needed to initiate the reaction. The arrows indicate increases and decreases in energy.

Connections to Language Arts

Use Multiple Sources of Information Encourage students to carefully study the graph as well as read the text under Energy in Living Systems in order to answer the question under the graph about the absorption or release of energy during cellular respiration.

EVIDENCE NOTEBOOK

3 Ethanol and glucose both contain carbon-carbon and oxygen-hydrogen bonds, hydroxl, groups.

4 Energy is released during cellular respiration. The graph shows that product molecules contain less energy than the reactant molecules.

Lesson 2 Cellular Respiration 129

Biology Teacher Edition

Enrich the Learning Experience

Additional Collaboration; Differentiate Instruction; Formative Assessment; and Claims, Evidence, and Reasoning suggestions provide a wealth of support and resources.

Incorporate English Language Arts and Math Connections

Strong math and reading skills are essential to ensuring STEM learning and science literacy. ***HMH Science Dimensions*** offers Common Core **Math and ELA connections** throughout the curriculum.

Clearly Labeled NGSS References

The NGSS labeling in the Teacher Edition clearly identifies all the PEs, SEPs, DCIs, and CCCs of NGSS, including the math and ELA connections. This helps educators **identify the standards** that are being covered in any given lesson.

LESSON 2

Cellular Respiration

Building to the Performance Expectations

The learning experiences in this lesson prepare students for mastery of:

HS-LS1-7 Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy.

HS-LS2-3 Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions.

Trace Tool to the NGSS
Go online to view the complete coverage of standards across lessons, units, and grade levels.

SEP Science & Engineering Practices

Developing and Using Models
Use a model based on evidence to illustrate the relationships between systems or between components of a system.

Constructing Explanations and Designing Solutions
Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.

DCI Disciplinary Core Ideas

LS1.C Organization for Matter and Energy Flow in Organisms
As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products. (HS-LS1-6), (HS-LS1-7)

LS1.C Organization for Matter and Energy Flow in Organisms
As a result of these chemical reactions, energy is transferred from one system of interacting molecules to another. Cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles. Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment.

LS2.B Cycles of Matter and Energy Transfer in Ecosystems
Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes. (HS-LS2-3)

CCC Crosscutting Concepts

Systems and System Models
Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales.

Energy and Matter
Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system.

Energy and Matter
Energy drives the cycling of matter within and between systems.

CONNECTIONS TO MATH

MP2 Reason abstractly and quantitatively.

HSN-Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

CONNECTIONS TO ENGLISH LANGUAGE ARTS

RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.

RST.11-12.9 Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.

128A Unit 3 Matter and Energy in Living Systems

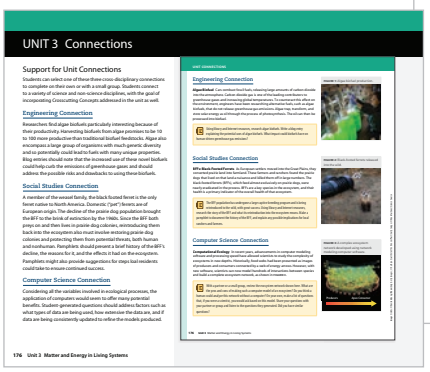
Biology Teacher Edition

Utilize the 5E Model

The **Teacher Edition** (online and print) is organized around the familiar **5E instructional model**. This helps to lower the learning curve and provide a solid foundation upon which to build an NGSS curriculum.

Cross-Curricular Integration

The TE provides connections to other science disciplines, like Physical Science, and Chemistry, within each lesson. Additionally, at the unit level, Unit Connections provide ideas for cross-curricular projects in engineering, social studies, computer science, and more.


UNIT 3 Connections

Support for Unit Connections

Students can select one of these three cross-disciplinary connections to complete on their own or with a small group. Students connect to a variety of science and non-science disciplines, with the goal of incorporating Crosscutting Concepts addressed in the unit as well.

Engineering Connection

Researchers find algae biofuels particularly interesting because of their productivity. Harvesting biofuels from algae promises to be 10 to 100 more productive than traditional biofuel feedstocks. Algae also encompass a large group of organisms with much genetic diversity and so potentially could lead to fuels with many unique properties. Blog entries should note that the increased use of these novel biofuels could help curb the emissions of greenhouse gases and should address the possible risks and drawbacks to using these biofuels.

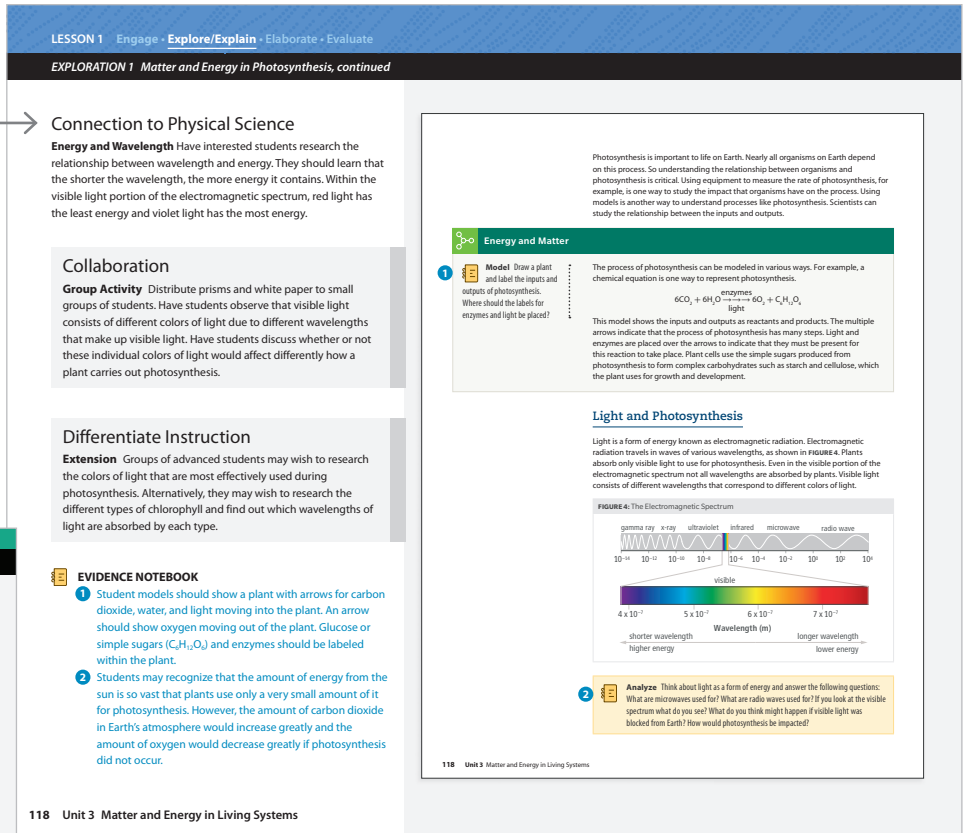
Social Studies Connection

A member of the wood family, the black-footed ferret is the only ferret native to North America. Domestic ("pet") ferrets are of European origin. The decline of the prairie dog population brought the BFF to the brink of extinction by the 1960s. Since the BFF both preys on and then lives in prairie dog colonies, reintroducing them back into the ecosystem also must involve restoring prairie dog colonies and protecting them from potential threats, both human and nonhuman. Pamphlets should present a brief history of the BFF's decline, the reasons for it, and the effects it had on the ecosystem. Pamphlets might also provide suggestions for steps local residents could take to ensure continued success.

Computer Science Connection

Considering all the variables involved in ecological processes, the application of computers would seem to offer many potential benefits. Student-generated questions should address factors such as what types of data are being used, how extensive the data are, and if data are being consistently updated to reflect the models produced.

176 Unit 3 Matter and Energy in Living Systems


LESSON 1 Engage • Explore/Explain • Elaborate • Evaluate

EXPLORATION 1 Matter and Energy in Photosynthesis, continued

Connection to Physical Science

Energy and Wavelength Have interested students research the relationship between wavelength and energy. They should learn that the shorter the wavelength, the more energy it contains. Within the visible light portion of the electromagnetic spectrum, red light has the least energy and violet light has the most energy.

Collaboration

Group Activity Distribute prisms and white paper to small groups of students. Have students observe that visible light consists of different colors of light due to different wavelengths that make up visible light. Have students discuss whether or not these individual colors of light would affect differently how a plant carries out photosynthesis.

Differentiate Instruction

Extension Groups of advanced students may wish to research the colors of light that are most effectively used during photosynthesis. Alternatively, they may wish to research the different types of chlorophyll and find out which wavelengths of light are absorbed by each type.

EVIDENCE NOTEBOOK

1. Student models should show a plant with arrows for carbon dioxide, water, and light moving into the plant. An arrow should show oxygen moving out of the plant. Glucose or simple sugars ($C_6H_{12}O_6$) and enzymes should be labeled within the plant.
2. Students may recognize that the amount of energy from the sun is so vast that plants use only a very small amount of it for photosynthesis. However, the amount of carbon dioxide in Earth's atmosphere would increase greatly and the amount of oxygen would decrease greatly if photosynthesis did not occur.

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Photosynthesis is important to life on Earth. Nearly all organisms on Earth depend on this process. So understanding the relationship between organisms and photosynthesis is critical. Using equipment to measure the rate of photosynthesis, for example, is one way to study the impact that organisms have on the process. Using models is another way to understand processes like photosynthesis. Scientists can study the relationship between the inputs and outputs.

Energy and Matter

1 **Model** Draw a plant and label the inputs and outputs of photosynthesis. Where should the labels for enzymes and light be placed?

The process of photosynthesis can be modeled in various ways. For example, a chemical equation is one way to represent photosynthesis.

$$6CO_2 + 6H_2O \xrightarrow[\text{light}]{\text{enzymes}} 6O_2 + C_6H_{12}O_6$$

This model shows the inputs and outputs as reactants and products. The multiple arrows indicate that the process of photosynthesis has many steps. Light and enzymes are placed over the arrows to indicate that they must be present for this reaction to take place. Plant cells use the simple sugars produced from photosynthesis to form complex carbohydrates such as starch and cellulose, which the plant uses for growth and development.

Light and Photosynthesis

Light is a form of energy known as electromagnetic radiation. Electromagnetic radiation travels in waves of various wavelengths, as shown in FIGURE 4. Plants absorb only visible light to use for photosynthesis. Even in the visible portion of the electromagnetic spectrum not all wavelengths are absorbed by plants. Visible light consists of different wavelengths that correspond to different colors of light.

FIGURE 4: The Electromagnetic Spectrum

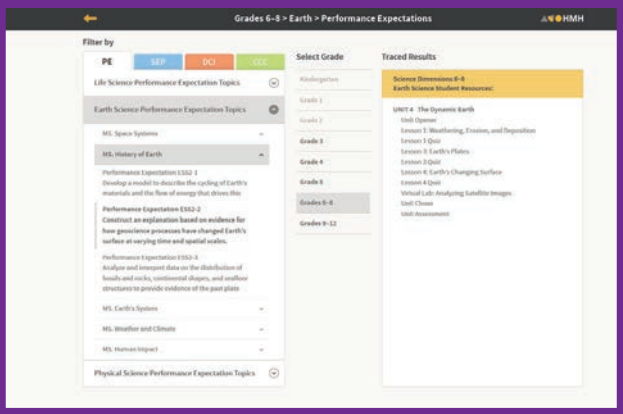
2 **Analyze** Think about light as a form of energy and answer the following questions: What are microwaves used for? What are radio waves used for? If you look at the visible spectrum what do you see? What do you think might happen if visible light was blocked from Earth? How would photosynthesis be impacted?

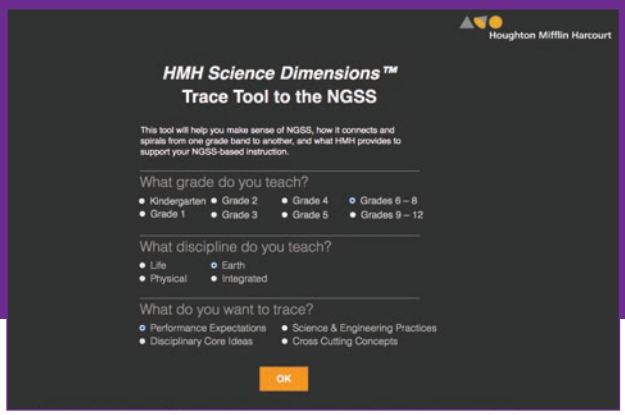
118 Unit 3 Matter and Energy in Living Systems

Biology Teacher Edition

Unmatched Professional Support Helps You Transition with Ease

An NGSS* curriculum requires a significantly different approach to teaching science, and although this new approach may be challenging, its **rewards** are immediate. HMH provides the support you need to make the transition to a **student-centered**, NGSS style of teaching.





Understand Where Your Instruction Fits

- The ***HMH Science Dimensions*** **Trace Tool to the NGSS** helps you make sense of the standards, understand how they connect and spiral from one grade to another, and **identify HMH resources** to support your NGSS-based instruction.
- You can **trace the standards** by PEs, SEPs, CCCs, or DCIs. When you click on a standard, you can view where in the program that standard is covered.
- But the **Trace Tool** is more powerful than a typical correlation—it also shows you **how each standard and each dimension spiral** throughout the entire K–12 sequence. See at a glance what students should know already and what you're preparing them for.

See NGSS in Action

Embedded professional development videos help teachers better prepare for this new approach to science education. Just-in-time videos featuring our **dynamic consulting authors** guide teachers through the key approaches that ensure NGSS success.

- » **Foundation** videos help educators and parents better understand NGSS, as well as the background that led up to their development.
- » **Engineering** videos support educators as they incorporate the design process into their classrooms.
- » **Challenging Content** videos for Grades 6–12 help educators know how to address specific content areas that students tend to struggle with in an NGSS curriculum.
- » **Labs & Classroom Practice** videos for Grades 9–12 provide suggestions for educators on how to implement NGSS curriculum.

Professional Support Videos

The **Support You Need**—When You Need It

Our comprehensive Professional Learning solutions for leaders, teachers, and families are data- and evidence-driven, mapped to your goals, centered around your students, and delivered by master educators. These tailored, flexible solutions were designed with one goal in mind: to help you more effectively prepare students for the Next Generation Science Standards.

Start Strong, Finish Stronger

A Getting Started with ***HMH Science Dimensions*** course will orient you to the program materials and technology, examine the instructional routines, help you support differentiation, and provide effective whole- and small-group instruction.

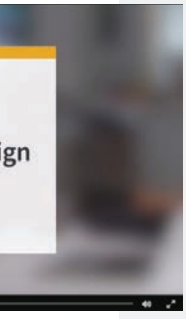
Need additional support with technology? Our **technical services team** can help you plan, prepare, implement, and optimize your technology so you can get the most out of ***HMH Science Dimensions*** digital tools. We will help to enhance your technology with learning management system interoperability, rostering, and single sign on within your environment.

Build Capacity, Ensure Success with In-Classroom Support

Our professional learning will provide you with a deeper focus on three-dimensional learning, in-class support to facilitate instructional strategies and routines, and confidence in your transition to the NGSS.

You'll get additional support with our **Team** and **Individual Coaching**. We'll be there to help you plan your lessons and model how to incorporate instructional strategies that help students' master the Next Generation Science Standards.

- **Ask questions, investigate and test ideas**
- **Collaborate, state claims and find resolutions**
- **Think like scientists**



Proven Results

In 2014, 80% of teachers reported that coaching significantly strengthened their classroom instruction.

Based on national survey data collected from teachers who received coaching from HMH during the 2014–2015 school year.

For more information, please visit us at **hmhco.com/professionalservices**

Program Components

Student Resources	Print	Online
Student Edition (includes *Thing Explainer* illustrations)	•	•
Student Edition, Interactive Online Edition		•
Math Handbook		•
English Language Arts Handbook		•
Science and Engineering Practices Handbook		•
Crosscutting Concepts Handbook		•
You Solve It! Simulations		•
Thing Explainer illustrations from Randall Munroe	• (SE)	•
CliffsNotes On the Job videos		•
Teacher Resources	**Print**	**Online**
Teacher Edition	•	•
Teacher Edition, Interactive Online Edition		•
Google Expeditions Teacher Guide		•
Assessment Guide (including Performance-Based Assessments)		•
Online Assessment with Item Banks		•

With its cohesive, spiraled approach to meeting the new standards, ***HMH Science Dimensions*** provides a consistent and engaging experience from kindergarten through high school. ***HMH Science Dimensions*** for Grades K–5 is available as a softcover, consumable write-in worktext for each grade, while Grades 6–8 content is available as 12 modules for Life Science, Earth & Space Science, Physical Science, and Engineering. ***HMH Science Dimensions*** for high school includes ***Biology, Earth & Space Science***, ***Chemistry,*** and ***Physics.*** (***Chemistry*** and ***Physics*** will be available in 2018.)

Three Ways to Learn More about This Groundbreaking New Program:

1. Visit **hmhco.com/ScienceDimensions**
2. Contact your HMH Account Executive: **hmhco.force.com/replocator**
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