Houghton Mifflin Harcourt

HMH SCIENCE DIMENSIONS™
ENGINEERED *for the* NEXT GENERATION

Earth & Space Science

Program Overview

GRADES 9–12

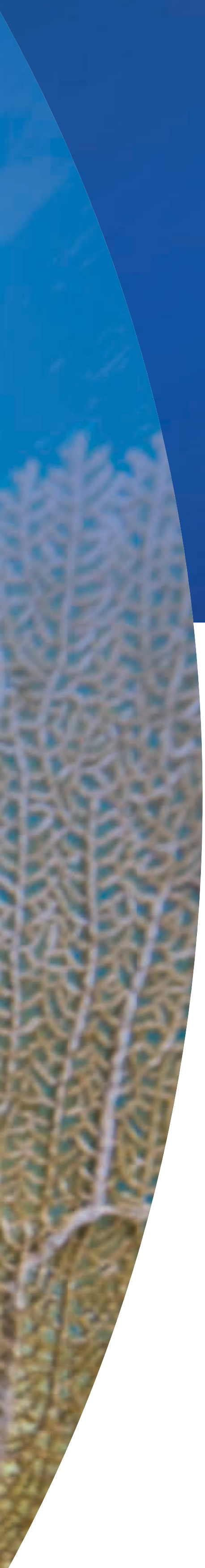
Built from the ground up for

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™

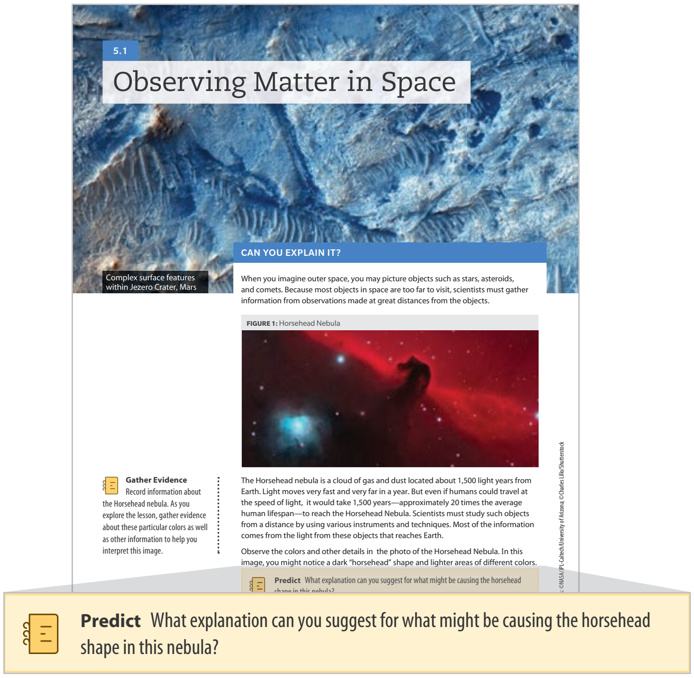
A **NEW** K–12 solution engineered for success with NGSS

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.**

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!


5.1

Observing Matter in Space

Complex surface features within Jezero Crater, Mars

CAN YOU EXPLAIN IT?

When you imagine outer space, you may picture objects such as stars, asteroids, and comets. Because most objects in space are too far to visit, scientists must gather information from observations made at great distances from the objects.

FIGURE 1: Horsehead Nebula

Gather Evidence Record information about the Horsehead nebula. As you explore the lesson, gather evidence about these particular colors as well as other information to help you interpret this image.

The Horsehead nebula is a cloud of gas and dust located about 1,500 light years from Earth. Light moves very fast and very far in a year. But even if humans could travel at the speed of light, it would take 1,500 years—approximately 20 times the average human lifespan—to reach the Horsehead Nebula. Scientists must study such objects from a distance by using various instruments and techniques. Most of the information comes from the light from these objects that reaches Earth.

Observe the colors and other details in the photo of the Horsehead Nebula. In this image, you might notice a dark "horsehead" shape and lighter areas of different colors.

©NASA/JPL-Caltech/University of Arizona; ©Charles Lillo/Shutterstock

Predict What explanation can you suggest for what might be causing the horsehead shape in this nebula?

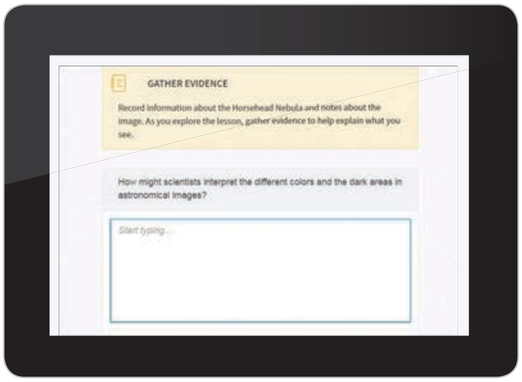
Print Student Edition

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

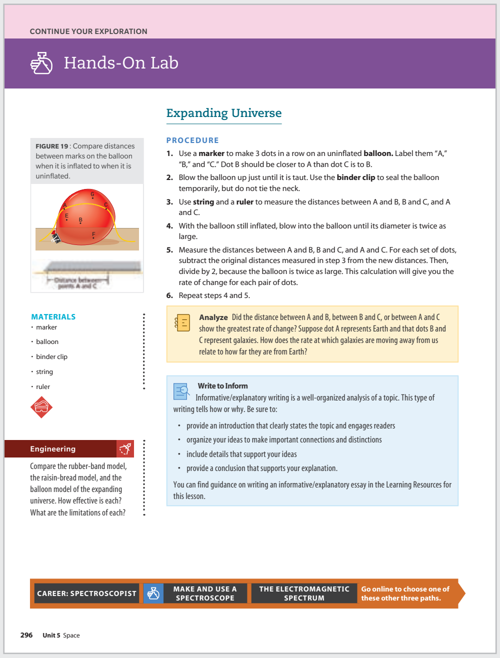
Many of the lessons in ***HMH Science Dimensions*** support the use of **Evidence Notebooks**. **Helpful prompts** have been inserted throughout the lessons to guide students on when to use these notebooks. Students will love creating their own study guides that can be taken into the next grade, and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


CONTINUE YOUR EXPLORATION

Hands-On Lab

Expanding Universe

FIGURE 19 : Compare distances between marks on the balloon when it is inflated to when it is uninflated.

PROCEDURE

1. Use a **marker** to make 3 dots in a row on an uninflated **balloon.** Label them "A," "B," and "C." Dot B should be closer to A than dot C is to B.
2. Blow the balloon up just until it is taut. Use the **binder clip** to seal the balloon temporarily, but do not tie the neck.
3. Use **string** and a **ruler** to measure the distances between A and B, B and C, and A and C.
4. With the balloon still inflated, blow into the balloon until its diameter is twice as large.
5. Measure the distances between A and B, B and C, and A and C. For each set of dots, subtract the original distances measured in step 3 from the new distances. Then, divide by 2, because the balloon is twice as large. This calculation will give you the rate of change for each pair of dots.
6. Repeat steps 4 and 5.

MATERIALS
- marker
- balloon
- binder clip
- string
- ruler

Analyze Did the distance between A and B, between B and C, or between A and C show the greatest rate of change? Suppose dot A represents Earth and that dots B and C represent galaxies. How does the rate at which galaxies are moving away from us relate to how far they are from Earth?

Engineering

Compare the rubber-band model, the raisin-bread model, and the balloon model of the expanding universe. How effective is each? What are the limitations of each?

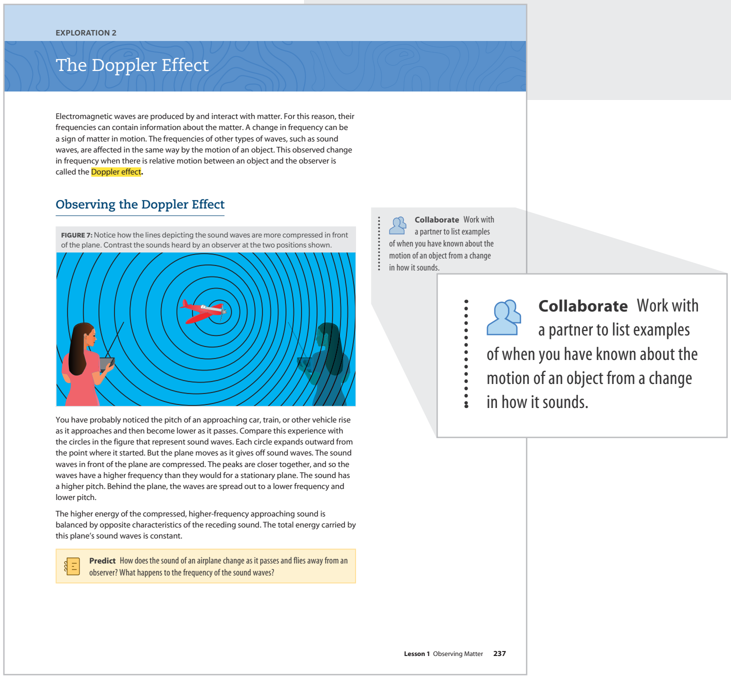
Write to Inform
Informative/explanatory writing is a well-organized analysis of a topic. This type of writing tells how or why. Be sure to:
- provide an introduction that clearly states the topic and engages readers
- organize your ideas to make important connections and distinctions
- include details that support your ideas
- provide a conclusion that supports your explanation.

You can find guidance on writing an informative/explanatory essay in the Learning Resources for this lesson.

CAREER: SPECTROSCOPIST | MAKE AND USE A SPECTROSCOPE | THE ELECTROMAGNETIC SPECTRUM | Go online to choose one of these other three paths.

296 Unit 5 Space

Print Student Edition


EXPLORATION 2

The Doppler Effect

Electromagnetic waves are produced by and interact with matter. For this reason, their frequencies can contain information about the matter. A change in frequency can be a sign of matter in motion. The frequencies of other types of waves, such as sound waves, are affected in the same way by the motion of an object. This observed change in frequency when there is relative motion between an object and the observer is called the Doppler effect.

Observing the Doppler Effect

FIGURE 7: Notice how the lines depicting the sound waves are more compressed in front of the plane. Contrast the sounds heard by an observer at the two positions shown.

Collaborate Work with a partner to list examples of when you have known about the motion of an object from a change in how it sounds.

You have probably noticed the pitch of an approaching car, train, or other vehicle rise as it approaches and then become lower as it passes. Compare this experience with the circles in the figure that represent sound waves. Each circle expands outward from the point where it started. But the plane moves as it gives off sound waves. The sound waves in front of the plane are compressed. The peaks are closer together, and so the waves have a higher frequency than they would for a stationary plane. The sound has a higher pitch. Behind the plane, the waves are spread out to a lower frequency and lower pitch.

The higher energy of the compressed, higher-frequency approaching sound is balanced by opposite characteristics of the receding sound. The total energy carried by this plane's sound waves is constant.

Predict How does the sound of an airplane change as it passes and flies away from an observer? What happens to the frequency of the sound waves?

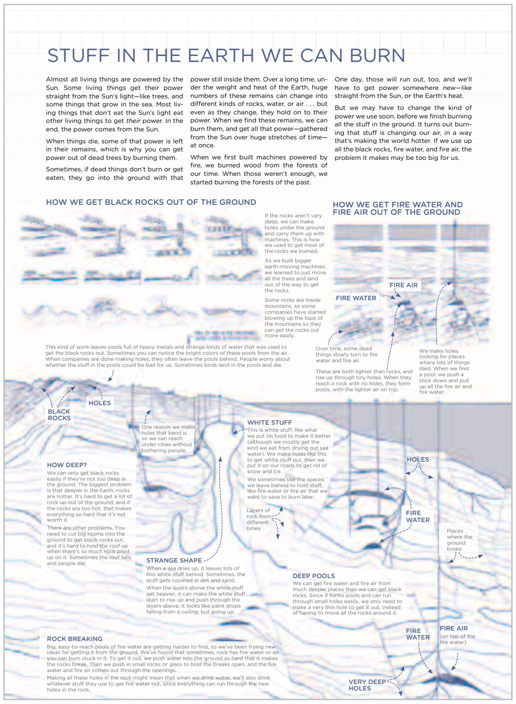
Lesson 1 Observing Matter 237

Collaborate Work with a partner to list examples of when you have known about the motion of an object from a change in how it sounds.

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.


STUFF IN THE EARTH WE CAN BURN

Almost all living things are powered by the Sun. Some living things get their power straight from the Sun's light—like trees, and some things that grow in the sea. Most living things that don't eat the Sun's light eat other living things to get *their* power. In the end, the power comes from the Sun.

When things die, some of that power is left in their remains, which is why you can get power out of dead trees by burning them.

Sometimes, if dead things don't burn or get eaten, they go into the ground with that power still inside them. Over a long time, under the weight and heat of the Earth, huge numbers of these remains can change into different kinds of rocks, water, or air . . . but even as they change, they hold on to their power. When we find these remains, we can burn them, and get all that power—gathered from the Sun over huge stretches of time—at once.

When we first built machines powered by fire, we burned wood from the forests of our time. When those weren't enough, we started burning the forests of the past.

One day, those will run out, too, and we'll have to get power somewhere new—like straight from the Sun, or the Earth's heat.

But we may have to change the kind of power we use soon, before we finish burning all the stuff in the ground. It turns out burning that stuff is changing our air, in a way that's making the world hotter. If we use up all the black rocks, fire water, and fire air, the problem it makes may be too big for us.

HOW WE GET BLACK ROCKS OUT OF THE GROUND

If the rocks aren't very deep, we can make holes under the ground and carry them up with machines. This is how we used to get most of the rocks we burned.

As we built bigger earth-moving machines, we learned to just move all the trees and land out of the way to get the rocks.

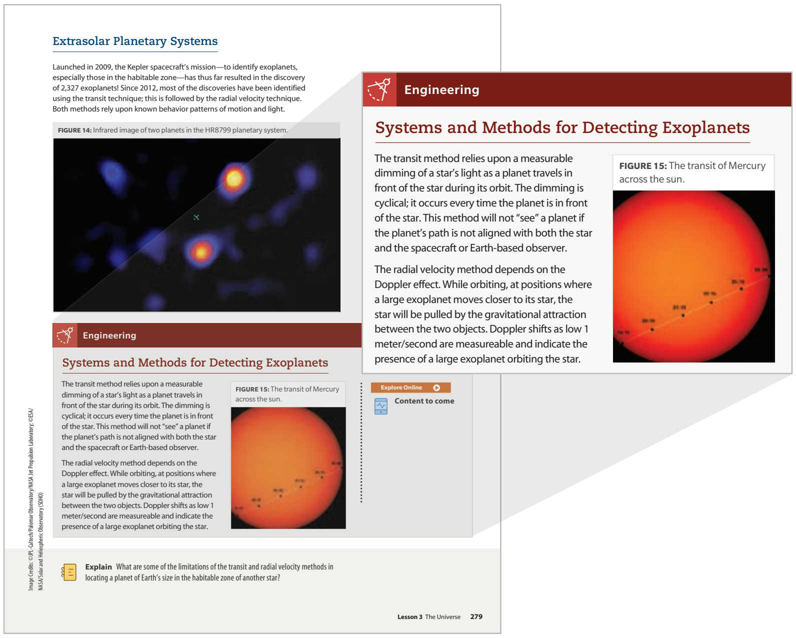
HOW WE GET FIRE WATER AND FIRE AIR OUT OF THE GROUND

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.



Extrasolar Planetary Systems

Launched in 2009, the Kepler spacecraft’s mission—to identify exoplanets, especially those in the habitable zone—has thus far resulted in the discovery of 2,327 exoplanets! Since 2012, most of the discoveries have been identified using the transit technique; this is followed by the radial velocity technique. Both methods rely upon known behavior patterns of motion and light.

FIGURE 14: Infrared image of two planets in the HR8799 planetary system.

Engineering

Systems and Methods for Detecting Exoplanets

The transit method relies upon a measurable dimming of a star’s light as a planet travels in front of the star during its orbit. The dimming is cyclical; it occurs every time the planet is in front of the star. This method will not “see” a planet if the planet’s path is not aligned with both the star and the spacecraft or Earth-based observer.

The radial velocity method depends on the Doppler effect. While orbiting, at positions where a large exoplanet moves closer to its star, the star will be pulled by the gravitational attraction between the two objects. Doppler shifts as low 1 meter/second are measureable and indicate the presence of a large exoplanet orbiting the star.

FIGURE 15: The transit of Mercury across the sun.

Explore Online

Content to come

Explain What are some of the limitations of the transit and radial velocity methods in locating a planet of Earth’s size in the habitable zone of another star?

Image Credits: ©JPL-Caltech/Palomar Observatory/NASA Jet Propulsion Laboratory; ©ESA/NASA/Solar and Heliospheric Observatory (SOHO)

Lesson 3 The Universe 279

Engineering

Systems and Methods for Detecting Exoplanets

The transit method relies upon a measurable dimming of a star’s light as a planet travels in front of the star during its orbit. The dimming is cyclical; it occurs every time the planet is in front of the star. This method will not “see” a planet if the planet’s path is not aligned with both the star and the spacecraft or Earth-based observer.

The radial velocity method depends on the Doppler effect. While orbiting, at positions where a large exoplanet moves closer to its star, the star will be pulled by the gravitational attraction between the two objects. Doppler shifts as low 1 meter/second are measureable and indicate the presence of a large exoplanet orbiting the star.

FIGURE 15: The transit of Mercury across the sun.

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

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

Dr. Mike Passow taught 44 years in middle school, high school, and college classrooms and continues to provide professional development for science teachers. He is the founder and organizer of the Earth2Class Workshops for Teachers at the Lamont-Doherty Earth Observatory of Columbia University and served multiple terms as President of the National Earth Science Teachers Association and National Association of Geoscience Teachers-Eastern Section.

Dr. Mike Passow

CONTINUE YOUR EXPLORATION

Careers in Science

Volcanologist

Volcanology is the study of volcanoes: volcanic landforms, volcanic rocks, and eruption processes. Many volcanologists are employed by federal and state governments to monitor active volcanoes. Others work as researchers and professors at universities.

Like other scientists, volcanologists **ask questions**, like *How does magma move underground? When will Yellowstone erupt again?* They **plan and carry out investigations** to make observations and collect data about active and extinct volcanoes in the field and in the lab; and **analyze and interpret data** collected using tools like temperature probes, gas meters, and seismographs. Volcanologists **make and use models** of volcanoes to describe the physical structure of the interior of a volcano, and **use math** to analyze their data and make predictions about eruptions. Finally and very importantly, volcanologists **communicate** their observations, analyses, and conclusions in volcano alert notifications, government reports, scientific journals, conferences, books, websites, films, and classes.

There are several different fields of volcanology. **Physical volcanologists** use simple tools like compasses and rock hammers as well as more complicated tools like gas samplers and thermal imaging cameras to map volcanic landforms and understand the processes that form them.

Geophysicists who work in volcanology use seismometers to understand how magma is moving underground and to predict when a volcano will erupt, gravity-meters to map structures underground, and magnetometers to identify and date different lava flows.

FIGURE 26

Collaborate With a partner, write a scientific question that a volcanologist might try to answer. What fields of volcanology would be involved? What tools would he or she need in an investigation to try to answer this question?

Language Arts Connection Choose a phenomenon related to volcanoes that you would like to investigate. Construct a plan for how you could investigate the phenomenon as well as how you would communicate your finding

HUMAN BOTTLENECK EVENT | HUMAN RESPONSE TO DISASTERS | VOLCANOLOGIST | Go online to choose one of these other paths.

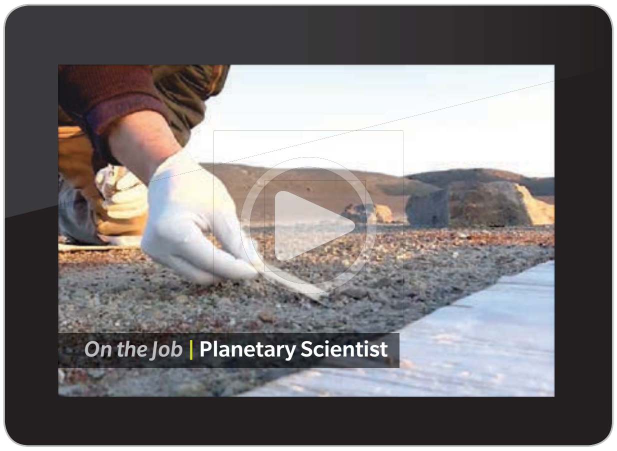
Image Credits:

19 Unit 6 Plate Tectonics

Earth and Space Science Print Student Edition

Inspire Students to Consider STEM Careers

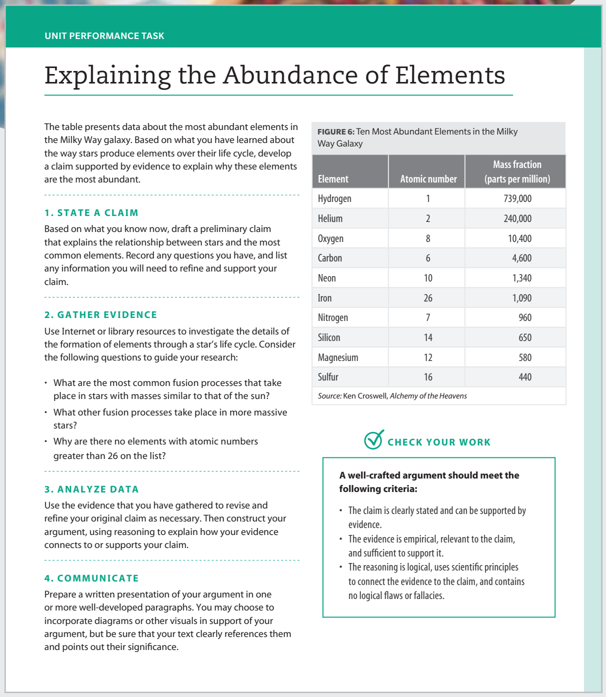
- The Take it Further (Elaborate) section of each unit features **Careers in Science**. These features show students the **real-world applications** of what they're learning and pique their interest in science-based careers.
- Additionally, as part of all our offerings, HMH now includes 29 *On the Job* 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

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.



UNIT PERFORMANCE TASK

Explaining the Abundance of Elements

The table presents data about the most abundant elements in the Milky Way galaxy. Based on what you have learned about the way stars produce elements over their life cycle, develop a claim supported by evidence to explain why these elements are the most abundant.

1. STATE A CLAIM

Based on what you know now, draft a preliminary claim that explains the relationship between stars and the most common elements. Record any questions you have, and list any information you will need to refine and support your claim.

2. GATHER EVIDENCE

Use Internet or library resources to investigate the details of the formation of elements through a star's life cycle. Consider the following questions to guide your research:

- What are the most common fusion processes that take place in stars with masses similar to that of the sun?
- What other fusion processes take place in more massive stars?
- Why are there no elements with atomic numbers greater than 26 on the list?

3. ANALYZE DATA

Use the evidence that you have gathered to revise and refine your original claim as necessary. Then construct your argument, using reasoning to explain how your evidence connects to or supports your claim.

4. COMMUNICATE

Prepare a written presentation of your argument in one or more well-developed paragraphs. You may choose to incorporate diagrams or other visuals in support of your argument, but be sure that your text clearly references them and points out their significance.

FIGURE 6: Ten Most Abundant Elements in the Milky Way Galaxy

Element	Atomic number	Mass fraction (parts per million)
Hydrogen	1	739,000
Helium	2	240,000
Oxygen	8	10,400
Carbon	6	4,600
Neon	10	1,340
Iron	26	1,090
Nitrogen	7	960
Silicon	14	650
Magnesium	12	580
Sulfur	16	440

Source: Ken Croswell, *Alchemy of the Heavens*

CHECK YOUR WORK

A well-crafted argument should meet the following criteria:

- The claim is clearly stated and can be supported by evidence.
- The evidence is empirical, relevant to the claim, and sufficient to support it.
- The reasoning is logical, uses scientific principles to connect the evidence to the claim, and contains no logical flaws or fallacies.

Performance-Based Assessment

Address Scientific Practices with Authentic Performance Assessments

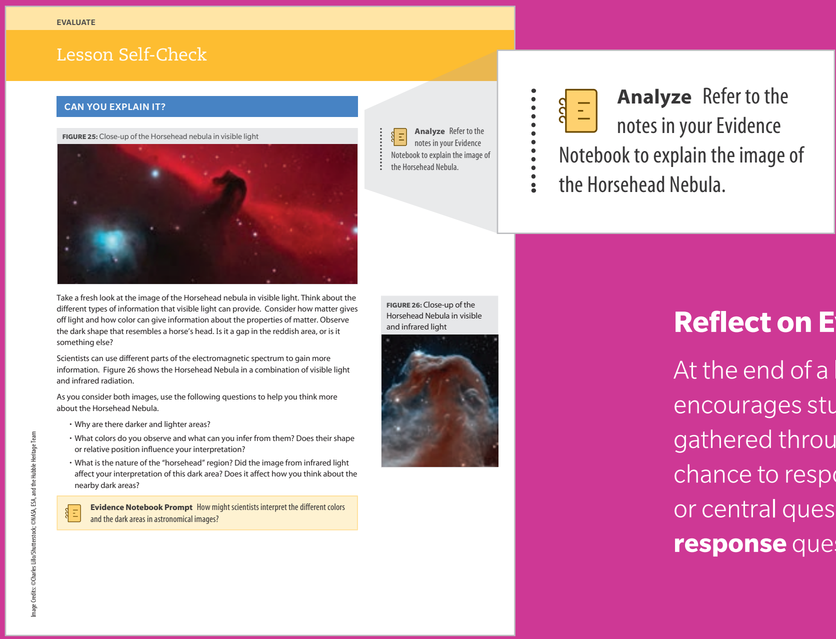
Performance-Based Assessments help you ensure that your students can perform the science and engineering practices called for by NGSS, and they guide students toward **making connections** across Performance Expectations.

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 Task Scoring Rubric

Points	Criteria
	claim is clearly stated and accurately describes the relationship between stellar fusion and the relative abundance of elements
	evidence is relevant to the claim and sufficient to support it
	reasoning is logical and clearly connects the evidence to the claim
	presentation is clearly written and makes effective use of visuals to help support the argument


EVALUATE

Lesson Self-Check

CAN YOU EXPLAIN IT?

FIGURE 25: Close-up of the Horsehead nebula in visible light

Take a fresh look at the image of the Horsehead nebula in visible light. Think about the different types of information that visible light can provide. Consider how matter gives off light and how color can give information about the properties of matter. Observe the dark shape that resembles a horse's head. Is it a gap in the reddish area, or is it something else?

Scientists can use different parts of the electromagnetic spectrum to gain more information. Figure 26 shows the Horsehead Nebula in a combination of visible light and infrared radiation.

As you consider both images, use the following questions to help you think more about the Horsehead Nebula.

- Why are there darker and lighter areas?
- What colors do you observe and what can you infer from them? Does their shape or relative position influence your interpretation?
- What is the nature of the "horsehead" region? Did the image from infrared light affect your interpretation of this dark area? Does it affect how you think about the nearby dark areas?

Evidence Notebook Prompt How might scientists interpret the different colors and the dark areas in astronomical images?

FIGURE 26: Close-up of the Horsehead Nebula in visible and infrared light

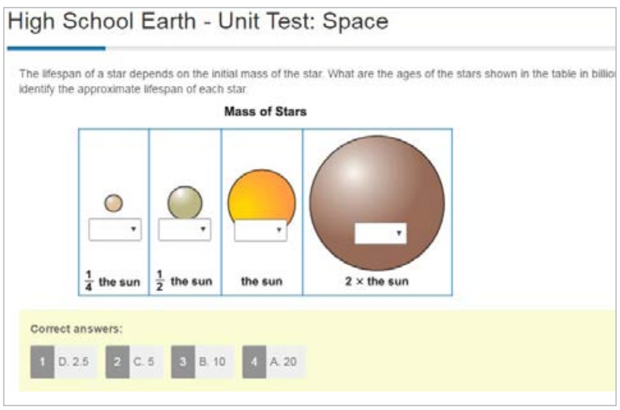
Analyze Refer to the notes in your Evidence Notebook to explain the image of the Horsehead Nebula.

Image Credits: ©Charles Lillo/Shutterstock; ©NASA, ESA, and the Hubble Heritage Team

Print Student Edition

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.



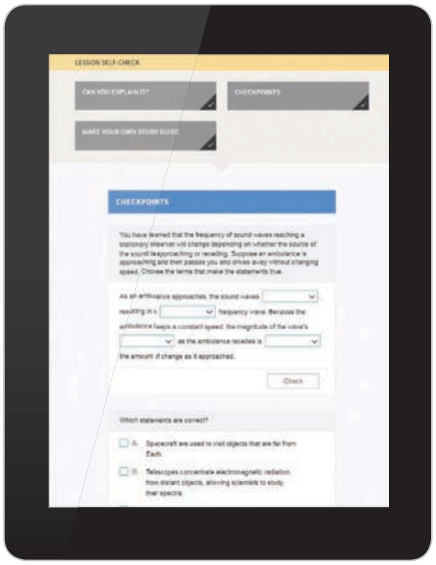
Unit Test

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

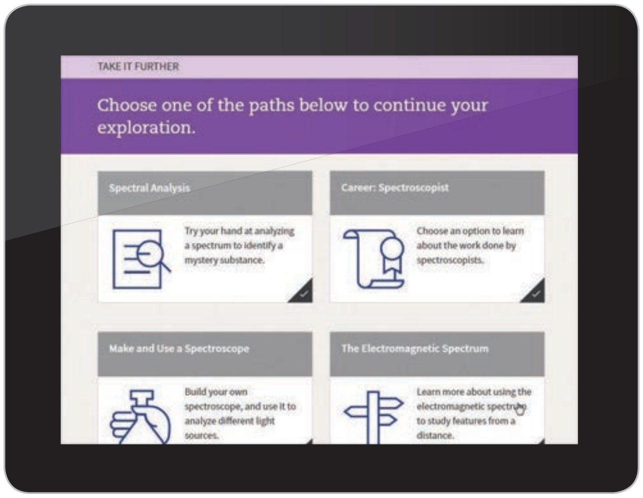
HMH Science Dimensions leverages the advantages of technology while prioritizing a **student-centered learning model**. Students can view videos and animations, interact with instructional images and text, enter responses, pursue their intellectual interests by choosing lesson paths, and enjoy simulation-based 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

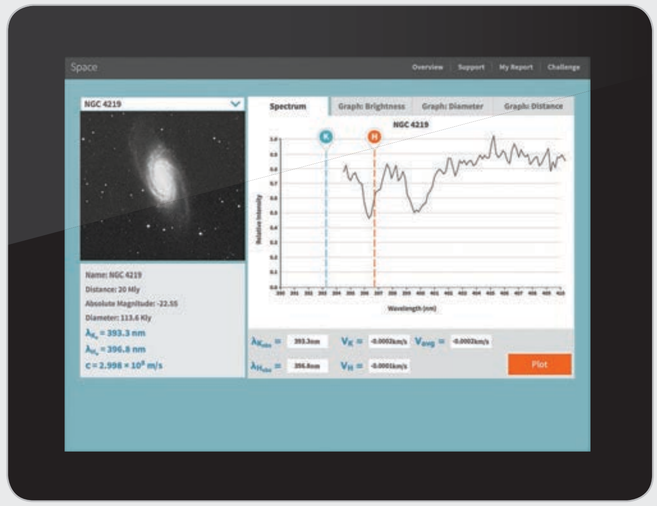
The **Take It Further** feature at the end of each lesson maximizes the opportunity for students to elaborate further on what they have learned so far. By leveraging the power of technology, students can continue to go in depth on **topics of their choice** to learn more and create stronger, more personal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

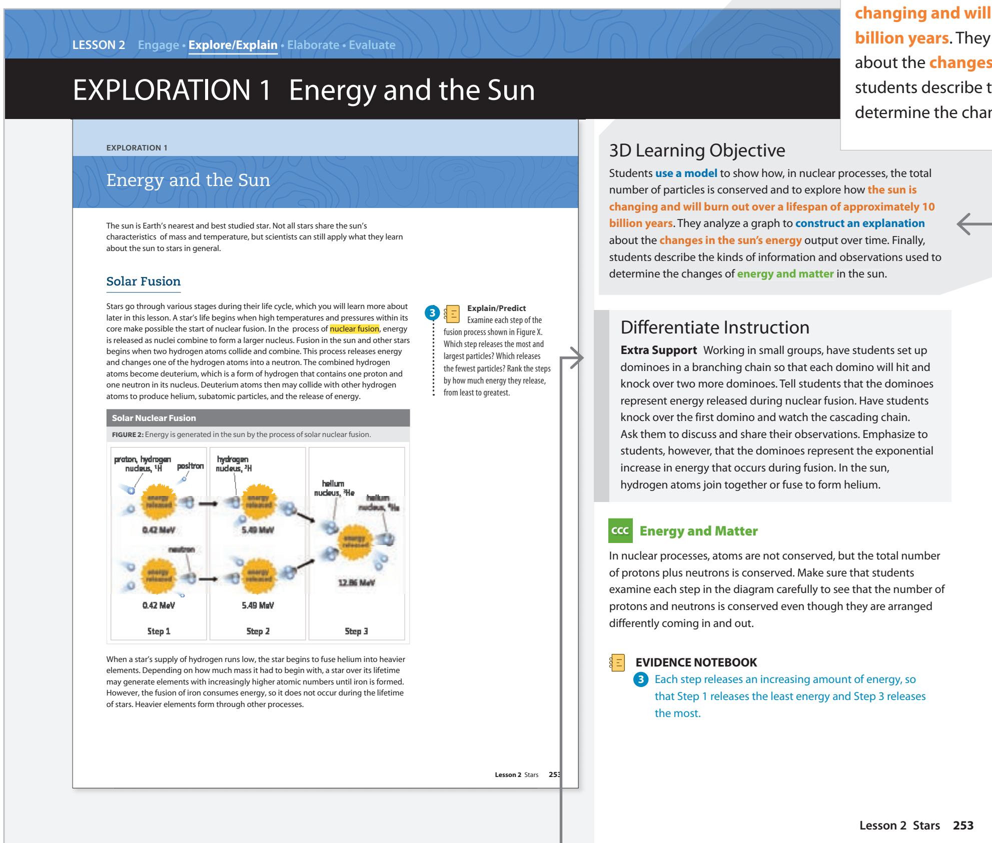
Making 1:1 Learning a Reality

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 Objective

Students **use a model** to show how, in nuclear processes, the total number of particles is conserved and to explore how **the sun is changing and will burn out over a lifespan of approximately 10 billion years**. They analyze a graph to **construct an explanation** about the **changes in the sun's energy** output over time. Finally, students describe the kinds of information and observations used to determine the changes of **energy and matter** in the sun.



LESSON 2 Engage • Explore/Explain • Elaborate • Evaluate

EXPLORATION 1 Energy and the Sun

EXPLORATION 1

Energy and the Sun

The sun is Earth's nearest and best studied star. Not all stars share the sun's characteristics of mass and temperature, but scientists can still apply what they learn about the sun to stars in general.

Solar Fusion

Stars go through various stages during their life cycle, which you will learn more about later in this lesson. A star's life begins when high temperatures and pressures within its core make possible the start of nuclear fusion. In the process of nuclear fusion, energy is released as nuclei combine to form a larger nucleus. Fusion in the sun and other stars begins when two hydrogen atoms collide and combine. This process releases energy and changes one of the hydrogen atoms into a neutron. The combined hydrogen atoms become deuterium, which is a form of hydrogen that contains one proton and one neutron in its nucleus. Deuterium atoms then may collide with other hydrogen atoms to produce helium, subatomic particles, and the release of energy.

3 Explain/Predict Examine each step of the fusion process shown in Figure X. Which step releases the most and largest particles? Which releases the fewest particles? Rank the steps by how much energy they release, from least to greatest.

Solar Nuclear Fusion

FIGURE 2: Energy is generated in the sun by the process of solar nuclear fusion.

When a star's supply of hydrogen runs low, the star begins to fuse helium into heavier elements. Depending on how much mass it had to begin with, a star over its lifetime may generate elements with increasingly higher atomic numbers until iron is formed. However, the fusion of iron consumes energy, so it does not occur during the lifetime of stars. Heavier elements form through other processes.

Lesson 2 Stars 253

3D Learning Objective

Students **use a model** to show how, in nuclear processes, the total number of particles is conserved and to explore how **the sun is changing and will burn out over a lifespan of approximately 10 billion years**. They analyze a graph to **construct an explanation** about the **changes in the sun's energy** output over time. Finally, students describe the kinds of information and observations used to determine the changes of **energy and matter** in the sun.

Differentiate Instruction

Extra Support Working in small groups, have students set up dominoes in a branching chain so that each domino will hit and knock over two more dominoes. Tell students that the dominoes represent energy released during nuclear fusion. Have students knock over the first domino and watch the cascading chain. Ask them to discuss and share their observations. Emphasize to students, however, that the dominoes represent the exponential increase in energy that occurs during fusion. In the sun, hydrogen atoms join together or fuse to form helium.

CCC **Energy and Matter**

In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. Make sure that students examine each step in the diagram carefully to see that the number of protons and neutrons is conserved even though they are arranged differently coming in and out.

EVIDENCE NOTEBOOK

3 Each step releases an increasing amount of energy, so that Step 1 releases the least energy and Step 3 releases the most.

Lesson 2 Stars 253

Earth & Space Science Teacher Edition

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.

Enrich the Learning Experience

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

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 3

The Universe

Building to the Performance Expectation(s)

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

HS-ESS1-2 Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe.

HS-ESS1-3 Communicate scientific ideas about the way stars, over their life cycle, produce elements.

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
Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.

Obtaining, Evaluating, and Communicating Information
Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (i.e., orally, graphically, textually, mathematically).

DCI Disciplinary Core Ideas

ESS1.A The Universe and Its Stars
The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth. [HS-ESS1-3]

ESS1.A The Universe and Its Stars
The Big Bang theory is supported by observations of distant galaxies receding from our own, of the measured composition of stars and non-stellar gases, and of the maps of spectra of the primordial radiation (cosmic microwave background) that still fills the universe. [HS-ESS1-2]

ESS1.A The Universe and Its Stars
Other than the hydrogen and helium formed at the time of the Big Bang, nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and the process releases electromagnetic energy. Heavier elements are produced when certain massive stars achieve a supernova stage and explode. [HS-ESS1-2] [HS-ESS1-3]

CCC Crosscutting Concepts

Scale, Proportion, and Quantity
The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs.

Energy and Matter
In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.

CONNECTIONS TO MATH

HSN-Q.A.1 Use units as a way to understand scale; interpret the scale in graphs and data displays.

HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling.

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

MP.4 Model with mathematics.

CONNECTIONS TO ENGLISH LANGUAGE ARTS

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

270A Unit 5 Space

Earth & Space Science Teacher Edition

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.

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.

LESSON 3 Engage • **Explore/Explain** • Elaborate • Evaluate

EXPLORATION 2 Patterns in the Universe, continued

Physical Science Connection

Patterns of Motion Prior to class, find an image showing the effect of magnetic fields on iron pilings. Display the image, and ask students to explain the principle behind the image. Correct student misconceptions as needed. Then, display the image in Figure 13. Ask students to compare how the two Images are similar. Pose the question: How does the similarity show that natural laws produce similar patterns in the universe? Discuss. Find other examples of patterns of motion, such as vortices generated by water and air and ripples created by objects dropped in a still body of water.

DCI ESS1.A The Universe and Its Stars

Have small student groups work together to complete a Cause-and-Effect Diagram showing how patterns of motion apply to the Big Bang Theory.

Collaboration

Write Fast Pose the question: How might a photograph of the entire universe resemble the images shown in Figure 13? What caption would explain the pattern of motion shown in the image? Give students three minutes to write a response. Organize students into small groups, and ask them to discuss their responses.

EVIDENCE NOTEBOOK

1 Students should recognize that objects found throughout the universe rotate and orbit around other objects as a result of gravitational attraction. Moons orbit planets; planets orbit stars. Objects such as planets, stars, and even galaxies and black holes also rotate around a central axis as a result of gravitational attraction. These patterns of motion provide can also be seen in the acceleration of matter from the point of the universe's initial formation, or birth, in the Big Bang.

278 Unit 5 Space

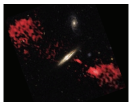
Patterns in Motion

You know that the moon orbits Earth and the Earth-moon system orbits the sun. As this occurs, Earth spins on its axis every 24 hours with one rotation defining the length of an Earth day. Objects rotating and orbiting around other objects are found throughout the universe, and the observed motion results from the gravitational attraction that formed these objects.

FIGURE 12: The same motion observed when the moon orbits Earth is seen in the rings orbiting the planet Saturn. The spiral galaxy and black hole spin around a central axis, much like Earth's rotation on its axis.

a **SATURN'S RINGS** Rings of icy and rocky material orbit Saturn

b **MILKY WAY** Spiral Galaxies rotate about their center



c **BLACK HOLE** A supermassive black hole rotates about a central axis.

1 **Explain** Describe the patterns of motion you have learned about and evaluate how they tell us about the processes shaping the evolution of the universe.

As an object rotates on its axis, areas closer to the equator must travel faster to complete a 360° rotation than areas located near the poles. As a result, the object flattens in the polar regions over time. Perfectly spherical objects are rarely observed in the universe because some degree of rotation is common.

A variety of other patterns can be observed in the universe. For example, Doppler shifts reveal yet another pattern of motion in the acceleration of all matter as a result of the Big Bang. On a much smaller scale, a pattern of motion results when small charged particles shed from stars in solar wind intercept the magnetic field of another object.

FIGURE 13: Small charged particles are deflected by a magnetic field much as the orientation of iron filings is affected by a bar magnet.

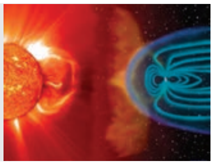


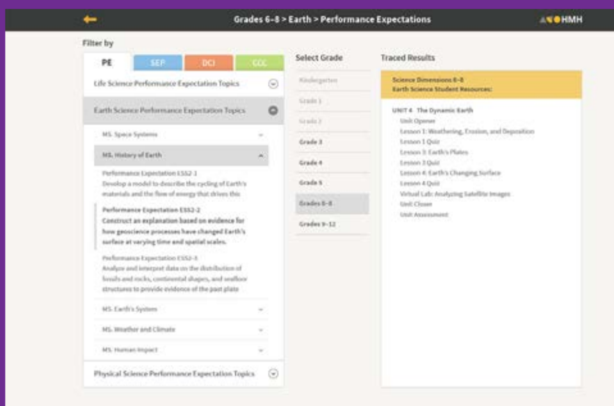
Image Credits: ©NASA; ©Hubble Heritage Team/STScI/AURA/NASA Goddard Space Flight Center; ©NRAO/AUI/NSF/W. Keel/University of Alabama, Tuscaloosa/NASA; SOHO (ESA & NASA)

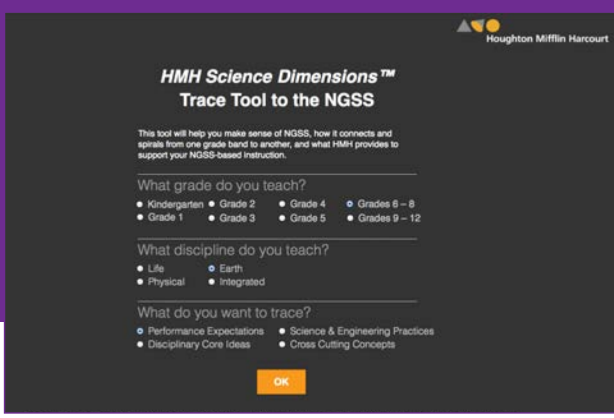
278 Unit 5 Space

Earth & Space Science 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 spirals** 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.) The high school Student Editions are available as hardcover textbooks.

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**
3. To request an online preview, go to: **hmhco.com/MeetEd**

Connect with us:

#HMHScience

Houghton Mifflin Harcourt