

Program Components

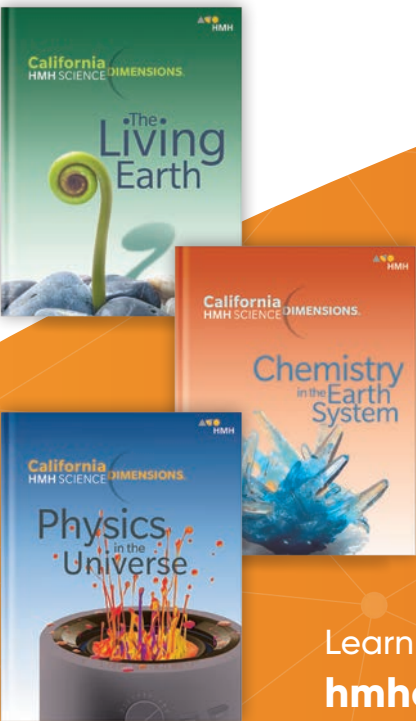
With its cohesive, spiraled approach to meeting the new standards, *California HMH Science Dimensions* provides a consistent and engaging curriculum from transitional kindergarten through high school.

GRADES K–12

Student Edition available as a softcover, consumable write-in worktext for each grade

HIGH SCHOOL

Follows the CA NGSS three-course model, and includes *The Living Earth*, *Chemistry in the Earth System*, and *Physics in the Universe*



Student Resources	Print	Online
Student Edition (includes <i>Thing Explainer</i> content and illustrations)	•	•
Math Handbook		•
English Language Arts Handbook		•
Science and Engineering Practices Handbook		•
Designated ELD: Student Workbook	•	•
Multilingual Science Glossary	•	•
Lab Safety Handbook		•
Crosscutting Concepts Handbook		•
You Solve It! Simulations		•
CliffsNotes® On the Job videos		•
CAST Readiness: Practice and Review		•
Teacher Resources	Print	Online
Teacher Edition	•	•
Google Expeditions Teacher Guide		•
Assessment Guide (includes Performance-Based Assessments)		•
Online Assessment with Item Banks		•
Designated ELD in Your Science Classroom Teacher Guide	•	•
Professional Learning Videos		•
Home Letters (multilingual)		•
CA NGSS Trace Tool		•

California HMH Science Dimensions™

Chemistry in the Earth System

Phenomena-Driven Instruction
Built for California NGSS

Grades 9–12



#CAScience

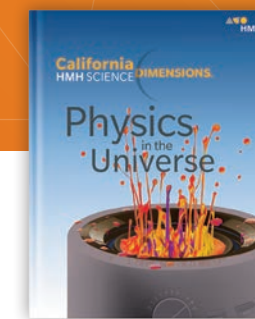
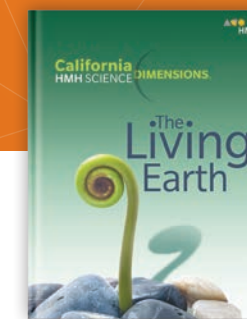
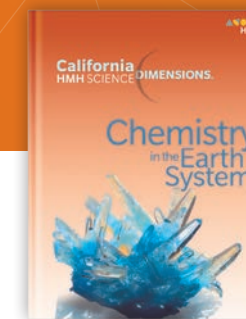
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A quality TK–12 science curriculum that helps students develop a **metacognitive mindset** to change the world.



California HMH Science Dimensions™

Phenomena-Driven Instruction



Integrated with earth and space science, **California HMH Science Dimensions™**: **Chemistry in the Earth System**, **The Living Earth**, and **Physics in the Universe** were designed to spark students' curiosity and inspire the next generation of scientists.

Students dive deep into phenomena through a hands-on, three-dimensional approach to learning science. They explore the world around them, think critically, defend their ideas, and reimagine their future.

Why choose **California HMH Science Dimensions**?

- ▶ A “no guesswork involved” **NGSS Trace Tool** systematically maps standards by PEs, SEPs, CCCs, and DCIs. See how they connect and spiral from one grade to another.
- ▶ **We provide, you decide customization** with unmatched flexibility allows teachers to customize units, lessons, and assessments.
- ▶ **Coherent storylines bring phenomena to life** and help students excel at the California Next Generation Science Standards* (CA NGSS) performance expectations and the California Science Test (CAST).
- ▶ **Academic language tools for long-term English learners** teach students to engage with academic discourse across the three dimensions of learning.
- ▶ A **California-based support team** that you can count on. We live and work right here in California.

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Education Leaders You Can Trust



Michael DiSpezio

Global Educator, North Falmouth, Massachusetts

Michael DiSpezio has authored many HMH instructional programs for science and mathematics. He has also authored numerous trade books and multimedia programs on various topics and hosted dozens of studio and location broadcasts for various organizations in the U.S. and worldwide. Most recently, he has been working with educators to provide strategies for implementing the Next Generation Science Standards, particularly the Science and Engineering Practices, Crosscutting Concepts, and the use of Evidence Notebooks. To all his projects, he brings his extensive background in science; his expertise in classroom teaching at the elementary, middle, and high school levels; and his deep experience in producing interactive and engaging instructional materials.

Thomas O'Brien, Ph.D.

Professor in the Department of Teaching, Learning and Educational Leadership at Binghamton University

Tom O'Brien has directed the graduate-level science teacher education programs at Binghamton since 1987. His scholarly interests include professional leadership development (e.g., co-principal investigator for NYS and national grants); science curriculum development, as related to science-technology-society themes and 5E Teaching Cycles; and K-12 science teacher education, as informed by cognitive learning theory. He is the author of *Brain-Powered Science: Teaching and Learning with Discrepant Events* and co-author/coeditor of *Science for the Next Generation: Preparing for the New Standards*.



Bernadine Okoro

STEM Learning Advocate & Consultant

A 12-year science educator and Albert Einstein Distinguished Fellow, Bernadine Okoro was one of the original authors of the Next Generation Science Standards. As a member of the Diversity and Equity Team, her focus on alternative education and community schools and on integrating social-emotional learning and brain-based learning into the NGSS is the vehicle she uses as a pathway to support underserved groups from elementary school to adult education.

Chemistry in the Earth System Scope & Sequence

UNIT 1: Measuring Matter and Energy

Lesson 1: Investigating Matter and Energy

Lesson 2: Identifying Physical and Chemical Properties of Matter

Thing Explainer: How to Count Things

UNIT 2: Heat and Energy in the Earth System

Lesson 1: Thermal Energy and the Behavior of Matter

Lesson 2: Analyzing the Flow of Energy in Systems

Lesson 3: Energy Transfer in Earth's Interior

Thing Explainer: Big Flat Rocks We Live On

UNIT 3: Patterns in the Properties of Matter

Lesson 1: Modeling Atomic Structure

Lesson 2: Investigating Patterns in the Periodic Table

Lesson 3: The Arrangement of Atoms in Compounds

Thing Explainer: The Pieces Everything Is Made Of

UNIT 4: Chemical Attractions

Lesson 1: The Properties of Materials

Lesson 2: Cycles of Matter in Chemical Reactions

Lesson 3: Intermolecular Forces in Mixtures

Thing Explainer: The Water in Our Bodies

UNIT 5: Reaction Energy

Lesson 1: Energy in Chemical Bonds

Lesson 2: Reaction Rates

Thing Explainer: Energy

UNIT 6: Human Activity and Earth's Atmosphere

Lesson 1: Human Populations and Energy Use

Lesson 2: Energy Flows and Feedback in the Earth System

Lesson 3: Solutions to Environmental Problems

Thing Explainer: Cloud Maps

UNIT 7: Chemical Equilibrium Systems

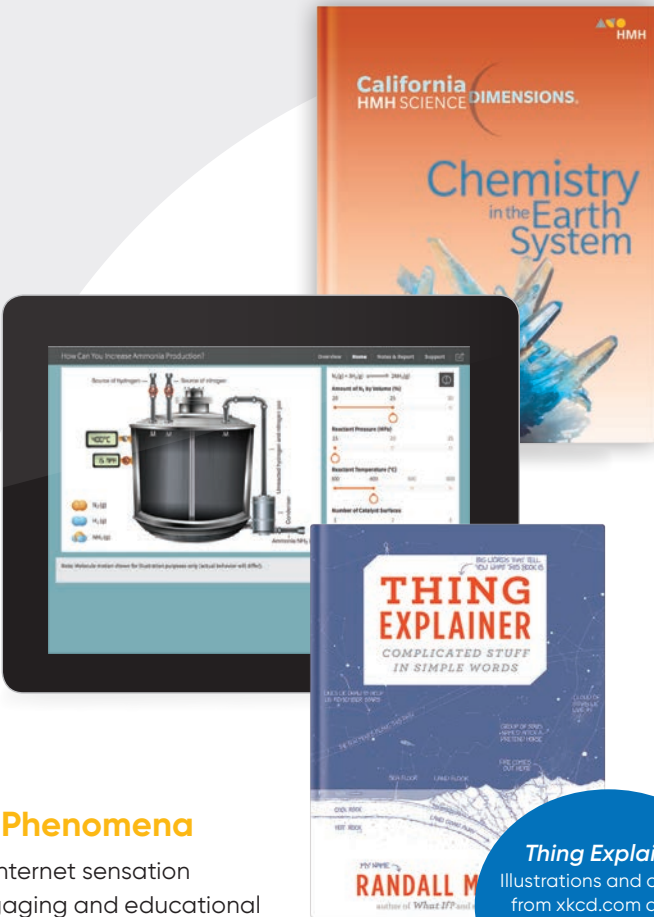
Lesson 1: The Nature of Chemical Equilibrium

Lesson 2: Equilibrium Systems

Lesson 3: Disrupting Equilibrium in the Ocean

Lesson 4: Engineering Solutions to Ecosystem Disruption

Thing Explainer: Earth's Surface



A Simplified 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.

Thing Explainer
Illustrations and content from xkcd.com author Randall Munroe are featured in the textbook!

Students dive deeper into inquiry with **coherent, 3D storylines**

With *California HMH Science Dimensions*, students approach each sequence of lessons with the three dimensions of learning and build upon investigations driven by their own questions, which arise from their personal interactions with authentic phenomena.

Lesson 1

Investigating Matter and Energy

SEP Planning and Carrying Out Investigations

SEP Developing and Using Models

SEP Using Mathematics and Computational Thinking

DCI PS1.B Chemical Reactions

DCI PS3.A Definitions of Energy

DCI PS3.B Conservation of Energy and Energy Transfer

CCC Systems and System Models

CCC Energy and Matter

CCC Scientific Knowledge Assumes an Order and Consistency in Natural Systems

Lesson 2

Identifying Physical and Chemical Properties of Matter

SEP Constructing Explanations and Designing Solutions

SEP Asking Questions and Defining Problems

SEP Planning and Carrying Out Investigations

DCI PS1.A Structure and Properties of Matter

DCI PS1.B Chemical Reactions

DCI ET51.B Developing Possible Solutions

CCC Energy and Matter

CCC Systems and System Models

CCC Patterns

CCC Influence of Science, Engineering, and Technology on Society and the Natural World

Math, English Language Arts, and English Language Development standards and features can be found in the teacher pages before each lesson.

LESSON 2

Identifying Physical and Chemical Properties of Matter

Building to the Performance Expectations

The learning experiences in this lesson prepare students for mastery of

HS-PS1-3 Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.

HS-ETS1-3 Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.

Trace Tool to the NGSS

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

SEP Science & Engineering Practices

Planning and Carrying Out Investigations

Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitation on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.

Constructing Explanations and Designing Solutions

Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

VIDEO Constructing Scientific Explanations

DCI Disciplinary Core Ideas

PS1.A Structure and Properties of Matter

The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. (HS-PS1-3)

PS1.B Structure and Properties of Matter

The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions. (PS1-7)

ETS1.A Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (HS-ETS1-1)

ETS1.B When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (HS-ETS1-3)

VIDEO Engineering: Chemistry

CCC Crosscutting Concepts

Energy and Matter

The total amount of energy and matter in closed systems is conserved.

VIDEO Energy

Systems and System Models

Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models.

Patterns

Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.

MATH STANDARDS

MP.2 Reason abstractly and quantitatively.

ELA STANDARDS

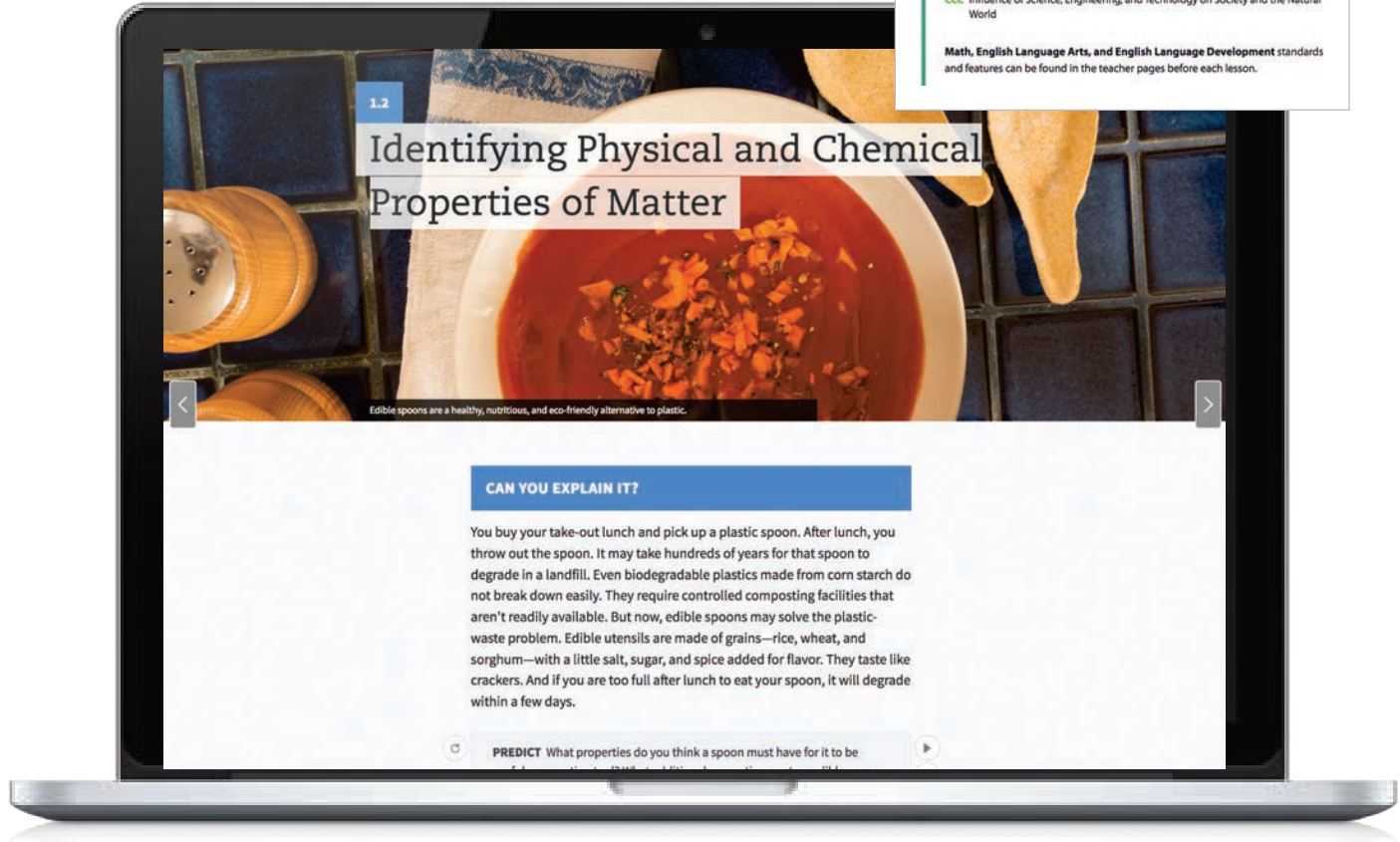
RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.

WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research.

Lesson 2. Identifying Physical and Chemical Properties of Matter 31A

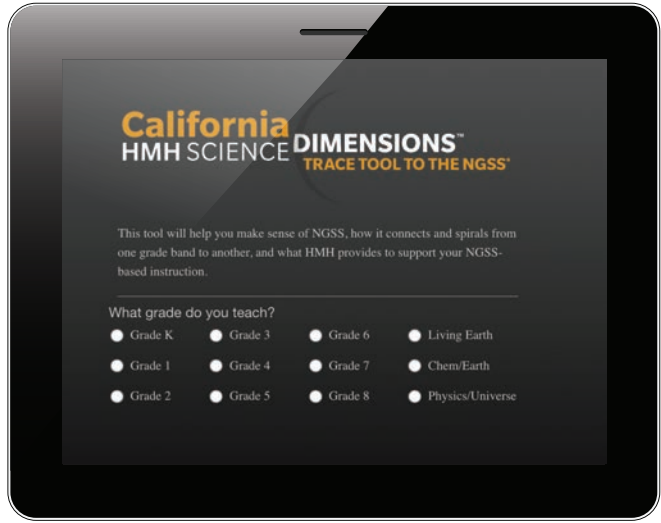
In the Teacher Edition, each lesson:

- Progresses through the **5E instructional model**
- Has unique, interrelated **3D Learning Objectives**
- Clearly identifies each unit's anchor phenomena, investigative phenomena, and performance expectations
- Includes clear, consecutive objectives ensuring lessons cover 100% of the CA NGSS performance expectations



Students explore science through:

- Hands-on activities
- Digital simulations
- Interdisciplinary activities
- Lessons enriched with digital media



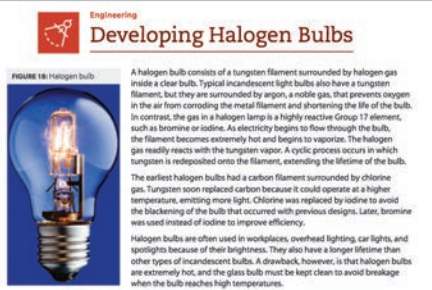
Cross-Curricular Connections help students develop an understanding of science and engineering concepts.

- Multi-disciplinary connections are linked to **California Common Core Math, ELA, Physical Science, Technology**, and more.
- Connections to the **History of Science and Environmental Principles & Concepts** are provided at point of use.
- **Unit Connections** provide ideas for cross-curricular projects.

NGSS Trace Tool: Understand where your instruction fits

Using the *California HMH Science Dimensions Trace Tool* you can:

- Make sense of the standards
- Understand how the standards connect and spiral from one grade to another
- Trace the standards by PEs, SEPs, CCCs, or DCIs



Math Connection

Calculating Force

Coulomb's law describes how to calculate electric force. This law states that the magnitude of the electric force (F_{elec}) between two point charges (q_1 and q_2) is directly related to the product of the charges and inversely related to the square of the distance (d) between them. The Coulomb constant (k_c) is a constant used in the calculation of electric force. The equation for Coulomb's law is:

$$F_{\text{elec}} = k_c \frac{q_1 q_2}{d^2}$$

2 Collaborate As charge increases, electric force increases. However, if the distance between two charges doubles, electric force decreases by a factor of four. How does the equation for this law demonstrate these relationships between charge, distance, and force?



Students engage with scientific phenomena through **hands-on investigations**

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



Investigative Phenomena Drive Every Lesson

Each lesson opens with **Can You Explain It?** or **Can You Solve It?**, a problem to solve or discrepant event to explain that focuses on an investigative phenomenon.



Evidence Notebook Refer to your notes in your Evidence Notebook to make a claim about the properties an edible spoon must have to be useful as an eating tool. Your explanation should include a discussion of the following points:

1. What properties should an edible spoon have?
2. What evidence supports the claim that these properties are useful for an edible spoon?
3. How does the evidence you provided support your claim about the properties of an edible spoon?

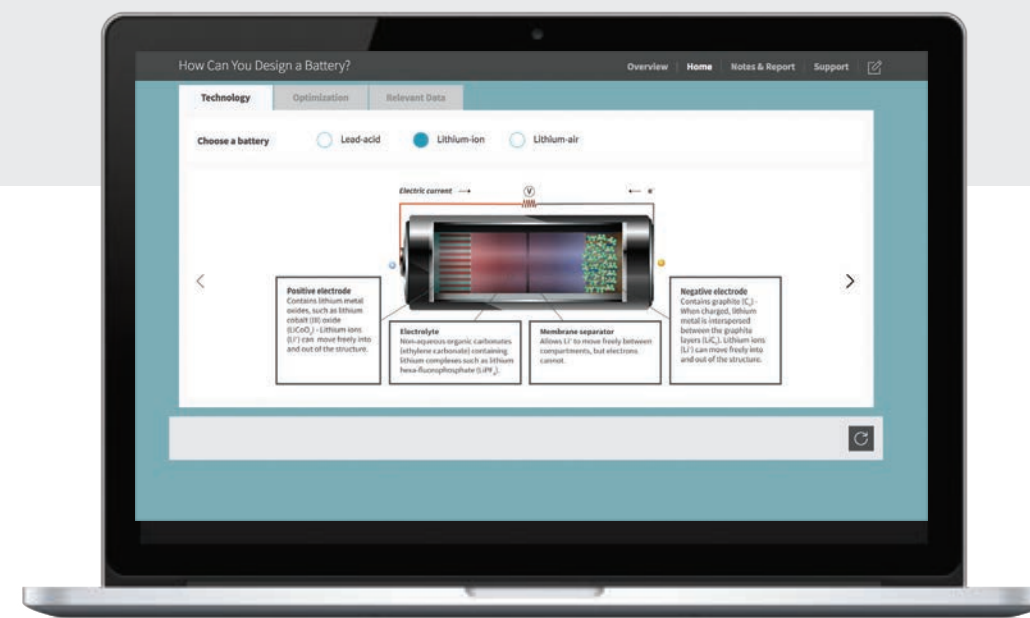


Evidence Notebook prompts help build metacognition by encouraging students to:

- keep their thoughts **organized** in context of the phenomena being explored,
- engage in **self-reflection** of their own learning, and
- consider how their learning experiences **shape their thinking**.

You Solve It! Student-Driven Simulations

You Solve It simulations are open-ended, interactive opportunities for students to run experiments, gather data, and analyze the impact of different variables on a closed system. Students explore and investigate real-world problems while developing in-depth explanations of scientific concepts and phenomena.



Hands-On Labs

- Labs guide students through designing and carrying out investigations, and through **analyzing and interpreting data**.
- Students actively “do science” as they make sense of everyday phenomena.
- They **think critically** about their observations, practice gathering evidence, and defend their claims, just like real scientists and engineers.

Math Connection

Calculating Force

Coulomb's law describes how to calculate electric force. This law states that the magnitude of the electric force (F_{electric}) between two point charges (q_1 and q_2) is directly related to the product of the charges and inversely related to the square of the distance (d) between them. The Coulomb constant (k_c) is a constant used in the calculation of electric force. The equation for Coulomb's law is:

$$F_{\text{electric}} = k_c \frac{q_1 q_2}{d^2}$$



Collaborate As charge increases, electric force increases. However, if the distance between two charges doubles, electric force decreases by a factor of four. How does the equation for this law demonstrate these relationships between charge, distance, and force?

Cultivate Collaboration

Working as a team is an essential part of developing 21st-century skills. *California HMH Science Dimensions* provides ample opportunities for students to:

- Participate in groups to complete activities
- Partner with peers to discuss their findings
- Practice speaking and listening skills

Students connect learning to real-life issues and develop a **mindset** to solve STEM challenges

The CA NGSS has raised the engineering design process to the same level as scientific inquiry. In *California HMH Science Dimensions*, **science**, **technology**, **engineering**, and **math** are considered integral parts of the curriculum. Lessons are designed to help students develop a mindset to explore science and solve problems the same way scientists and engineers do.



Integrated Engineering

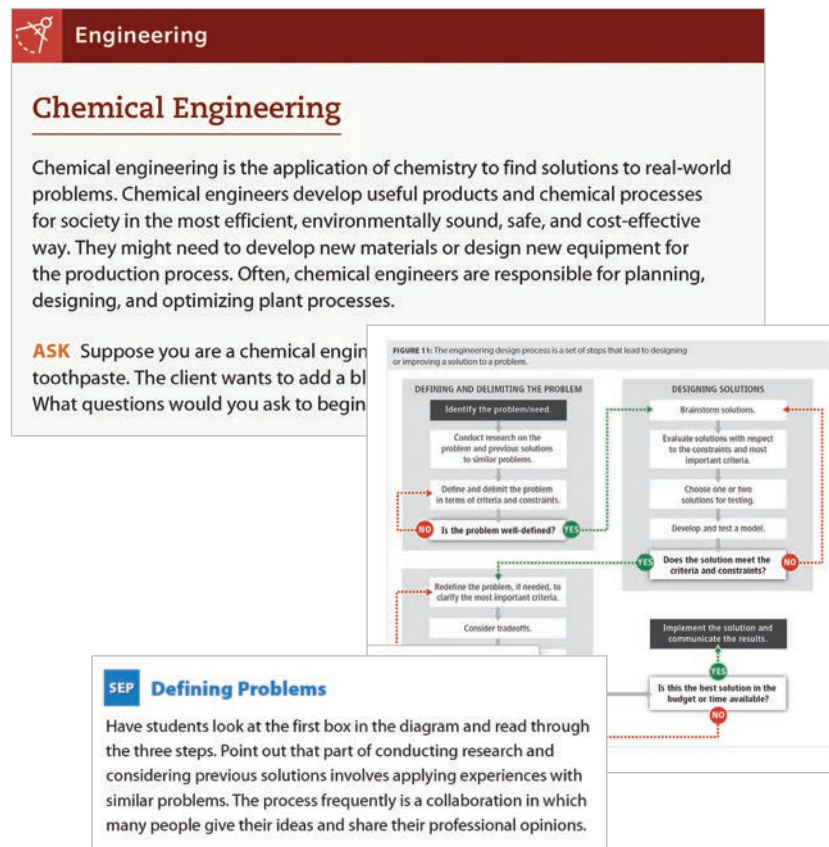
With *California HMH Science Dimensions*:

- Engineering and STEM are integrated throughout every unit
- Engineering design is elevated to the same level as scientific literacy
- A **Performance Task**, included in every unit, gives students multiple opportunities to apply the engineering design process by **defining a problem** and **designing a solution**

Tools That Build Scientific Literacy Skills

The online **Science and Engineering Practices Handbook** helps students achieve a higher level of understanding. They build their experience by applying the **Science and Engineering Practices** of the CA NGSS. Handbook includes:

- Asking questions
- Planning investigations
- Analyzing data
- Constructing explanations
- And more!



TAKE IT FURTHER

Careers in Science

Food Scientist

How many food scientists does it take to make a loaf of bread? It sounds like the beginning of a joke, but the work of many food scientists is involved with nearly every food item you purchase. These scientists play many important roles in food production and preparation.

Take a look at any nutritional information label and you will see data about the nutrients, ingredients, and energy content of the food. Food scientists work at processing plants, government agencies, and universities. These specialists work to make and improve food products, like bread, to make sure that the food is properly prepared and labeled. Food scientists use calorimetry to determine the energy content of foods. But they don't just burn a slice of whole-grain bread to see how much energy it releases. The reason is because some components, such as fiber, are not digested by the body and therefore do not provide usable energy. Instead, scientists determine the amount of protein, carbohydrates, fats, and fiber in the bread. Strictly controlled calorimetry experiments have provided average values of 4 kcal/g for proteins, 4 kcal/g for carbohydrates, and 9 kcal/g for fat. (Remember, a Calorie is the same as a kilocalorie.) Food scientists then use these averages along with the analyzed components in the food to calculate the energy content.

Food scientists also use calorimetry to analyze steps of the production process that are temperature sensitive. For example, they might find that the temperatures needed to kill microorganisms also result in proteins breaking down. This could make the food unappetizing or reduce its nutritional value. They may also want to determine if too much oil is being used to fry chips. Testing chips from different batches in a calorimeter can indicate whether too much oil remains on the chips.

Food scientists look for ways to improve the preservation of food and prevent spoilage. They analyze different cooking and baking processes.

FIGURE 13: A food scientist studies the nutritional content of different foods.

to better understand how the foods. They help develop new for substitutes that can replace additives. Some food scientist processing plants to make use cleaned and maintained.

Whether you're buying food ingredients to prepare your on food scientists for helping out nutritional, as well as taste go.

Language Arts Connection

to find out at a career of food scientists. Research examples of work that scientists do in the food industry. Areas of research might include production (pesticides and fertilizers, GMO crops), processing, preservation (methods to reduce spoilage, shelf-stable foods), preparation, or a topic of your choosing. In your paragraph, give background on your topic, explain what questions scientists are trying to answer, and describe the methods they use to find these answers.

MORE PRACTICE WITH UNIT CONVERSION **MEASURING WITH PRECISION** **DEBATING FOOD LABELING** Go online to choose one of these other paths.

Inspire Students to Consider STEM Careers

The **Take It Further** sections of each unit feature diverse **People and Careers in Science & Engineering**. These features show students the **real-world applications** of what they're learning and spark their interest in science-based careers.

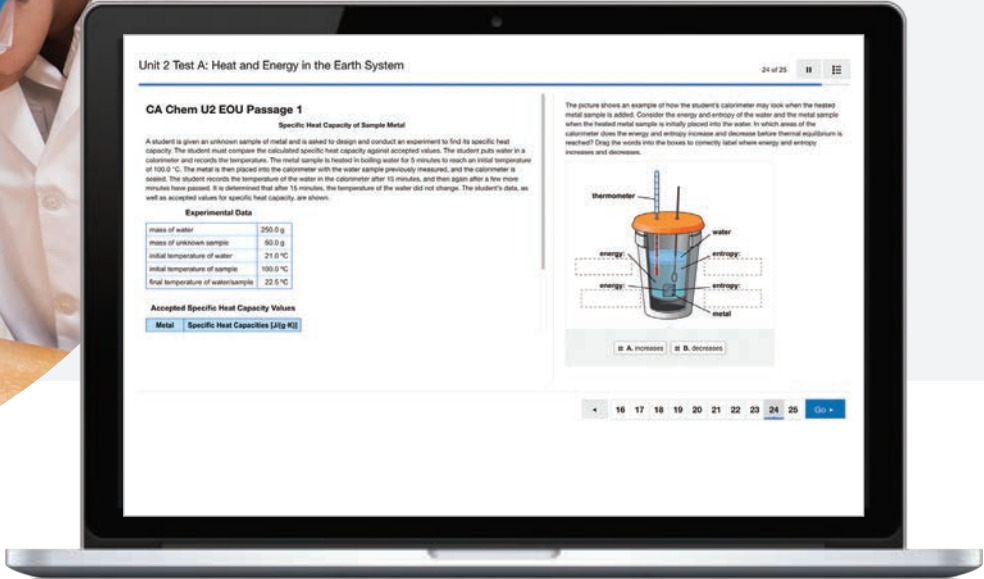
Additionally, 29 **On the Job STEM videos** profile STEM careers in today's fastest-growing industries, including jobs like:

- Civil engineer
- Biochemist
- Graphic designer
- Nurse
- Emergency medical technician
- Planetary scientist



Students demonstrate mastery of CA NGSS performance expectations

In *California HMH Science Dimensions*, assessments are specifically designed to ensure students can successfully apply what they have learned. Test items mimic the style of the CAST assessment items and, throughout every lesson, students are scaffolded towards deeper knowledge and ability to apply that knowledge in new situations.



Performance-Based Assessment
Teacher Resources

Energy Transfer

Task 1: Radiator Coolant

The student will use knowledge of energy transfer in the form of heat to conduct an investigation to determine which liquid works best as a coolant in a car radiator.

Performance Expectations and 3D Learning:

HS-PS3-4 Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperatures are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).

Safety:

- Instruct students to use materials only as directed.
- Instruct students to wear safety goggles and gloves at all times.
- Instruct students to wear closed-toe shoes on the day of the lab activity.
- Instruct students in the expected protocol for solution disposal and cleanup following the task.

Tip: Preparation Quick Tips:

- Determine the necessary number of stations to accommodate two to four students at each station. Depending on the availability of hot plates, liquids, and space, adjust the number of students per station.
- Gather all materials in advance. Approximately 500 mL of each liquid will be required per station.
- Prepare Mystery Liquids A, B, C, and D. Do this well in advance so that all liquids will be at room temperature when starting the investigation. Use a large enough container for each liquid based on the number of stations required. For Liquid A, dissolve 35 g of salt per liter of water. Liquid B is distilled water. Liquid C is vegetable oil. Liquid D is corn syrup.
- Place a hot plate, thermometer, and four beakers at each station. Inspect beakers to ensure there are no cracks or chips.
- Turn on the hot plates just before each investigation, or have students run them on. The temperature of each hot plate should be between 150 °C and 200 °C. In advance, determine the appropriate setting that gives the desired temperature, and mark it on the hot plate.
- Organize materials in advance to allow for ease of distribution to students.
- Consider in advance how to group students.
- Consider options for adjusting materials or providing tips to students who require modification or additional assistance.

Performance-Based Assessment
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Time Rating:

1 = less time; 4 = more time

Teacher Prep: 2
Student Prep: 1
Student Cleanup: 1
Time on Task: 1 hr

Materials:

For each group

- balance
- beakers (4, glass, 600 mL)
- beaker tongs or rubber hand protector
- calculator
- grease pencil
- hot plate
- Mystery Liquid A (500 mL, see Preparation Quick Tips)
- distilled water (1 L)
- table salt (35 g)
- Mystery Liquid B (500 mL, distilled water)
- Mystery Liquid C (500 mL, vegetable oil)
- Mystery Liquid D (500 mL, corn syrup)
- stirring rods (4)
- stopwatch or timer
- thermometer (4, Celsius)

For each student

- apron
- Cooling Systems
- gloves
- safety goggles

New Resource Available Online:

CAST Readiness: Practice and Review

This digital resource provides high-quality practice tests (Form A and Form B) consistent with the CAST for Grades 5, 8, and high school.

Performance-Based Assessment
Teacher Resources

Task 1 Performance Rubric

Rating Scale

3 Outstanding	1 Needs Improvement
2 Satisfactory	0 Did Not Demonstrate Skill
NS Did not have the opportunity to observe	

Group Name _____

Names of Students _____

Skills										
DCLHS-PS3.B.2 Conservation of Energy and Energy Transfer The student conducts an investigation in which they describe how energy is transferred between systems.										
SEP.HS.C.1 Planning and Carrying Out Investigations The student conducts an investigation to produce data that serve as the basis of evidence to determine which liquid would work best in a car radiator.										
SEP.HS.F.4 Constructing Explanations and Designing Solutions The student explains different types of heat transfer and ways they occur in this experiment.										

Teacher Directions:

This rubric allows for performance observation of 10 students. Make copies as needed. If students are working in groups, record the group name.

Performance-Based Assessments

Students will be able to perform the Science and Engineering Practices using the context of the **phenomenon** through investigations, experiments, and technologies that tie back to the **unit storyline**. These **hands-on assessments** provide teachers a means of truly assessing students' engineering skills.

Assess Each of the Three Dimensions

Formal assessment questions are aligned to multiple dimensions, and unique **3D Evaluation Rubrics** allow teachers to:

- Evaluate open-ended student responses
- Identify the underlying cause of student misunderstanding
- Target remediation where it is needed most

Formal Assessments

Adding depth to student learning, these assessments evaluate prior knowledge, address misconceptions, and inform remediation needs.

- **Unit Pretests** ensure students have the foundational knowledge they need for lessons.
- **Lesson Quizzes** quickly check that students understand the 3D concepts.
- **Unit Tests** measure understanding and challenge students to apply what they've learned.
- **Mid-Year and End-of-Year Benchmark Tests** help ensure students are on track to achieve the Performance Expectations.

Unit 2 Test A: Heat and Energy in the Earth System
17 of 25

Select the terms that show the effect of the composition of Earth's interior on seismic waves.

Seismic Wave Patterns

Prepare for High-Stakes Tests

- Technology-enhanced assessment items, similar to the ones found on **CAST** (multi-select, drag and drop, short response, etc.), prepare students for modern **computer-based high-stakes tests**.
- Rigorous Mid-Year and End-of-Year Benchmarks help ensure that students perform with a high depth of knowledge.
- Leveled benchmark tests help make the assessment accessible for all students.

Students build self-awareness and confidence with equity resources that support differentiation

California HMH Science Dimensions was built to provide inclusiveness to students of different learning levels and styles, English learner status, cultural and ethnic backgrounds, socioeconomic or foster status, disability status, gender identity, and sexual orientation—ensuring educational equity for all California students.

Access and Equity

Within *California HMH Science Dimensions* you will find people represented that reflect California's **diverse population and cultures**. Individual spotlight features and integrated discussions within lessons explore historical and contemporary contributors to science and engineering who reflect the full range of ethnic and cultural groups in California, while paying heed to the **FAIR Education Act**.

UNIT 7 Chemical Equilibrium Systems

California Connections

Ocean Acidification Along the California Coast
Ocean acidification is the reduction of the pH of ocean water, which occurs over an extended period of time. It is caused by factors such as the uptake of CO₂ from the atmosphere, nutrient runoff, and the deposition of nitrogen oxides and sulfur oxides. Increased acidic ocean water dissolves the hard parts of mollusks and sea urchins.

Sacramento-San Joaquin Levee System
The Sacramento-San Joaquin Delta consists of over 1,700 kilometers of levee-protected islands which were built in the 1800s to protect cultivated soil in the delta from flooding. Unfortunately, the islands in the delta have been subsiding (sinking), which puts pressure on the levees. One possible solution involves growing marsh plants which have already been shown to reverse subsidence.

Mono Lake
Mono Lake formed more than a million years ago from ancestral Lake Russell. With no outlets, evaporation caused it to shrink in size, becoming Mono Lake, with a pH of 10. Snowmelt from the Sierras provides water containing salts and other minerals, but without outlets, the water simply evaporates. The best known of the lake's landforms are the tufa towers, formed underwater when calcium from springs mixes with carbonate in the water to form calcium carbonate.

Environmental Principles & Concepts
Principle I p. 461
Principle III pp. 447, 455, 459, 475, 495
Principle IV p. 479

For additional support, see the California Education and the Environment Initiative (EEI) Curriculum: The Greenhouse Effect on Natural Systems, The Life and Times of Carbon, and Living Under One Roof.

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Tufa towers rise from the water of Mono Lake.

The Sacramento-San Joaquin Delta is California's most important water resource.

4258 Unit 7 Chemical Equilibrium Systems

In the Teacher's Unit Planner, specific examples from California's different regions precede each unit to help **localize the learning** and foster student engagement.

Connections to Community

Use these opportunities for informal science learning to provide local context and to extend and enhance unit concepts.

At Home
HOME CHEMICAL REACTIONS Have students work with a family member to make a list of chemical reactions they observe in their home over an entire weekend. Examples may include various types of cooking or a burning candle. For each reaction, have students classify whether they think the reaction is reversible. *Use with Lesson 1.*

ACIDS AND BASES AT HOME Provide each student with several acid-base indicator strips. Have them use the strips to test several liquids in their home, such as foods or personal care products. Then have them make a list describing their results. *Use with Lesson 2.*

In the Community
ACIDITY MONITORING Arrange for a representative from a local water-management plant to speak to the class about techniques used to measure and monitor the acidity levels of water systems in the area and problems associated with managing these levels. If you live in a coastal community, ask the representative to discuss measuring and monitoring of ocean acidity levels. *Use with Lesson 2.*

Culture
EFFECT OF ACIDITY LEVELS ON FISHING Some cultures depend strongly on local fishing as a primary source of food. If water sources become highly acidic because of people's actions, their food source can be endangered. Invite students who have lived in this type of community, in the United States or elsewhere, to share their experiences. *Use with Lesson 4.*

Home Letters
Use these letters to engage family members with unit concepts.

Collaborate
Opportunities for students to work collaboratively in this unit:
Debate p. 493
Discussion pp. 430, 438, 469, 470
Numbered Heads Together pp. 444, 478
One Moves p. 474
Say Something p. 446
Think-Pair-Share p. 436, 448, 460, 494

Connections to Other Disciplines
Opportunities to connect to other content areas in this unit:
Biology Connection pp. 468, 492
Earth Science Connection pp. 454, 459
Engineering Design Connection pp. 500, 501
Language Arts Connection pp. 439, 455, 480, 497
Math Connection pp. 432, 452, 474

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UNIT 7 Chemical Equilibrium Systems

California Access and Equity

California Diversity
Students Living in Poverty Keep in mind that some students may not have a family car. Word questions and discussions carefully to avoid references to the impact a family vehicle has on carbon emissions.

Ethnically Diverse Learners Engage students from diverse ethnic backgrounds by using examples of human impact on the climate in students' country of origin. Invite them to share their experiences with the class. Be sure to emphasize positive outcomes of efforts in those countries to counteract human impact on climate.

Migrant Students Invite students who have traveled and lived in various areas to describe any places they have seen where human activities have adversely affected the local land or water supplies.

Additional support for California's diverse population can be found throughout the unit in Support for All Learners features.

Language and Science Literacy

Unit Vocabulary
reversible reaction Lesson 1
chemical equilibrium Lesson 1
equilibrium constant Lesson 1
acid-base indicator Lesson 2
buffer Lesson 2
solubility product Lesson 2
common-ion effect Lesson 2
ocean acidification Lesson 3
Le Chatelier's principle Lesson 3
interest group Lesson 4

Reinforcing Vocabulary
Have students work as a class to make a two-column list on the board in which they classify common chemical reactions as reversible or not reversible.

Greek and Latin Word Parts
Have students use an online etymology dictionary to identify the origins of word parts for the following words. For each word, have students tell how the word parts lead to the scientific definition of the term.
= equilibrium
= dissociation
= swelling

Academic Vocabulary
An important term students must understand in the study of chemical equilibrium is stable—and its related form stability. Guide students in a discussion of these terms, and ask them to provide examples of their use in everyday life. Emphasize that objects are stable if the forces on them are balanced. Then help students transition to an understanding of the use of the words when describing particles in a chemical system.

Integrated ELD
Have students maintain a list on the board of terms in the unit that they find unfamiliar or difficult. Help them define each word as they encounter it, and write the definition on the board as a reminder.

Integrated ELD
English Language Development support resources include a supplemental book entitled **Designated ELD in Your Science Classroom**. Integrated ELD teaching strategies in this unit include:
Lesson 1 p. 433
Lesson 2 pp. 445, 453
Lesson 3 p. 483

MTSS Tier 2
Strategies for students who need extra support in this unit include:
Lesson 1 pp. 431, 435, 439
Lesson 2 pp. 447, 453, 455, 457, 459, 463
Lesson 3 pp. 481, 485
Lesson 4 pp. 493, 501, 503

Advanced/Gifted
Strategies for students who have mastered core content in this unit include:
Lesson 1 p. 435
Lesson 2 pp. 445, 459
Lesson 3 pp. 477, 481
Lesson 4 p. 497

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LESSON 3 Engage • Explore/Explain • Elaborate • Evaluate

EXPLORATION 5 Catalysts and Equilibrium

Engineering
Catalysts and Equilibrium
Ammonia is produced industrially by reacting nitrogen and hydrogen:
 $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$
Ammonia is one of the top industrially produced, inorganic chemicals in the world. The majority of it is used directly or indirectly as agricultural fertilizer to increase crop yields. Without ammonia-based fertilizers, mass starvation would be more common. Under normal conditions, the reaction that produces ammonia proceeds too slowly to obtain a significant amount of product. Scientists and engineers need a way to increase the rate of this reaction.

REACTION RATES AND CONCENTRATION
The mechanism of a reaction can be altered by adding a catalyst, a substance that changes the rate of the reaction without being consumed or changed significantly. The addition of a catalyst speeds up the overall rate of a reaction for both the forward and the reverse reactions in an equilibrium system. The graph below shows that equilibrium is reached faster in the presence of a catalyst.

MODEL Draw two additional lines showing how the equilibrium reaction will proceed when a more efficient catalyst is present.

INFER How does a catalyst affect an equilibrium system? Each answer choice may be used more than once. Some answer choices may not be used at all.
increases decreases does not change
The addition of a catalyst to an equilibrium system _____ the rate of the forward reaction and _____ the rate of the reverse reaction. The equilibrium concentration of each product and reactant _____ with the addition of a catalyst to an equilibrium system.

Lesson 3 Disrupting Equilibrium in the Ocean 485

CALIFORNIA

Support for All Learners
MTSS Tier 2 Explain to students that most chemical reactions take place in a sequence of steps rather than in a single step. This sequence is called a **reaction mechanism**. Several different mechanisms are often possible to convert reactants into products. When no catalyst is involved, one mechanism usually occurs. However, when a catalyst is involved, a different mechanism occurs.

3D Learning Objective
Students explore the impact of new technologies on society and how scientists and engineers refine solutions to a complex problem using criteria and tradeoffs. Using the Haber-Bosch process as an example, students relate the development of the process to major global challenges involving food supplies and explore how these challenges were addressed.

Exploring Visuals
The purpose of the concentration-time graph is to show that equilibrium—the flat, horizontal part of the curve—is reached earlier when a catalyst is present than when a catalyst is not present. Be sure students understand that the top pair of curves represents reactants that decrease in concentration. The bottom pair of curves represents products that increase in concentration.

1 Students should add lines that begin at the same places as the other lines, but that reach the equilibrium position earlier than the blue or red lines.
2 increases, increases, does not change

Point-of-Use Support

Strategies for the many diverse categories of learners are embedded throughout the **Teacher Edition** and in the Teacher's Unit Planner.

Tips and suggestions for supplementing instruction provide a **Multi-Tiered System of Support (MTSS)**.

Teacher Guide
Designated ELD in Your Science Classroom

California HMH SCIENCE DIMENSIONS.

Chemistry in the Earth System

Designated ELD Resources Include

- Word Network
- Vocabulary Cards for each lesson
- Blank Vocabulary Cards for students to create their own study words
- Sentence Frames for class discussion of:
 - Hands-On Labs
 - Claims, Evidence, and Reasoning
 - DCIs, SEPs, and CCCs
- Language X-Rays for each lesson, including Vocabulary Building support and Unpacking the Text
- Bibliography of recent research on ELD topics
- Developing and Using Models
- Constructing Explanations and Designing Solutions

Multilingual Glossary

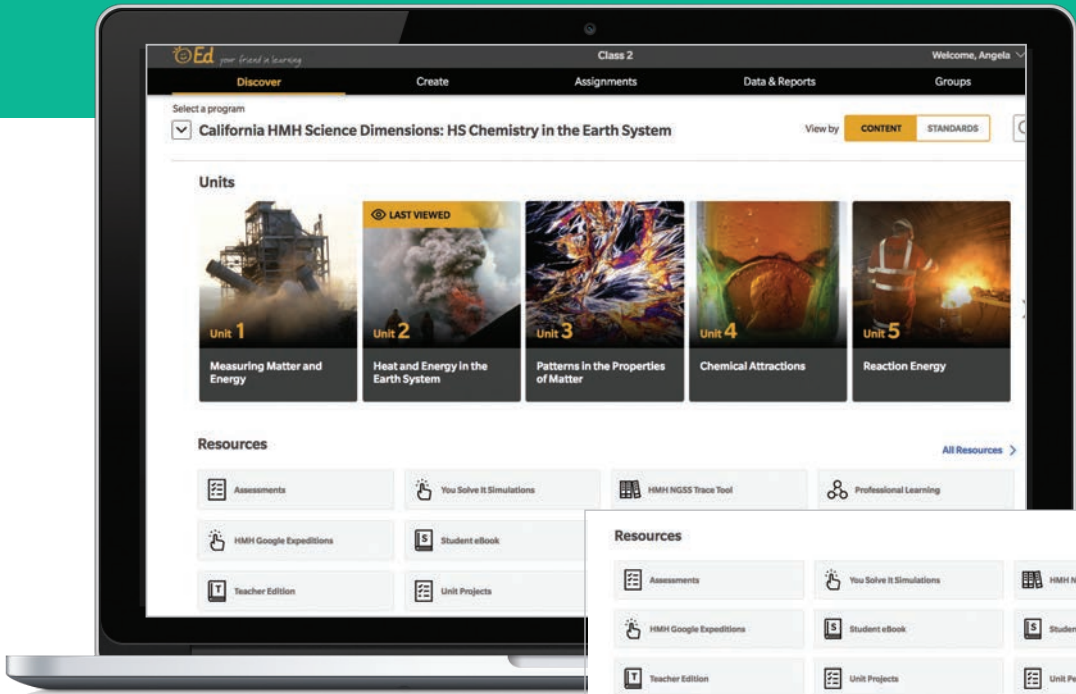
Understanding the need for support of diverse languages, the **Multilingual Science Glossary** provides translation of common high school science terms and definitions in:

- English
- Spanish
- Chinese
- Vietnamese
- Hmong
- Tagalog
- Arabic
- Korean
- Haitian Creole
- Russian
- Punjabi
- Portuguese

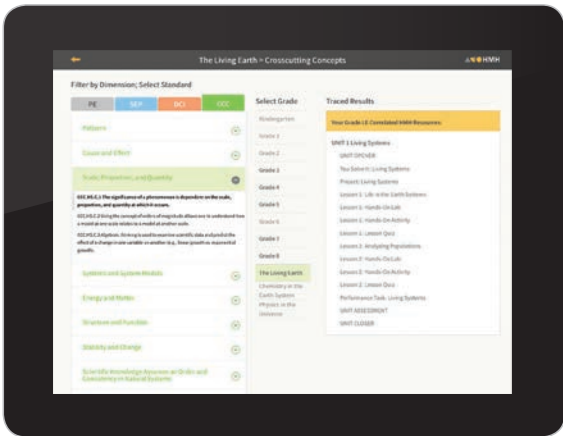
Grades 9–12
Multilingual Science Glossary

Bring science to life with our digital platform, **Ed: Your Friend in Learning**

Ed: Your Friend in Learning® is a new online learning system that combines powerful digital media content and accessibility resources to customize teaching and learning experiences. Teachers can implement a flexible, **blended approach to teaching science**—or go completely digital supporting the next generation of science leaders. *Ed* is user-friendly and provides teachers with the support they need to foster a student-centered learning environment.



Program content can be accessed offline, allowing maximum compatibility in 1:1 or Bring Your Own Device learning environments, and also supports the wide variety of technology that students have at home.



Start with the CA NGSS Trace Tool

- The Trace Tool identifies HMH resources, allowing teachers to customize their CA NGSS–based instruction.
- Teachers see exactly what students should already know and the concepts they are about to learn.

The Trace Tool shows how and where each of the PEs, SEPs, DCIs, and CCCs are addressed in *California HMH Science Dimensions*.

Data and Reporting

Student Growth Measure

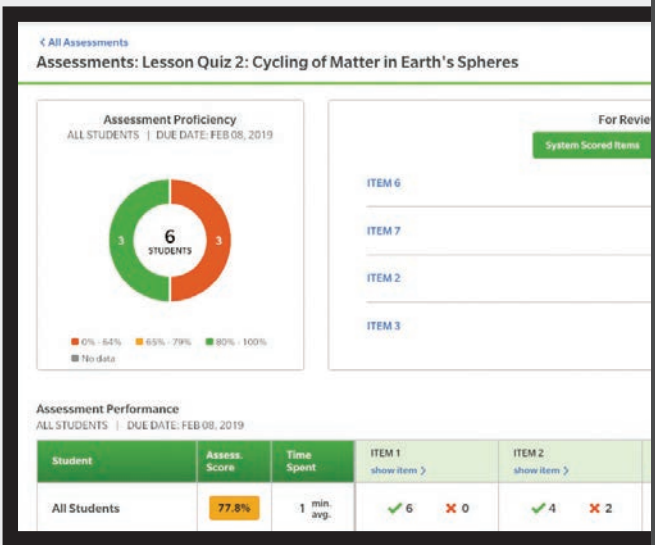
- Easily identify where students are now and where they've made progress based on data insights at the student, class, and district level.
- Administrative leaders receive the insight to drive student growth and identify strengths and weaknesses across their district.

Accessibility

- Education must be accessible to all learners, and we are committed to meeting WCAG 2.0 AA standards on *Ed: Your Friend in Learning* for those using assistive technologies.

Anytime, Anywhere Access

- With the ability to connect to quality content both online and offline, all learners have equal access to resources.



Explore Immersive Virtual Worlds with Google Expeditions

- As a Google® content partner, HMH has developed **HMH Field Trips powered by Google Expeditions**. Students are swept away into **360-degree 3D experiences** in fascinating locations directly tied to science content.
- A correlated HMH Teacher Guide provides ideas for incorporating Field Trips into your lessons, as well as tips on how to **guide and customize** the experience.
- Featured **virtual field trips** include California State Parks, Orange Blossom Cannonball, the Great Barrier Reef, and more!



HMH Field Trips

powered by



Unmatched **professional support** helps you transition with ease

A CA NGSS curriculum requires a significantly different approach to teaching science, and although this new approach involves a lot of change, its rewards are immediate. HMH provides the support you need to make the transition to a student-centered, CA NGSS-style of teaching.



SEE CA NGSS IN ACTION

Embedded professional development videos guide teachers through the key approaches that ensure CA NGSS success.

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



Your California-based support team lives and works right here in California.

Contact your HMH Account Executive today:
hnhco.force.com/relocator

Create Long-Term, Sustainable Growth

Our blended professional learning model moves beyond the one-size-fits-all approach to include in-person and online support that is flexible, collaborative, and personalized to meet your needs.

Comprehensive Implementation Support

Your implementation will begin with a **Getting Started with CA HMH Science Dimensions** course and a **Professional Learning Guide**, which provides suggestions for prioritizing content with manageable milestones.

Getting Started Modules and **Classroom Videos** on *Ed: Your Friend in Learning*, along with **Author 3D videos**, will help you hone your craft and discover new strategies and techniques for teaching.

Personalized Follow-Up

Our in-person and live online **Follow-Up** sessions focus on supporting key *California HMH Science Dimensions* topics. Choose from these relevant, 90-minute videos to create a personalized follow-up experience:

- Maximize Learning with the Digital Resources
- Plan and Prioritize Instruction
- Make Science Accessible to ALL Learners
- Integrate Meaningful STEM Experiences
- Build Literacy and Science Content Knowledge
- Use Data to Monitor Progress and Inform Science Instruction

Blended Coaching

Our blended coaching not only focuses on a successful *California HMH Science Dimensions* implementation, but also offers instructional strategies that will help students collaborate, test ideas, state claims, find resolutions, and think like scientists.

Our coaches will work with you in person and online to analyze and set your goals, learn new instructional practices, and apply them in your classroom. And, you will receive ongoing support from your coach through the **Coaching Studio**.

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



Coaching Studio

