Houghton Mifflin Harcourt™

HMH SCIENCE DIMENSIONS™ ENGINEERED for the NEXT GENERATION

Earth & Space Science

© 2018
GRADES 9–12

Effective NGSS Instruction

Your Guide to the 5Es and Three-Dimensional Learning

NEXT GENERATION SCIENCE STANDARDS

Print & Digital Curriculum

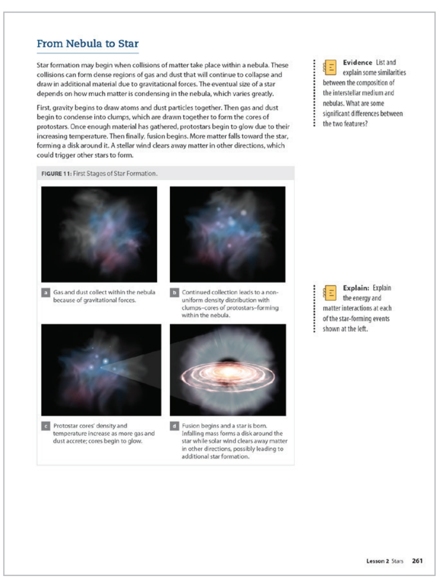
HMH Science Dimensions™ provides the richest NGSS*-based 3D learning experiences available. Whether you choose print, digital, or a combination approach, students will be ready to succeed at the **Performance Expectations**.

BOTH PATHS OFFER

- Parallel Lesson Content
- Hands-on Investigations
- 5E Learning Model
- Math & ELA Connections
- Evidence Notebooking
- Engineering Activities
- Collaborative Learning
- Assessments
- Unit Performance Tasks
- Three-Dimensional Learning

PRINT PATH

High school *Earth & Space Science* builds interest with a hardcover text enlivened by cartoons from Randall Munroe's *Thing Explainer.*


From Nebula to Star

Star formation may begin when collisions of matter take place within a nebula. These collisions can form dense regions of gas and dust that will continue to collapse and draw in additional material due to gravitational forces. The eventual size of a star depends on how much matter is condensing in the nebula, which varies greatly.

First, gravity begins to draw atoms and dust particles together. Then gas and dust begin to condense into clumps, which are drawn together to form the cores of protostars. Once enough material has gathered, protostars begin to glow due to their increasing temperature. Then finally, fusion begins. More matter falls toward the star, forming a disk around it. A stellar wind clears away matter in other directions, which could trigger other stars to form.

Evidence List and explain some similarities between the composition of the interstellar medium and nebulas. What are some significant differences between the two features?

FIGURE 11: First Stages of Star Formation.

a Gas and dust collect within the nebula because of gravitational forces.

b Continued collection leads to a non-uniform density distribution with clumps–cores of protostars–forming within the nebula.

c Protostar cores' density and temperature increase as more gas and dust accrete; cores begin to glow.

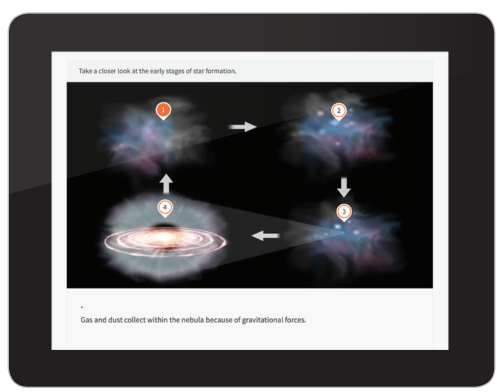
d Fusion begins and a star is born. Infalling mass forms a disk around the star while solar wind clears away matter in other directions, possibly leading to additional star formation.

Explain: Explain the energy and matter interactions at each of the star-forming events shown at the left.

Lesson 2 Stars 261

DIGITAL PATH

The robust interactive online Student Edition contains all the content from the print books, enhanced with high-interest interactive elements!



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Digital? Print? It's Your Choice!

Because both the digital and print paths include the same content, your learners can follow *any* path to the Performance Expectations that you designate. Leverage digital for small-group work, flipped classrooms, learning centers, and 1:1 technology situations.

Lesson	PRINT	OR	DIGITAL
Lesson Assessment	PRINT	OR	DIGITAL
Unit Assessment	PRINT	OR	DIGITAL
Unit Performance Task	PRINT	OR	DIGITAL
You Solve It! Simulations			DIGITAL

Whether you use the print book or the online interactive Student Edition, your students will encounter plenty of opportunities for **science and engineering practices, small-group work,** and **collaborative projects!**

HMH Science Dimensions

Designed—not aligned—for NGSS

HMH Science Dimensions Earth & Space Science was built for you from the ground up to authentically and effectively address both the spirit and the letter of the Next Generation Science Standards (NGSS)*.

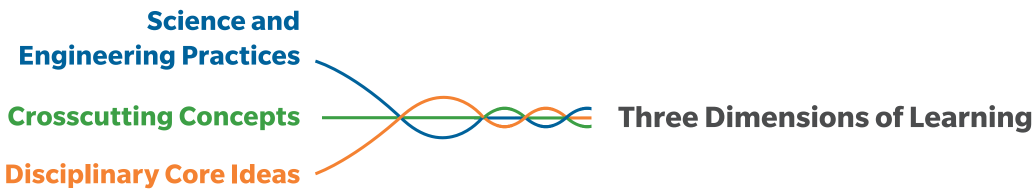
The Digital Advantage

HMH Science Dimensions Earth & Space Science incorporates highly motivating interactive digital elements, such as animations, videos, simulations, and more. This approach allows the program to harness the power of technology so that students are more engaged, resulting in a more effective learning experience. Throughout this walkthrough, note the **DIGITAL ADVANTAGE** sections highlighting the interactive elements designed to optimize learning.

NEXT GENERATION SCIENCE STANDARDS

Three-Dimensional Learning

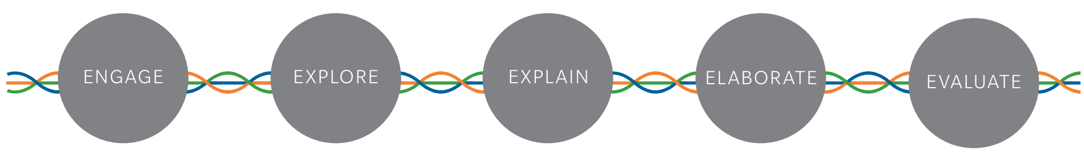
Any curriculum based on the NGSS must integrate the **Science and Engineering Practices, Crosscutting Concepts,** and **Disciplinary Core Ideas** (the Three Dimensions of Learning) throughout all lessons. ***HMH Science Dimensions*** intertwines the Three Dimensions into a cohesive, braided approach that ensures students will increase science proficiency.



Lesson Structure—the 5E Model

HMH Science Dimensions consists of units containing closely related lessons.

Each lesson is built around the familiar **5E instructional model**, endorsed by NGSS thought leaders. We've overlaid the **Claims/Evidence/Reasoning** learning model below with the 5Es to give you a better understanding of how a pedagogy driven by NGSS aligns to the 5Es.



ENGAGE Stimulated to engage with a discrepant phenomenon or puzzling question, students begin each lesson by making connections to the real world around them.

▶ **CLAIMS** Students hypothesize a model or explanation to the puzzle or problem presented. By evaluating their own mental models, students are prepared to study the phenomenon.

EXPLORE Inspired to explore new concepts and gather evidence, they learn actively through a variety of activities and resources.

▶ **EVIDENCE** Students perform experiments and pursue several methods of scientific inquiry to gather data and explore their model.

EXPLAIN Challenged to explain and test their ideas and claims, students become skilled at reasoning about how well their evidence supports their claims.

▶ **REASONING** Armed with real data related to the initial phenomenon or problem, students draw conclusions and adjust models.

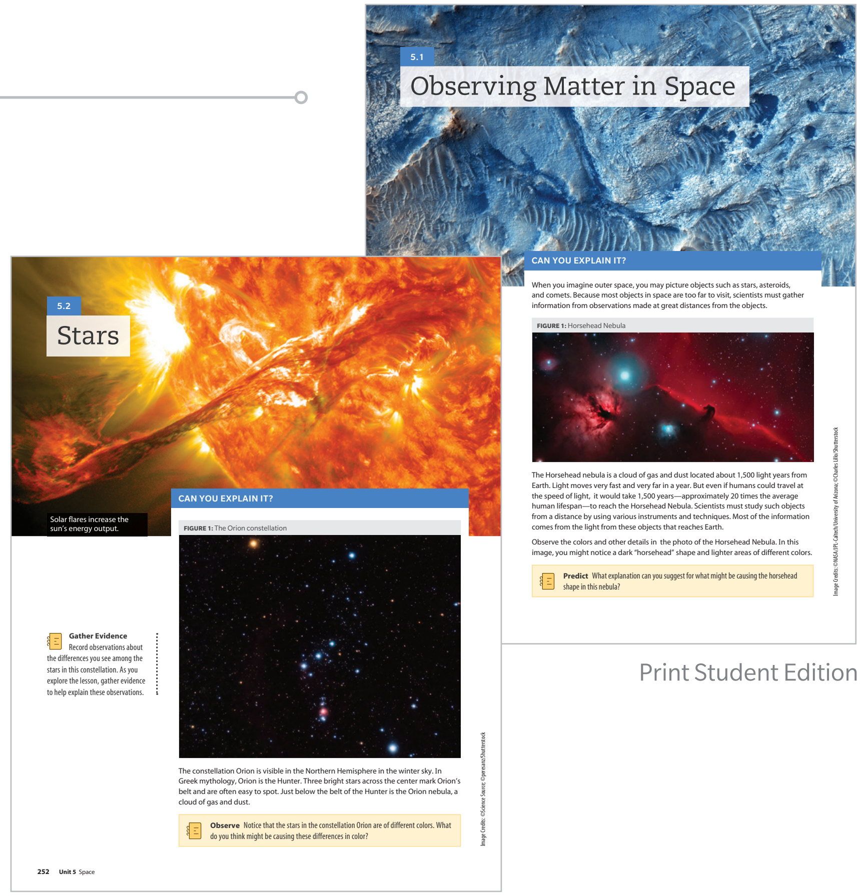
ELABORATE Motivated to extend their new learning, students apply this knowledge in different situations to deepen understanding.

EVALUATE Enabled to evaluate how their understanding has changed, students are supported by a progression of formative and summative activities during the lesson.

ENGAGE

Every lesson starts with an Engage opportunity that asks: **Can You Explain It?** The Engage section involves a **phenomenon to explain**, **a problem to solve**, or a **discrepant event** to spark students' curiosity.

As students state **claims**, they begin to analyze their assumptions and ideas, preparing for the learning experiences that follow.



Print Student Edition

DIGITAL ADVANTAGE

Interactive Illustrations

The interactive nature of online illustrations maximizes student engagement. ***HMH Science Dimensions Earth & Space Science*** encourages learners to interact with images online. The digital delivery platform also supports students in **entering and organizing their thoughts** as they collect evidence throughout the lesson.

Interactive Online Student Edition

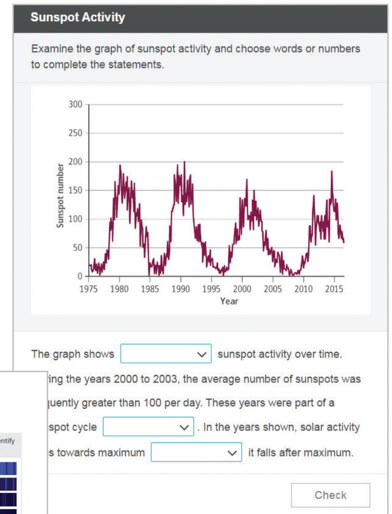
EXPLORE & EXPLAIN

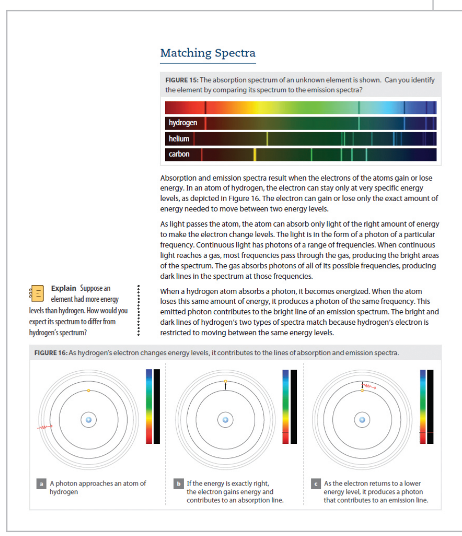
In the next phases of the 5E model, a series of related Explore & Explain activities are organized as **Explorations**. During these activities, learners embark on a discovery process of gathering **evidence** to either support or challenge their **claims** through:

- hands-on activities and labs
- data analysis
- instructional diagrams
- informative videos
- immersive virtual activities

Throughout the lesson, students are prompted to record their evidence using **Evidence Notebooks** where appropriate.

Student-directed formative assessments embedded in the lesson help students assess the evidence they gather. They also share their evidence with peers and collaborate on the activities.





Matching Spectra

FIGURE 15: The absorption spectrum of an unknown element is shown. Can you identify the element by comparing its spectrum to the emission spectra?

hydrogen
helium
carbon

Absorption and emission spectra result when the electrons of the atoms gain or lose energy. In an atom of hydrogen, the electron can stay only at very specific energy levels, as depicted in Figure 16. The electron can gain or lose only the exact amount of energy needed to move between two energy levels.

As light passes the atom, the atom can absorb only light of the right amount of energy to make the electron change levels. The light is in the form of a photon of a particular frequency. Continuous light has photons of a range of frequencies. When continuous light reaches a gas, most frequencies pass through the gas, producing the bright areas of the spectrum. The gas absorbs photons of all of its possible frequencies, producing dark lines in the spectrum at those frequencies.

Explain Suppose an element had more energy levels than hydrogen. How would you expect its spectrum to differ from hydrogen's spectrum?

When a hydrogen atom absorbs a photon, it becomes energized. When the atom loses this same amount of energy, it produces a photon of the same frequency. This emitted photon contributes to the bright line of an emission spectrum. The bright and dark lines of hydrogen's two types of spectra match because hydrogen's electron is restricted to moving between the same energy levels.

FIGURE 16: As hydrogen's electron changes energy levels, it contributes to the lines of absorption and emission spectra.

a A photon approaches an atom of hydrogen

b If the energy is exactly right, the electron gains energy and contributes to an absorption line.

c As the electron returns to a lower energy level, it produces a photon that contributes to an emission line.

Predict If hydrogen gas were illuminated by emission from another gas, rather than by a continuous source, how would the spectrum appear?

Hands-On Activity

Modeling Parallax

PROCEDURE

1. Hold your thumb at arm's length. Close your left eye and note the position of your thumb relative to a distant object, such as a tree or a picture on the wall.
2. Without moving your head, open your left eye and close your right eye. Again note the position of your thumb relative to the distant object. How does the amount of observed parallax change if your thumb is closer to your eyes?

Analyze Describe the parallax you observed. How might parallax help you tell the difference between a distant airplane and a nearby model airplane?

Print Student Edition

CLAIMS EVIDENCE REASONING

ENGAGE EXPLORE EXPLAIN ELABORATE EVALUATE

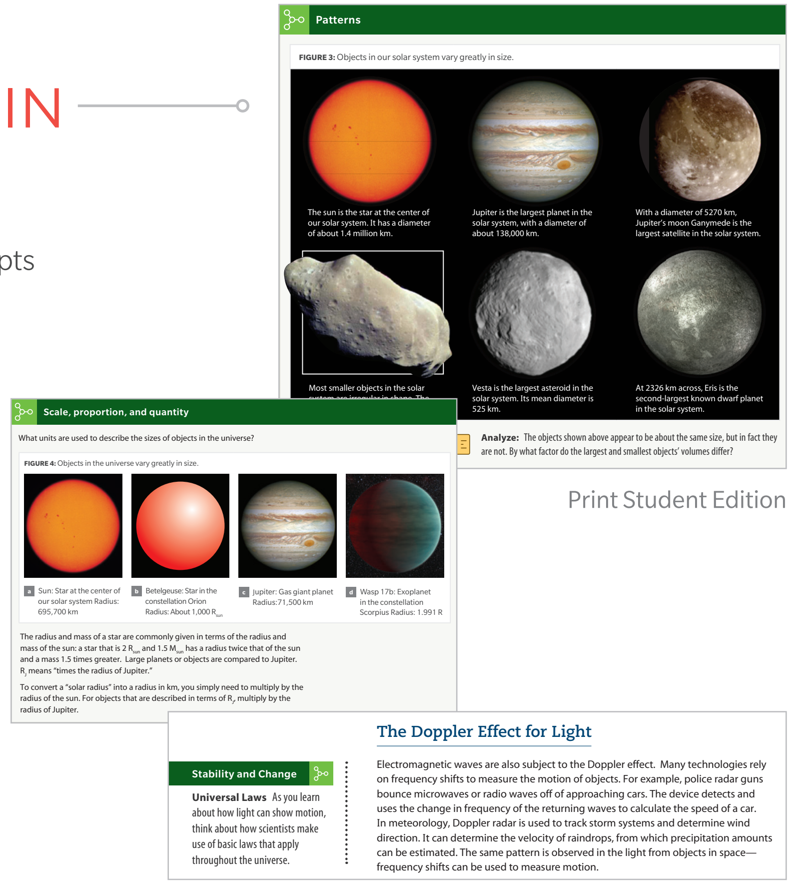
Three Dimensions of Learning

EXPLORE & EXPLAIN

Crosscutting Concepts

In each lesson, important Crosscutting Concepts are called out via a special feature and icon. Students are asked to dive deeper into the intelligent patterns of life, including:

- Energy and Matter
- Cause and Effect
- Scale, Proportion, and Quantity
- Systems and System Models
- Structure and Function
- Stability and Change

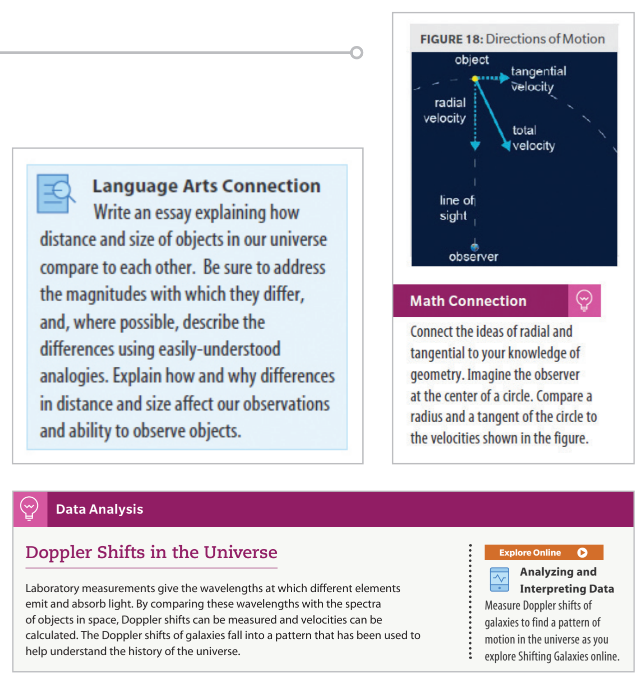


Print Student Edition

EXPLORE & EXPLAIN

Language Arts and Math Connections and Data Analysis

Being science literate requires a strong foundation in English language arts and math. So ***HMH Science Dimensions Earth & Space Science*** includes strong connections to these disciplines. These features, called **Language Arts Connection, Math Connection,** and **Data Analysis**, offer activities that are **integral to the core objectives** of the lesson.

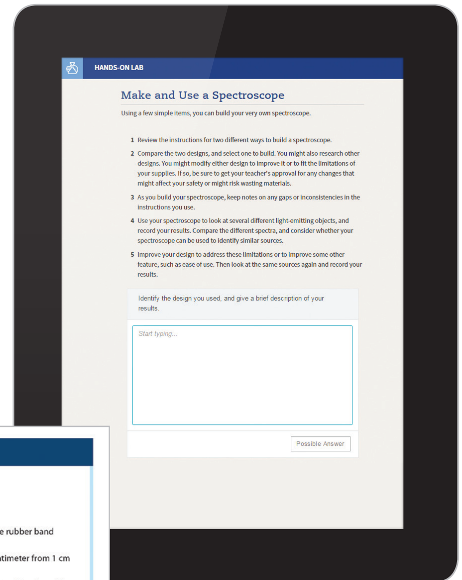


Print Student Edition

EXPLORE & EXPLAIN

Hands-On Labs

Hands-On Labs are one way of addressing the Science and Engineering Practices of NGSS*. ***HMH Science Dimensions Earth & Space Science*** offers plenty of **Hands-On Labs** that encourage students to **gather their own evidence**.


HANDS-ON LAB

Make and Use a Spectroscope

Using a few simple items, you can build your very own spectroscope.

1 Review the instructions for two different ways to build a spectroscope.
2 Compare the two designs, and select one to build. You might also research other designs. You might modify either design to improve it or to fit the limitations of your supplies. If so, be sure to get your teacher's approval for any changes that might affect your safety or might risk wasting materials.
3 As you build your spectroscope, keep notes on any gaps or inconsistencies in the instructions you use.
4 Use your spectroscope to look at several different light-emitting objects, and record your results. Compare the different spectra, and consider whether your spectroscope can be used to identify similar sources.
5 Improve your design to address these limitations or to improve some other feature, such as ease of use. Then look at the same sources again and record your results.

Identify the design you used, and give a brief description of your results.

Start typing...

Possible Answer

Interactive Online Student Edition

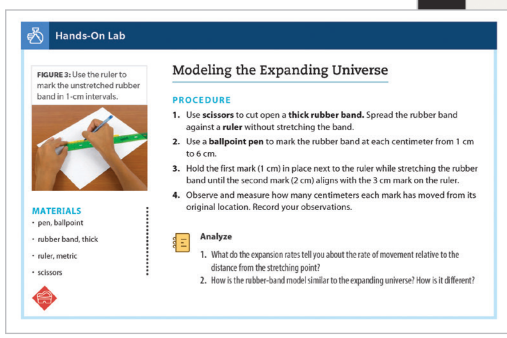

Hands-On Lab

FIGURE 3: Use the ruler to mark the unstretched rubber band in 1-cm intervals.

Modeling the Expanding Universe

PROCEDURE
1. Use **scissors** to cut open a **thick rubber band.** Spread the rubber band against a **ruler** without stretching the band.
2. Use a **ballpoint pen** to mark the rubber band at each centimeter from 1 cm to 6 cm.
3. Hold the first mark (1 cm) in place next to the ruler while stretching the rubber band until the second mark (2 cm) aligns with the 3 cm mark on the ruler.
4. Observe and measure how many centimeters each mark has moved from its original location. Record your observations.

MATERIALS
- pen, ballpoint
- rubber band, thick
- ruler, metric
- scissors

Analyze
1. What do the expansion rates tell you about the rate of movement relative to the distance from the stretching point?
2. How is the rubber-band model similar to the expanding universe? How is it different?

Print Student Edition

EXPLORE & EXPLAIN

Science Notebooks and Journals

While completing the variety of data gathering activities within a lesson, students are often prompted to **Model, Gather Evidence, Explain,** and **Analyze** their findings. These writing prompts encourage students to act like scientists by handling data like a scientist.

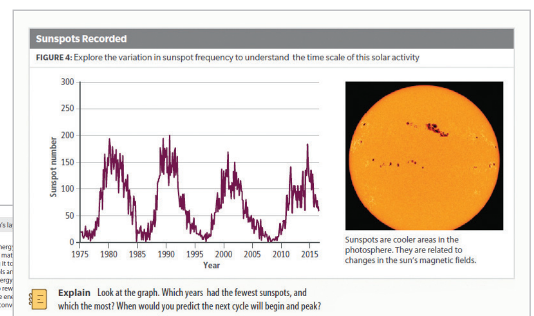

Sunspots Recorded

FIGURE 4: Explore the variation in sunspot frequency to understand the time scale of this solar activity

Sunspots are cooler areas in the photosphere. They are related to changes in the sun's magnetic fields.

Explain Look at the graph. Which years had the fewest sunspots, and which the most? When would you predict the next cycle will begin and peak?

Print Student Edition

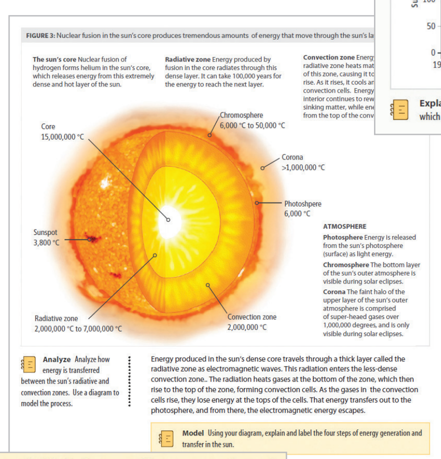


FIGURE 3: Nuclear fusion in the sun's core produces tremendous amounts of energy that move through the sun's la

The sun's core Nuclear fusion of hydrogen forms helium in the sun's core, which releases energy from this extremely dense and hot layer of the sun.

Radiative zone Energy produced by fusion in the core radiates through this dense layer. It can take 100,000 years for the energy to reach the next layer.

Convection zone Energy radiative zone heats mat of this zone, causing it to rise. As it rises, it cools an convection cells. Energy interior continues to rew sinking matter, while ene from the top of the conv

ATMOSPHERE

Photosphere Energy is released from the sun's photosphere (surface) as light energy.

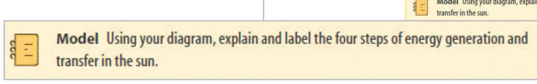
Chromosphere The bottom layer of the sun's outer atmosphere is visible during solar eclipses.

Corona The faint halo of the upper layer of the sun's outer atmosphere is comprised of super-heaed gases over 1,000,000 degrees, and is only visible during solar eclipses.

Analyze Analyze how energy is transferred between the sun's radiative and convection zones. Use a diagram to model the process.

Energy produced in the sun's dense core travels through a thick layer called the radiative zone as electromagnetic waves. This radiation enters the less-dense convection zone.. The radiation heats gases at the bottom of the zone, which then rise to the top of the zone, forming convection cells. As the gases in the convection cells rise, they lose energy at the tops of the cells. That energy transfers out to the photosphere, and from there, the electromagnetic energy escapes.

Model Using your diagram, explain and label the four steps of energy generation and transfer in the sun.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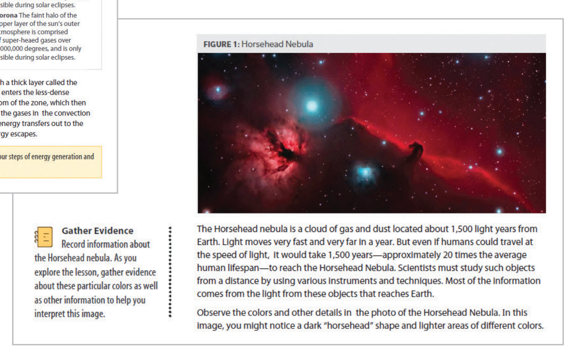


FIGURE 1: Horsehead Nebula

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.

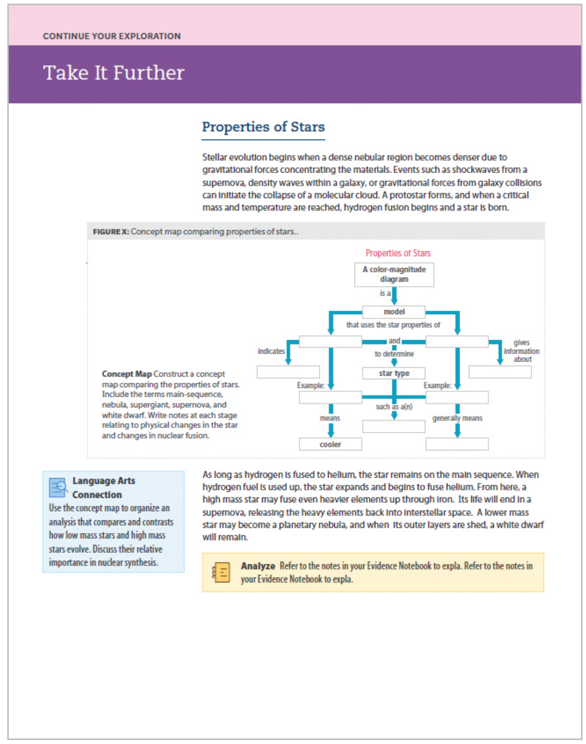
The Horsehead nebula is a cloud of gas and dust located about 1,500 light years from Earth. Light moves very fast and very far in a year. But even if humans could travel at the speed of light, It would take 1,500 years—approximately 20 times the average human lifespan—to reach the Horsehead Nebula. Scientists 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.

ELABORATE

Take It Further and Continue Your Exploration

To promote interest in science and prepare students for college and careers in engineering and science, we've added a **Take It Further** or **Continue Your Exploration** feature to EVERY lesson. These features **relate science to students' own lives and futures**, inspiring their interest in STEM. The **Guided Research** feature provides students with tips on how to consider research questions, analyze evidence, and prepare responses in the forms of presentations or papers, thus further strengthening their language arts skills.



Print Student Edition

DIGITAL ADVANTAGE

Student's Choice: Take It Further

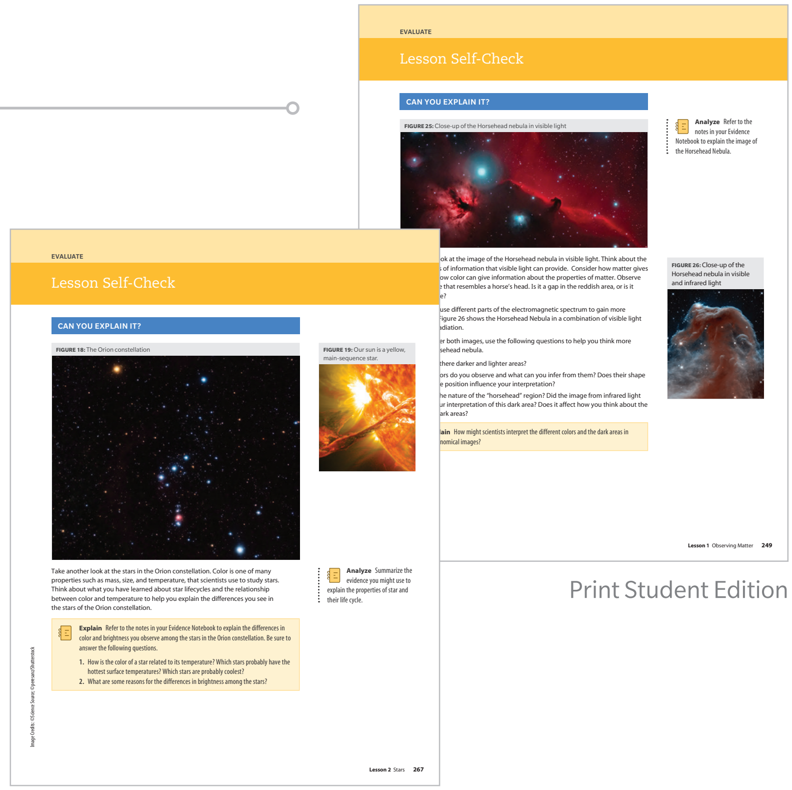
Digital delivery allows for more student choice than in print. Nowhere is this more evident than the **Take It Further** and Continue Your Exploration (Elaborate) portion of the lesson. Online, students have **several options to choose from**, one of which is sure to capture their interest.

Interactive Online Student Edition

EVALUATE

Lesson Self-Check

All the students' learning experiences come together in the Evaluate section. Students revisit the puzzling occurrence or intriguing problem they made a claim about in the Engage section. As students progressed through the lesson, they gathered evidence throughout the Explore and Explain sections. When they reach Evaluate, students return to their **claim** and evaluate the **evidence** they gathered. They **reason** how the evidence supports or challenges their claim, thereby strengthening their understanding of the science.

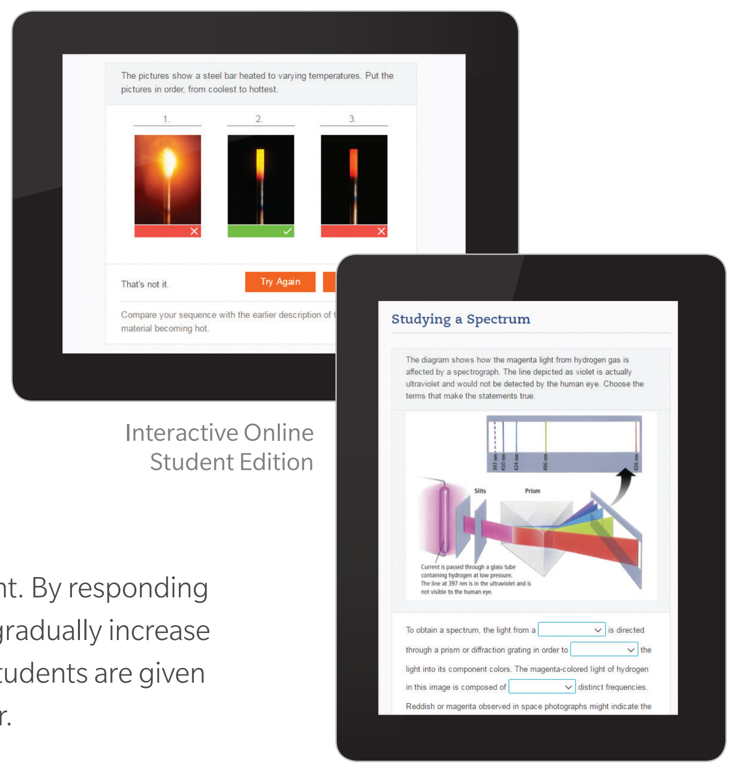


Print Student Edition

DIGITAL ADVANTAGE

Formative Assessment with Instant Feedback

Online delivery of assessments can provide **instant feedback**. This allows learners to truly take charge of their learning by monitoring their progress while actively engaging with the lesson.



Interactive Online Student Edition

Scaffolded Formative Assessment

Online learning allows scaffolded formative assessment. By responding to questions with limited-response options, students gradually increase their understanding of concepts. In these examples, students are given a choice of answers or an example of a possible answer.

CLAIMS EVIDENCE REASONING

ENGAGE EXPLORE EXPLAIN ELABORATE EVALUATE Three Dimensions of Learning

EVALUATE

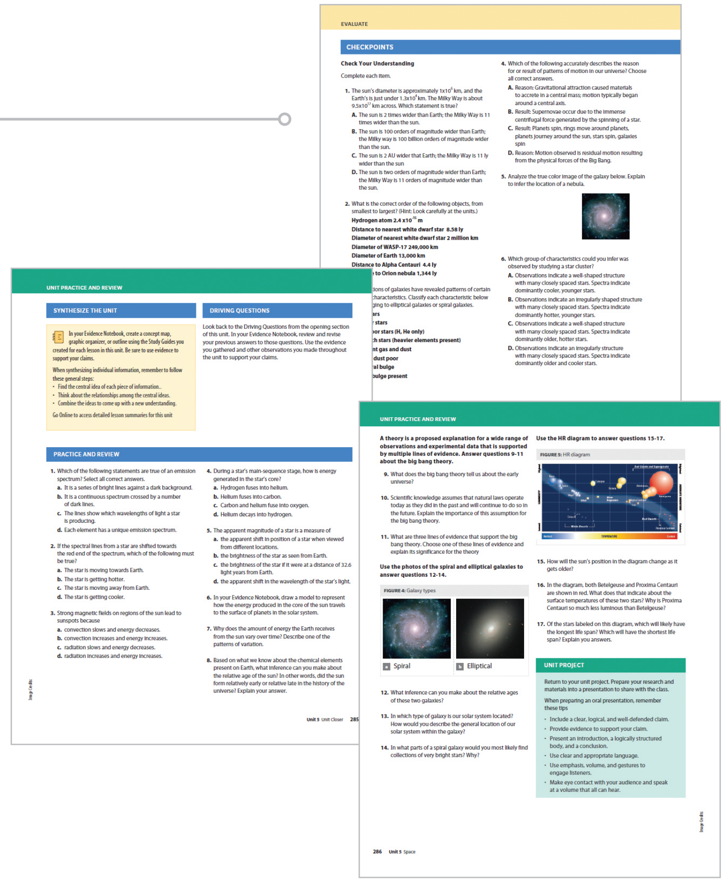
Formative Assessment

Lesson Formative Assessment

The interactive nature of the lessons provides constant formative assessment, but additional formative assessment is provided in the **Self-Check** and **Checkpoints** at the end of each lesson. As is true throughout the program's lessons, the assessment **fully integrates all three dimensions** of science learning—Crosscutting Concepts, Disciplinary Core Ideas, and Science and Engineering Practices.

Unit Formative Assessment

At the end of each Unit, learners have access to the **Unit Practice and Review**. This formative assessment covers the same three dimensions of learning for the entire Unit.



Print Student Edition

Summative Assessment

Each Unit includes a **Unit Project** and a separate **Performance Task** so students can demonstrate the **NGSS* Performance Expectation** competency using the **Claims/Evidence/Reasoning** approach they practiced using in the lessons.

The authentic and practical application of student learning creates a full three-dimensional science learning experience, addressing Science and Engineering Practices, Disciplinary Core Ideas, and Crosscutting Concepts.

Many performance-based activities are designed around STEM applications and the Engineering Design Process.

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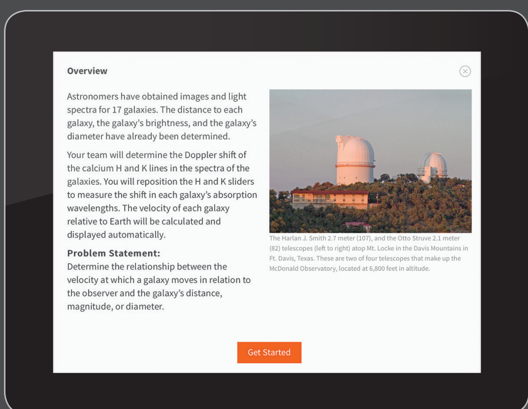
Unique Digital Simulations Reinforce Three-Dimensional Learning and Claims/Evidence/Reasoning

DIGITAL ADVANTAGE

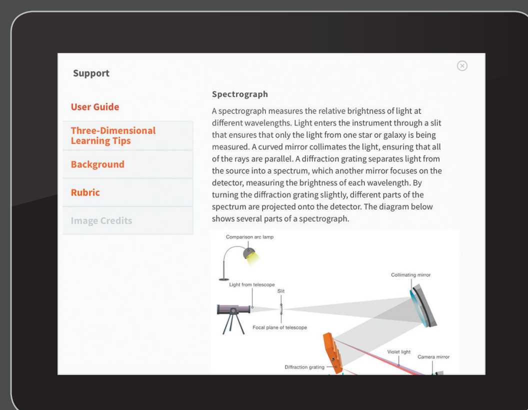
You Solve It! Open-ended Simulations

You Solve It! simulations involve a rich data-gathering or problem-solving exploration that goes far beyond requiring merely a single right answer. Available as part of the digital path, these unparalleled NGSS-centric open-ended simulations support the **Claims/Evidence/Reasoning** instructional model and allow students to answer questions and solve problems in their own way.



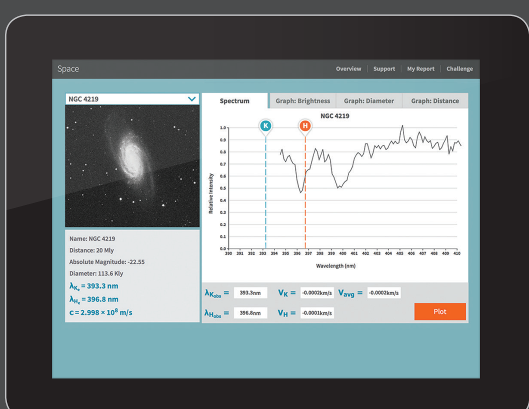
Overview

This provides context and some basic instructions on using the open-ended simulation.



Support

The Support section reminds students of the NGSS connections, such as relevant SEPs, DCIs, and CCCs. It also provides helpful background information and instruction on how to control the simulation.



Simulation

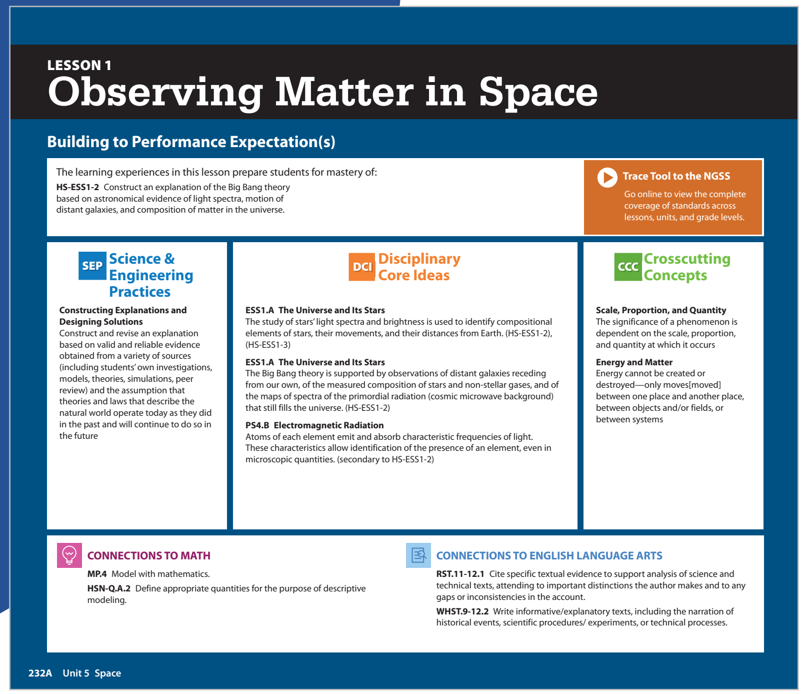
This open-ended simulation gives students FULL control. They make their own choices on how to gather evidence or achieve a solution.

Notes/Report

Students can jot notes about their evidence and reasoning for later creating a report about their claim. They can restart their work at home or on the go when they log into their online Student Edition with any compatible device.

The Teacher Edition—Your NGSS Companion

The Teacher Edition is designed to easily guide you through an NGSS* lesson organized around the 5E model.


LESSON 1

Observing Matter in Space

Building to 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.

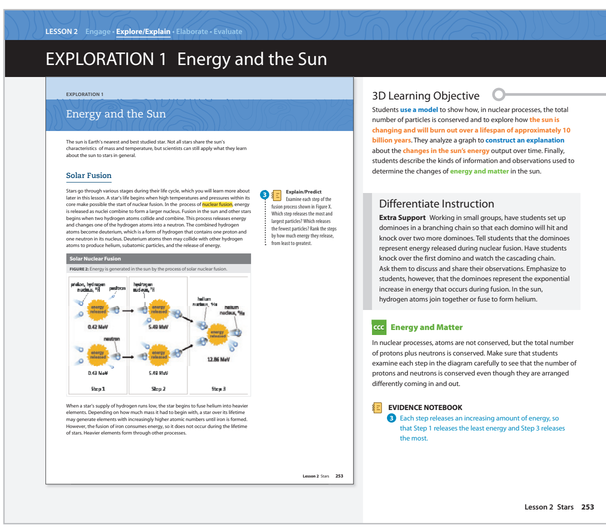
Trace Tool to the NGSS
Go online to view the complete coverage of standards across lessons, units, and grade levels.

SEP Science & Engineering Practices	DCI Disciplinary Core Ideas	CCC Crosscutting Concepts
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	**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-ESS1-2), (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) **PS4.B Electromagnetic Radiation** Atoms of each element emit and absorb characteristic frequencies of light. These characteristics allow identification of the presence of an element, even in microscopic quantities. (secondary to HS-ESS1-2)	**Scale, Proportion, and Quantity** The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs **Energy and Matter** Energy cannot be created or destroyed—only moves[moved] between one place and another place, between objects and/or fields, or between systems

CONNECTIONS TO MATH
MP.4 Model with mathematics.
HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling.

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.

232A Unit 5 Space

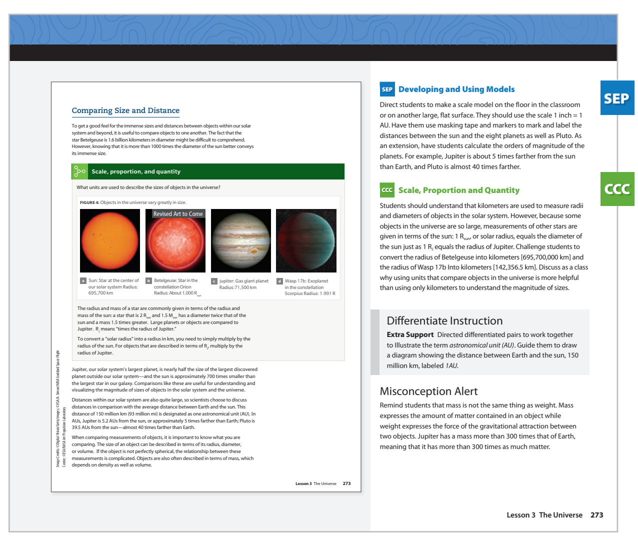


3D Learning Objectives

Using the program's customized 3D Learning Objective and clearly labeled Disciplinary Core Ideas, Crosscutting Concepts, and Science and Engineering Practices, educators can keep track of the specific standards that students are covering at any given point in the lesson.

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.



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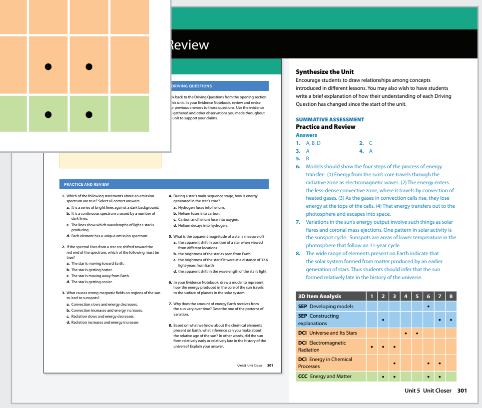
3D Item Analysis

The 3D Item Analysis in the Unit Review identifies the associated Three Dimensions of Learning for EACH review question. This helps educators assess students' knowledge of each component of the Next Generation Science Standards.

3D Item Analysis	1	2	3	4	5	6	7	8
SEP Developing models						•		
SEP Constructing explanations		•					•	•
DCI Universe and Its Stars				•	•			
DCI Electromagnetic Radiation	•	•	•					
DCI Energy in Chemical Processes			•			•	•	
CCC Energy and Matter		•	•			•	•	

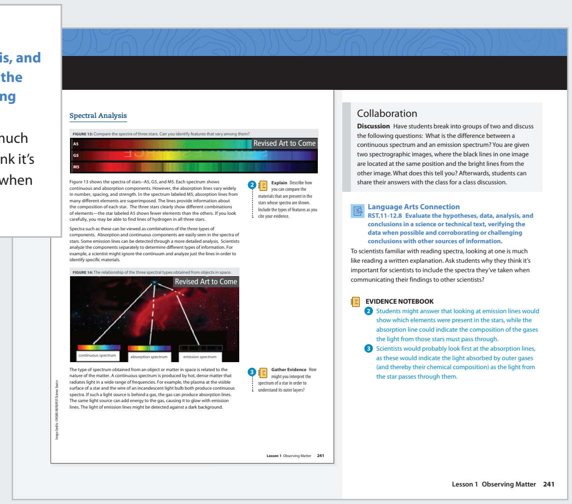


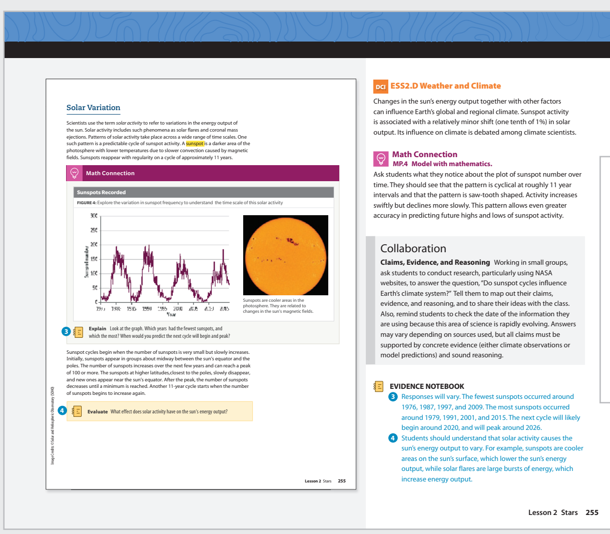
Common Core State Standards

For added convenience, many of the Math and ELA features in the lessons identify the Common Core State Standards that are referenced by NGSS.

Language Arts Connection
RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.

To scientists familiar with reading spectra, looking at one is much like reading a written explanation. Ask students why they think it's important for scientists to include the spectra they've taken when communicating their findings to other scientists?





Math Connection
MP.4 Model with mathematics.

Ask students what they notice about the plot of sunspot number over time. They should see that the pattern is cyclical at roughly 11 year intervals and that the pattern is saw-tooth shaped. Activity increases swiftly but declines more slowly. This pattern allows even greater accuracy in predicting future highs and lows of sunspot activity.