So Now You Are Teaching Earth Science—What Do You Need to Know to Be Prepared?

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HMH

Who Am I to Be Sharing Ideas with You?

- 44-year Earth Science teacher in Middle School, High School, College, and Informal Science + 4 years as Science Ed Consultant/PD Provider

- BA (Geology); MAT and EdD (Science Education); MEd (C & T) from Columbia University

- Founder/organizer of the Earth2Class professional development program at the Lamont-Doherty Earth Observatory of Columbia University

- President of NESTA, NAGT-Eastern Section, and STANYS

- Session presenter at local, state, regional, and international conferences

- *HMH Science Dimensions Earth & Space Science* Consulting Author

So You Are Teaching Earth Science Now—What Do You Need to Know to Be Prepared?

- This question really requires a semester-long course, so today's session will only present 'highlights' and selected examples

- It's based on my experiences and teaching materials, combined with resources created for the *HMH Science Dimensions Earth & Space Science* program, print and online

- Many resources shared here are available in more extensive form: https://earth2class.org/site/?p=14856

What Will We Explore Today?

- Brief background about the NGSS and other Standards
- General Content Topics and Key Ideas in MS/HS ES courses
- Lab Activities and suggested classroom equipment needs
- Selected Web-based resources and other ideas
- Incorporating Field Experiences

and…

What Will We Explore Today? cont‘d.

- Lab Reports, Essays, Slideshows, and other Communications
- Helping Students—Spatial Thinking and Differentiated Instruction
- What HMH Science Dimensions Can Offer
- Your Questions/Comments

Why Is It Important for Students to Learn Earth Science?

- Open discussion of the questions your group discussed as you entered

- Did you include something like:
  - How to respond to weather forecasts, especially warnings?
  - How to create effective emergency plans for other natural hazards such as tsunamis?
  - What to do to assure sustainable water and material supplies?
  - Where can you go to enjoy the beauties of Nature?

  - Earth Science can be optimal for Phenomenon-Based Learning

What's Our Target?

- We want to help create a 100% scientifically-literate citizenry

- We want competent research and applied scientists, engineers, first responders, etc. (maybe 5 % of the population, 1 out of 20 students?)

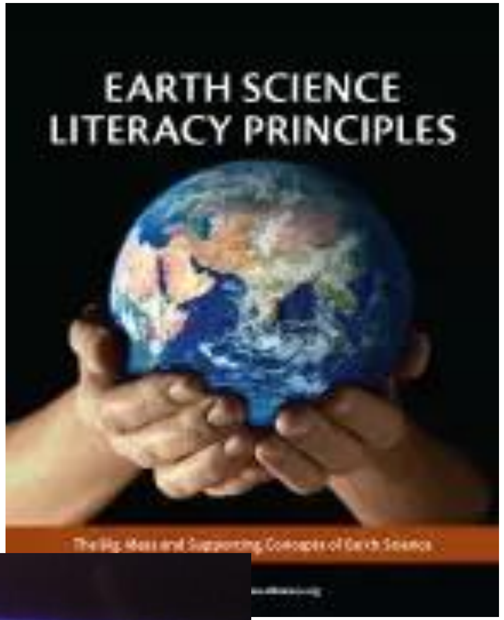
- We want qualified/science-based decision-makers (maybe 1%, 1 out of 100?)

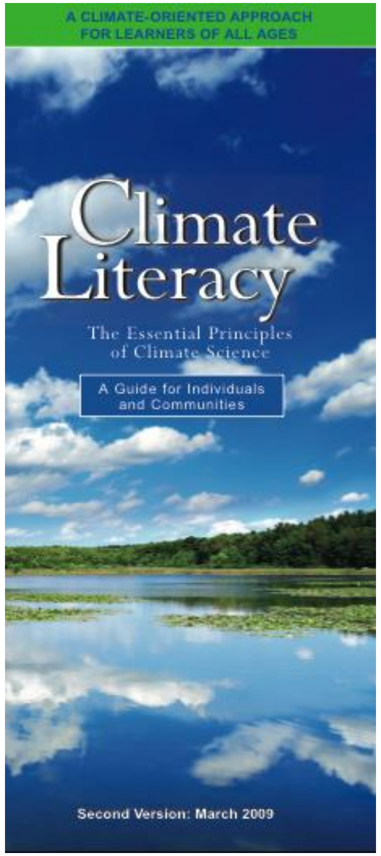
As teachers, we never know what impact we will have on our students. But there is no doubt that what we help them learn will stay with them their entire lives. So we try to meet the challenges as well as we can.

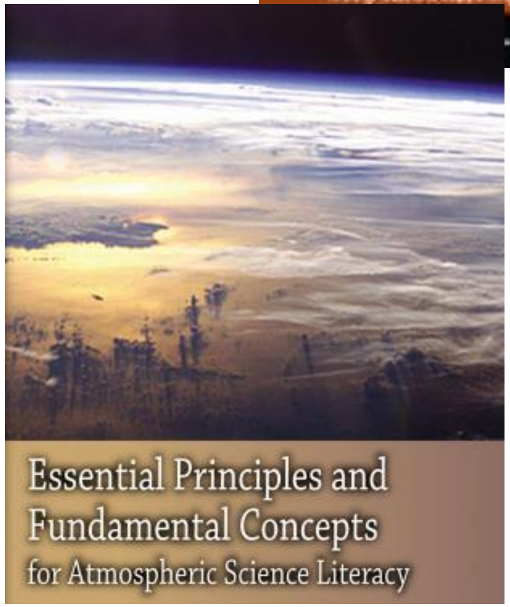
Brief background about ES Education

- The Science Literacy Documents (https://earth2class.org/site/?page_id=4725)

- Atmospheric Science Literacy
- Climate Literacy
- Earth Science Literacy
- Energy Literacy
- Ocean Literacy







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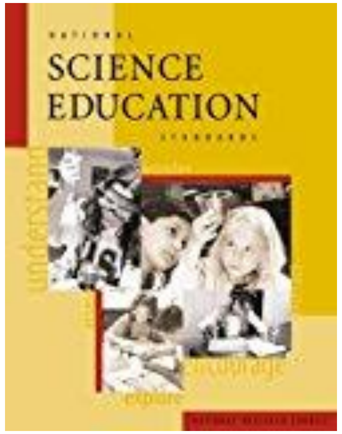
The "Big Ideas" in Earth Science

- http://www.earthsciweek.org/big-ideas

- Big Idea 1: Earth scientists use repeatable observations and testable ideas to understand and explain our planet.
- Big Idea 2: Earth is 4.6 billion years old.
- Big Idea 3: Earth is a complex system of interacting rock, water, air, and life.
- Big Idea 4: Earth is continuously changing.
- Big Idea 5: Earth is the water planet.
- Big Idea 6: Life evolves on a dynamic Earth and continuously modifies Earth.
- Big Idea 7: Humans depend on Earth for resources.
- Big Idea 8: Natural hazards pose risks to humans.
- Big Idea 9: Humans significantly alter the Earth.

State and National Science Standards

- Created/revised in response to "National Science Education Standards" (National Academies of Sciences, Engineering, Medicine, 1996)
  - Inspired by AAAS Project 2061 (1986)



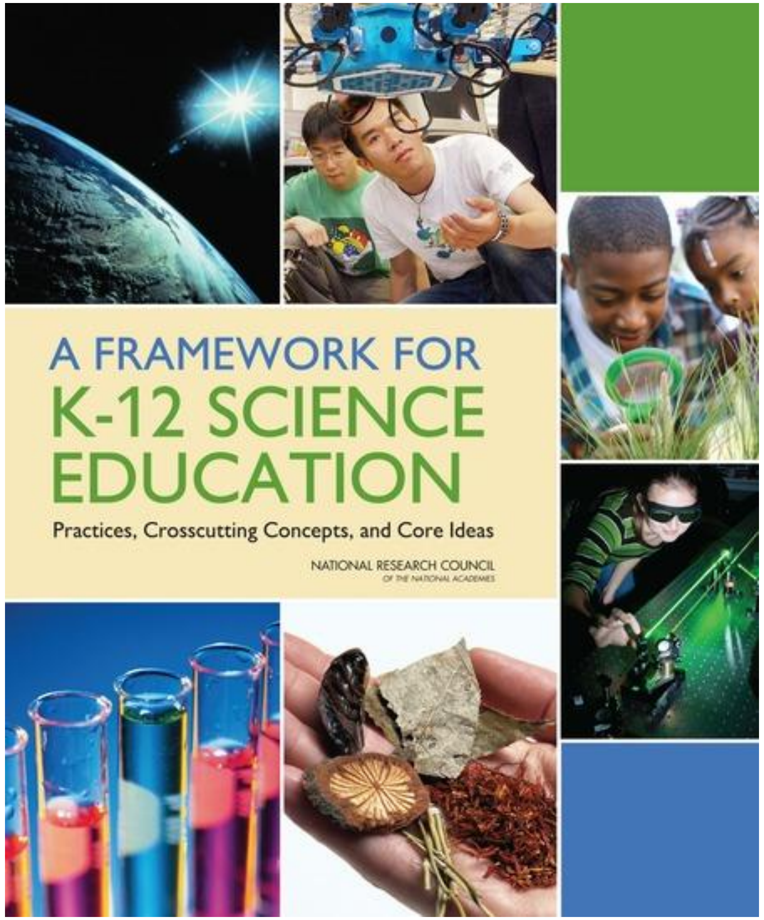
- Individual State initiatives – tremendous variability
  AGI Indicators of Geoscience Education

- New York State "Physical Setting/Earth Science" (Regents Earth Science)
  Core Curriculum Guide
  Earth Science Reference Tables (ESRT)
  Regents ES Exams
  Other levels – Intermediate and Elementary

  - Influenced by the **Earth Science Curriculum Project (ESCP)**

A Framework for K – 12 Science Education Patterns, Crosscutting Concepts, and Core Ideas (2012)

- National Research Council of the National Academies



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A Framework for K – 12 Science Education Patterns, Crosscutting Concepts, and Core Ideas

- Represents first step in a process to create new standards in K-12 science education

- Capitalized on a major opportunity that exists at this moment—a large number of states are adopting common standards in mathematics and English/Language Arts

- Poised to consider adoption of common standards in K-12 science education

- Impetus grew from recognition that existing national documents developed in 1990s were an important step, but much room for improvement

Next Generation Science Standards

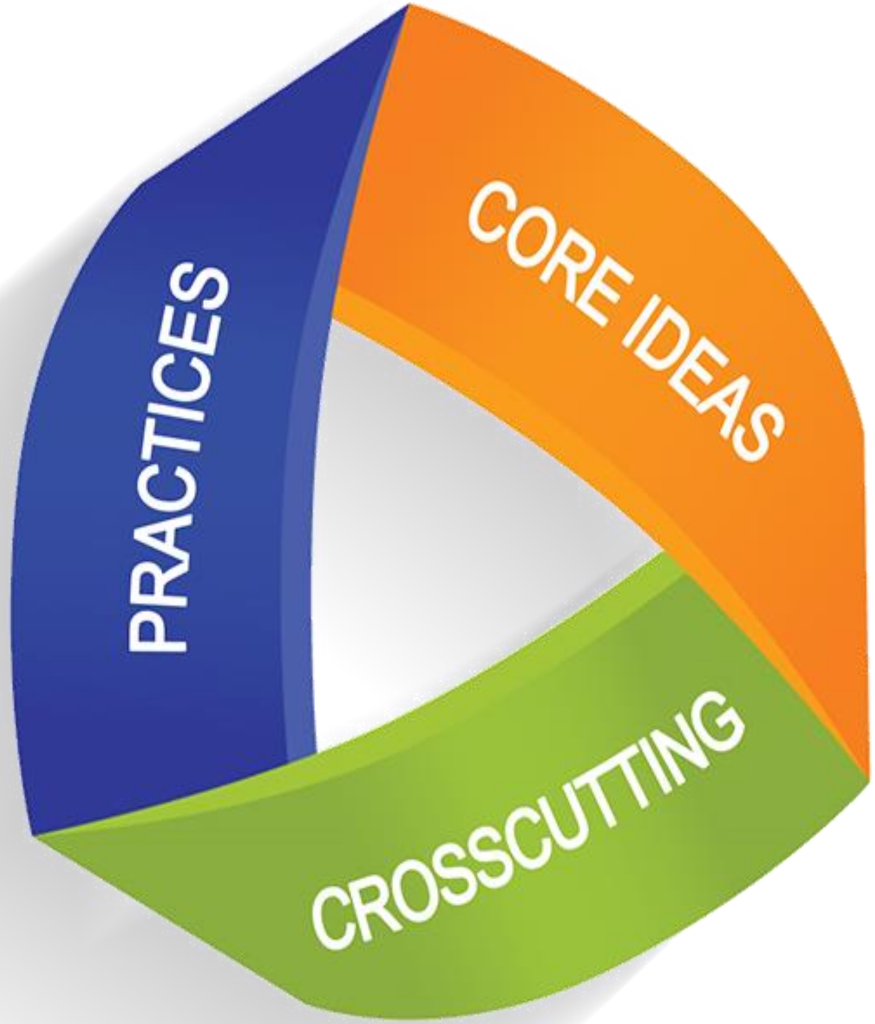
https://www.nextgenscience.org/ (2013)

- Collaborative, state-led process
- Incorporate advances in science education research so as to enable students to *learn science* by *doing science.*
- Rich in both content and practice
- Arranged in coherent manner across disciplines and grades to provide all students an internationally benchmarked science education

NEXT GENERATION SCIENCE STANDARDS

For States, By States

The “3-Dimensions of Science Learning”



- Practices-- “what students do”
- Core Ideas – “what students know”
- Crosscutting– “how students think”

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Performance Expectations

- What students should know and be able to do
- Parsed by grade bands and grades
- Progressions for Science and Engineering Practices (SEPs); Disciplinary Core Ideas (DCIs); and Crosscutting Concepts (CCCs)

MS-ESS2-1.	**Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process.** [Clarification Statement: Emphasis is on the processes of melting, crystallization, weathering, deformation, and sedimentation, which act together to form minerals and rocks through the cycling of Earth’s materials.] [*Assessment Boundary: Assessment does not include the identification and naming of minerals.*]

Other Expectations

- English Language Arts & Math
  "Common Core" influence on mandated testing

- Social Studies and other subjects
  integration with Earth Science, especially physical geography

- Arts – expanding STEM to STEAM

- NGSS Adopted by more than 15 States + DC/Adapted by many others

Teacher Edition

Alignment with NGSS

LESSON 1

Solar System Formation

Building to the Performance Expectation

The learning experiences in this lesson prepare students for mastery of

HS-ESS1-6 Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth's formation and early history.

Trace Tool to the NGSS

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

SEP Science & Engineering Practices

Analyzing and Interpreting Data
Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.

Engaging in Argument from Evidence
Construct, use, and/or present an oral and written argument or counter-argument based on data and evidence.

DCI Disciplinary Core Ideas

ESS1.C The History of Planet Earth
Although active geologic processes, such as plate tectonics and erosion, have destroyed or altered most of the very early rock record on Earth, other objects in the solar system, such as lunar rocks, asteroids, and meteorites, have changed little over billions of years. Studying these objects can provide information about Earth's formation and early history. (HS-ESS1-6)

ESS2.A.1 Earth Materials and Systems
Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. (HS- ESS2-1), (HS-ESS2-2)

CCC Crosscutting Concepts

Influence of Engineering, Technology, and Science on Society and the Natural World
New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology.

Stability and Change
Much of science deals with constructing explanations of how things change and how they remain stable.

Stability and Change
Feedback (negative or positive) can stabilize or destabilize a system.

What Should You Be Teaching?

- Probably your first question is, “What should I be teaching?”

- The next is, “How should I teach it?”

- There is no ‘one size fits all’ or any ‘usual’ curriculum. You will need to create your own, and re-create it each year.

- But here are some thoughts and resources to help you.

Most Earth Science courses include, in some order:

- Introduction and general skills (ex, observation and measurement)
- Earth's Geography (globes and maps)
- Materials of the Earth (minerals, rocks, resources)
- Earth's dynamic interior and exterior processes
  (including Plate Tectonics, weathering, erosion, deposition, water resources)
- Weather and climate
- Earth's place in Space (Astronomy)
- Earth's History
- Humans and Earth – Sustainability
- Optional areas (ex., oceanography, local environmental issues)

One Source for ‘Plain Language Key Ideas’

https://earth2class.org/site/?p=14924

- Observation and Measurement
- Models of the Earth
- Energy and the Environment
- Minerals, Rocks, and Resources
- Earthquakes, Volcanoes, and Plate Tectonics
- Weather and Climate
- Astronomy (Earth in the Solar System–Space)
- History of Earth

Key ideas — Minerals, Rocks, and Resources

Minerals are solid, inorganic, crystalline substances with definite chemical compositions.

Minerals properties include: crystal shape, hardness, cleavage, fracture, color, luster, streak, density, and special properties, such as reaction to acid, salty taste, magnetism, and fluorescence.

Minerals properties depend upon their internal arrangement of atoms.
The silicon-oxygen tetrahedron is the building block of all the silicate minerals and has a pyramid shape.
Quartz (SiO_2, silicon dioxide) is the most common mineral. Sand is mostly quartz and window glass is usually made of quartz
Other mineral groups include the oxides, carbonates, sulphides, halides, and native elements.
Rocks are solid mixtures composed of minerals.
Monomineralic rocks made of only one mineral and are rare. Most rocks are polymineralic, made of two or more minerals combined physically (not chemically).

Rocks are classified according to their origin (how they were formed.)
Igneous rocks formed through melting and solidification/crystallization. This produced a random pattern of intergrown crystals or, with very rapid cooling, a glassy appearance. Fossils are very rarely found in igneous rocks.

Igneous rocks with a coarse texture consisting of large (easily visible) crystals probably cooled slowly underground. They are sometimes called plutonic. Two examples are granite and gabbro.
Igneous rocks with a fine texture (barely visible crystals) cooled faster on the surface. They are called volcanic. Two examples are basalt and rhyolite. Pumice and obsidian are volcanic rocks that solidified so rapidly that no crystals could grow, so they have a glassy texture..
Basalts form most of the ocean crust, underlying almost three-quarters of the surface.

Sedimentary rocks form in several ways. Some form by compaction and cementation of sediments or rock fragments. Others form by chemical reactions, often in seawater. Most fossils are fond in sedimentary rocks.
Clastic sedimentary rocks are often classified by their grain size, from shale through sandstones and conglomerates. They are the most common rocks on the continent's surface. But they are really a thin veneer above non-sedimentary rocks forming most of the continental crust.

Sedimentary rocks can also form by chemical reactions to produce precipitate rocks, such as limestones and dolostones, and evaporites such as rock salt and rock gypsum.

Metamorphic rocks are created by changing pre-existing rocks under intense heat and pressure.

Some metamorphic rocks, exhibit banding or foliation.

Relationships among the various rock types can be represented by a diagram of the Rock Cycle.

All of the resources used to manufacture our everyday world come from some rock or mineral. Oresare extracted from the Earth by mining and refining processes.
Some ores are renewable and will replenish themselves in a short time, but most resources are non-renewable. Therefore, it is important to conserve or recycle.
Many common materials used in buildings and streets–such as bricks and concrete–are really 'artificial' sedimentary rocks. Window glass is really an 'artificial' igneous rock.

What Does *HMH Science Dimensions E & SS* Include?

1) Introduction to Earth and Space
2) Systems of Matter and Energy
3) Natural Resources
4) Earth in the Solar System
5) Space
6) Plate Tectonics
7) Earth's Changing Surface
8) Earth's Water
9) The Atmosphere
10) Exploring Earth's History
11) Human Activity and Earth

5 E's: Engage, Explore, Explain, Elaborate, Evaluate

Aligned with NGSS

Utilizes 'Best Practices'

Ed your friend in learning

1

Welcome, Tito

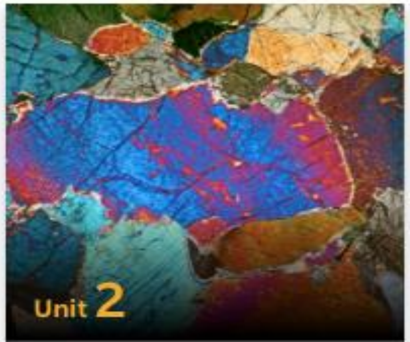
Discover | Assignments | Data & Reports

HMH Science Dimensions: Earth & Space Science

View by CONTENT STANDARDS

Units

Introduction to Earth and Space



Systems of Matter and Energy

Natural Resources

Earth in the Solar System

Space

Resources

All Resources

- Assessments
- You Solve It Simulations
- HMH NGSS Trace Tool
- Professional Learning
- HMH Google Expeditions
- Thing Explainer

Show All

Can You Explain It?
(Engage)

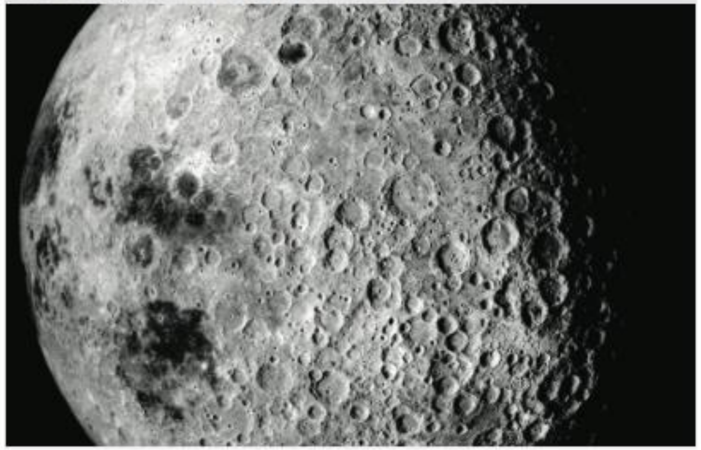
4.1

Solar System Formation

Comet Churyumov-Gerasimenko, as seen from the *Rosetta* spacecraft in 2014

CAN YOU EXPLAIN IT?

FIGURE 1: The ancient surface of Earth's moon is covered with impact craters that formed when other objects smashed into it and exploded.



Gather Evidence Record observations about the composition and structure of the solar system and the objects that make it up. As you explore the lesson, gather evidence that can be used to explain how the solar system formed.

On the lunar surface, nested impact craters ranging in size from microscopic to hundreds of kilometers in diameter cover the desolate moonscape. They bear witness to the violent history of the early solar system. On Earth's mostly watery surface, reminders of this period are harder to find. What is there to be learned from impact craters on the moon and on Earth?

Explain Why doesn't Earth's surface show the same violent history as the moon's surface?

Teacher Edition

Alignment with NGSS

Teacher Wrap-Discussion

ENGAGE: Lesson Phenomenon

Lesson Objective

Explain the origin of the solar system, describe the characteristics of the solar system, and analyze evidence to make inferences about Earth's formation and early history.

Can You Explain It?

Students are asked to gather evidence about the composition, structure, and formation of the solar system. They will use evidence to compare and contrast the characteristics of objects in the solar system. Students will use what they have learned about the solar system to explain its formation and Earth's early history.

Collaboration

Accessing Prior Knowledge You may wish to have students read and discuss the question as a whole-class activity. In this way, you can get a good sense of the level of prior knowledge that students may have about the solar system and Earth's early history. Many students will be familiar with the heliocentric model based upon prior knowledge. Ask students to consider how our understanding of the solar system and Earth's formation has changed over time.

EVIDENCE NOTEBOOK

1. Encourage students to pay attention to the types of materials that make up the objects in the solar system. Remind them to look for patterns in the distribution, motion, and physical characteristics of these objects. Encourage them to think about how the solar system, and Earth in particular, might have changed since its formation.
2. Guide students to think about this question as they work through the lesson, collecting evidence about Earth's formation and early history. As they attempt to answer this question, encourage students to apply prior knowledge about differences between Earth and the moon.

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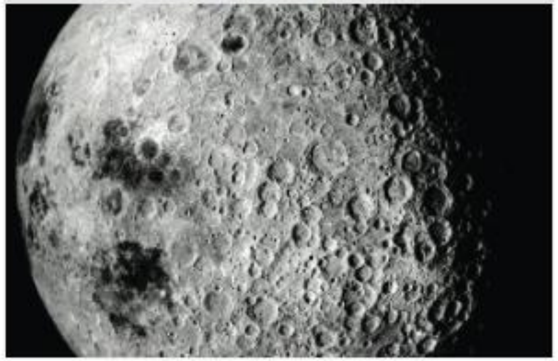

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Image Credits: (t) ©Science Source; (b) ©Apollo 16/NASA

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2-4 **Explorations** Per Lesson

- Key ideas
- Discussion of historical changes
- Interpreting data in various forms
- Sidebars linking to other challenges

EXPLORATION 2

Solar System Formation

Gather Evidence Assuming the solar system is a closed system (no material has entered or left the system since it began to form), what was the composition of the material that the solar system came from?

Analyze Compare the densities of the inner and outer planets. What can explain these differences?

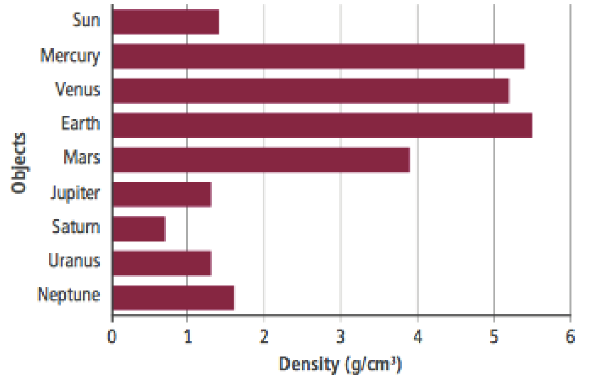
Our current model of the solar system illustrates our understanding of its structure and composition as it exists today. By studying its characteristics and gathering evidence, scientists developed a model to explain how the solar system and Earth formed.

Observations and Characteristics

How is matter distributed in the solar system? There are trillions of tons of material in the solar system, but it is not distributed evenly throughout. More than 99.8% of the mass of the solar system, or about 1.99×10^{30} kg, is found in the sun. Most of the rest is concentrated in the planets. The sun is composed almost entirely of hydrogen and helium. All other elements make up only about 2% of the composition of the sun.

Density Distribution

FIGURE 8: Comparing the masses and densities of the planets and sun confirms the fact that material is not mixed evenly throughout the solar system.



The sun may have most of the mass in the solar system, but Mercury, the smallest planet, has more than three times its average density. How is that possible? Recall that density is the ratio between the mass and volume of a substance. The sun is the largest object in the solar system, larger than Jupiter, the largest planet.

What else do you notice about the relative average densities of the inner and outer planets? What about their relative sizes? The inner planets have relatively high average densities, while the outer planets have very low average densities. However, although they are less dense, the outer planets are much more massive. In fact, together, the outer planets contain more than 99% of the total mass of the planets.

Explain What is the relationship between the size, mass, average density, composition, and location of the planets?

Teacher Edition

Alignment with NGSS

Teacher Wrap-Discussion

Differentiated Instruction

LESSON 1 Engage • **Explore/Explain** • Elaborate • Evaluate

EXPLORATION 1 The Solar System

EXPLORATION 1

The Solar System

If you compare a model of the solar system made today with models constructed in the past, you will find that they are different. The solar system itself has not changed significantly over the past 2000 years, but our understanding of it has.

Solar System Models

What comes to mind when you think about the solar system? You might remember seeing a recent full moon, the shimmering light of a distant star, or the brightness of a nearby planet. Like you, ancient people also noticed the objects in the night sky.

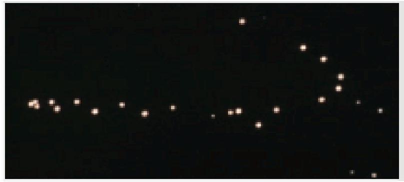


FIGURE 2: From night to night, some objects in the sky appear to wander relative to the background of stars. This figure shows the path of an object studied by ancient observers.

3 **Explain** What is a possible cause of the apparent motion of the object shown in Figure 2?

Early astronomers made careful observations to construct explanations and build models of the solar system. They were familiar with the daily motion of the sun and moon and discovered that throughout the year, different groups of stars appeared in the night sky. They also identified five starlike objects that wandered back and forth relative to more distant stars and called them planets. Based on their observations, these observers developed the geocentric model of the solar system. In this model, all the objects in the sky moved in circular paths around Earth. The paths of Mars, Jupiter, and Saturn had loops called epicycles that help explain and predict their apparent back-and-forth motion.

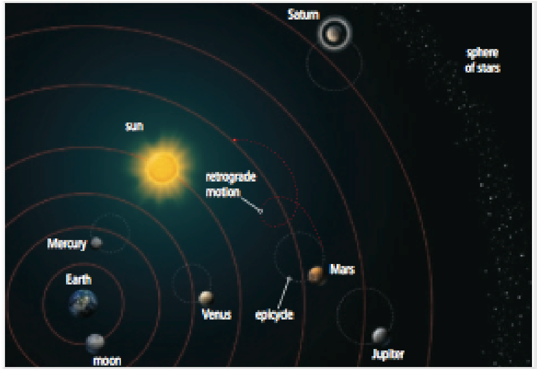


FIGURE 3: Geocentric models of the solar system explain careful observations such as the apparent motion of the sun, moon, planets, and stars across the sky.

3D Learning Objective

Students will learn how much of our understanding of the solar **science deals with constructing explanations of how things change and how they remain stable.** They will **analyze** evidence **using models in order to make valid and reliable scientific claims** about our current understanding of the structure, composition, and formation of the solar system. Students will further explore how **studying the structure and composition of the solar system can provide information about Earth's formation and early history.**

Differentiate Instruction

Extension Explain that retrograde motion is an optical illusion that occurs when Earth passes slower-moving planets. Because our frame of reference is from the perspective of Earth, it appears that the other planet is changing direction, although it is actually not—we are simply passing it. As a class, challenge students to demonstrate how planets would appear to move backward (retrograde) based on the perspective of the observer.

CCC Scale, Proportion, and Quantity

Before going over the Evidence Notebook question on this page, explain that the object in Figure 2 is the planet Mars. Mars's location and apparent motion in space were known to ancient astronomers. Have students discuss the role distance played in these astronomers' ability to observe Mars and to describe its motion. Lead students to understand that because Mars was one of five planets relatively close to Earth with respect to the more distant stars, ancient astronomers were able to notice them and their motion in the night sky.

EVIDENCE NOTEBOOK

3 The apparent motion of the object is a result of the fact that it is actually moving in space relative to the stars, but also because it is much closer to Earth than the stars are. As Earth moves, the object appears to move back in space relative to the stars in the background.

Lesson Self-Check
(Evaluate)

- Challenges based on lesson content
- Involves higher-order thinking and open-ended responses

EVALUATE

Lesson Self-Check

CAN YOU EXPLAIN IT?

FIGURE 24: Impact craters on the moon's surface record part of the solar system history.

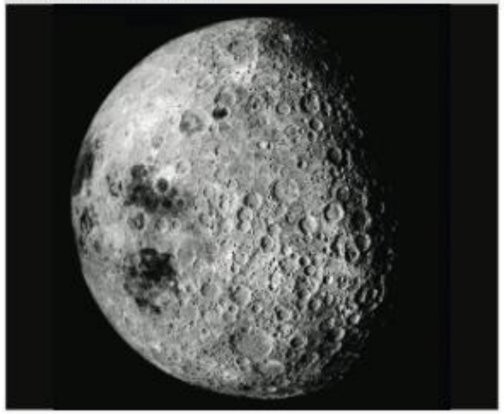


FIGURE 25: Manicouagan crater in Québec, Canada

Take another look at this picture of the moon. On Earth, evidence of this early, violent period in the history of the solar system has been erased by the processes that tear down and build up the land. The Manicouagan impact crater in Canada, believed to be the oldest crater on Earth, is only about 214 million years old.

Radiometric evidence from lunar rock samples brought back to Earth suggests that most of the lunar craters formed within a narrow period of time around 4 billion years ago. Scientists can draw conclusions about the early history of the moon based on this evidence. They can also make inferences about conditions on Earth, other planets and moons, and the solar system at the time the craters were formed.

The radiometric evidence from lunar rock samples confirms that the moon already had a solid surface 4 billion years ago. It also suggests that there was a sudden increase in the number of impactors—asteroids, comets, and other solar system debris—at the time. Evidence suggests that this increase lasted approximately 200–300 million years.

Today, large asteroid and comet impacts on planets and moons are very rare. However, every year for a few days during mid–July to mid–August, Earth passes through the Perseid Cloud. Small debris, left over by a comet that crosses Earth's orbit every 133 years, strike Earth and burn up in its atmosphere.

Explain What can the existence of craters on the moon and on other planets tell us about the early history of solar system?

Lesson Self-Check (Evaluate)

- Challenges based on lesson content
- Involves higher-order thinking and open-ended responses
- Variety of questions
  - Identify right/wrong
  - Compare
  - Word fill-in
  - Other formats

EVALUATE

CHECKPOINTS

Check Your Understanding

1. Although the geocentric model of the solar system was incorrect, there were aspects of it that were relatively accurate. Identify which components of the geocentric model (prior to the 1700s) are accurate and which are inaccurate.
   a. The sun orbits Earth.
   b. The moon orbits Earth.
   c. Planets are closer than stars.
   d. Orbits and epicycles are perfectly circular.
   e. Saturn is farther away from Earth than Jupiter.
   f. Stars are farther away than planets but not much farther away.

2. Over the centuries, scientists have constructed models and explanations of the solar system based on evidence and reasoning. Compare the evidence and reasoning used to support the geocentric model with the evidence and reasoning used to support the modern model of the solar system.

3. A model for how the solar system formed must explain observations and reasoning. Identify each statement as an example of an observation or reasoning. If a statement is false or invalid, identify it as such.
   a. Most of the mass of the solar system is in the sun.
   b. The sun is composed primarily of hydrogen and helium.
   c. The sun formed more than 13.8 billion years ago when the universe formed.
   d. Most objects in the solar system orbit the sun in the same direction.
   e. If most of the mass of the solar system is in the sun and the sun is mostly hydrogen and helium, then the solar system must primarily be hydrogen and helium.

4. Modern telescopes have allowed us to see far beyond the solar system. We have been able to capture images of nebulae, regions where stars are forming, stars of different ages, and planets that orbit other stars. Write two scientific questions about solar system formation that observations of other nebulae, stars, and solar systems can help us answer.

5. Complete items a–c to demonstrate how a systems approach can be used to describe the solar system and its formation.
   a. What are the primary components of matter in the solar system?
   b. What are the energy components of the solar system?
   c. Identify some processes that are at work (or have been at work) in the system.

6. Use the following words and phrases to complete the paragraph below describing events in the formation of the solar system.

increased	*planetesimals*
dust particles	*gravity*
fusion	*accretion*
flattened	*collapse*
solid core	*star*
cloud of dust and gas	*massive bulge*

The solar system began as a swirling ____. Some disturbance caused the cloud to ____. As this happened, the density, temperature, and pressure within the cloud ____. As material swirled toward the center, the cloud ____ into a disk. A ____ developed at the center of the disk as mass accumulated there under the force of ____. At some point, ____ began and the bulge became a ____. At the same time, in the surrounding disk, ____ came together to form rocks. These rocks came together to form ____ which grew larger through ____ to form the inner planets and the ____ of the outer planets.

Continue Your Exploration
(Elaborate)

- Includes collaborative investigations

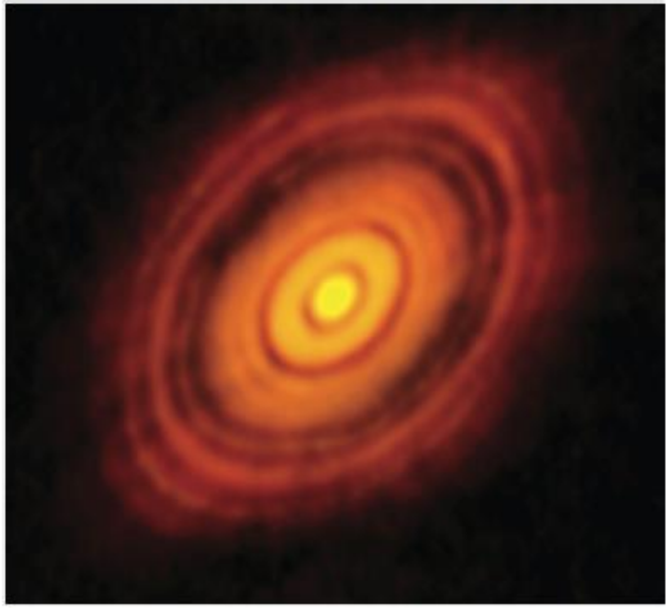
- Not just “What?”
- Also, “How do we know?”

CONTINUE YOUR EXPLORATION

Guided Research

Taurus Molecular Cloud

FIGURE 23: The HL Tauri system, as viewed by a radio telescope on Earth

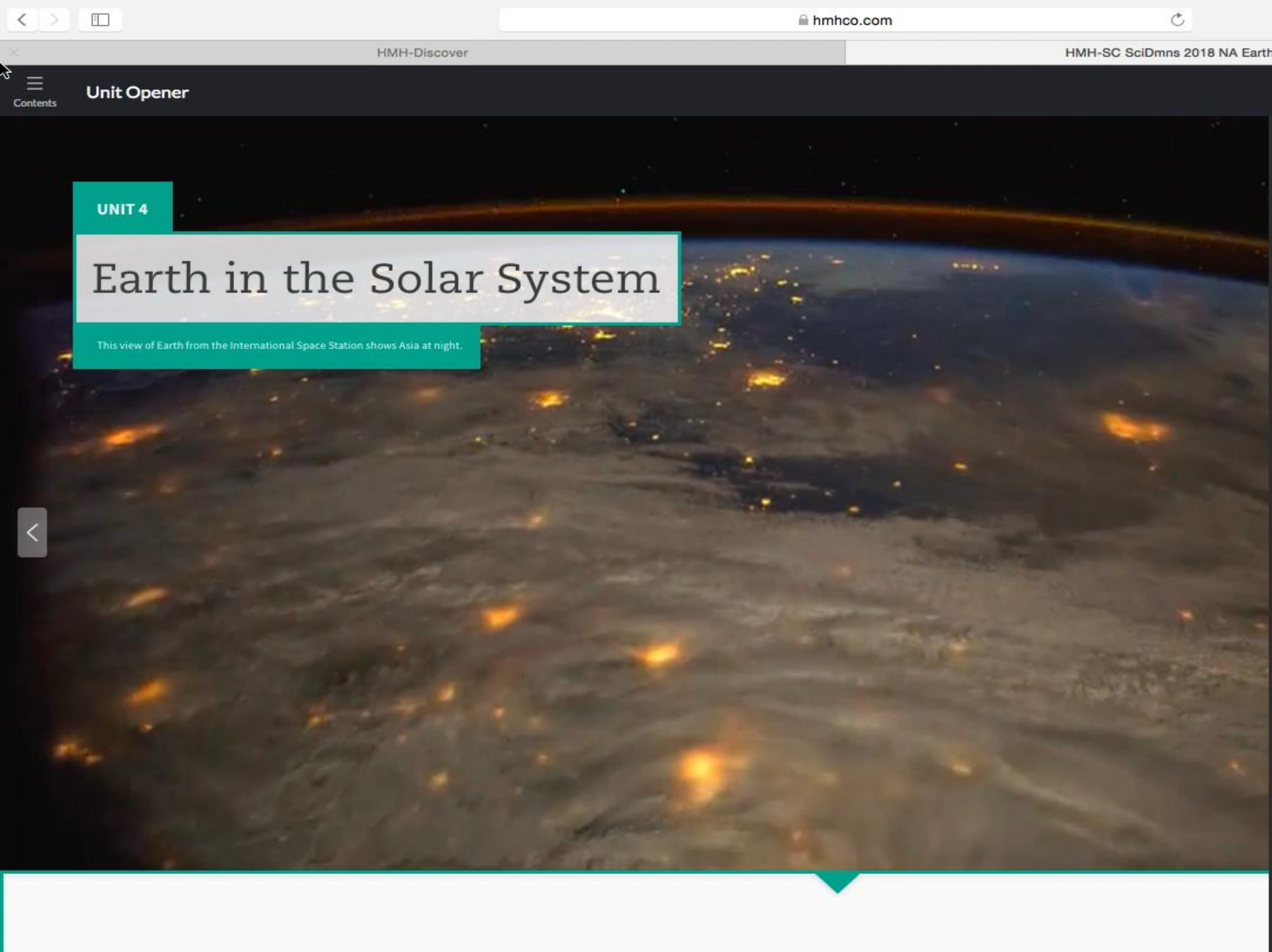


HL Tauri is a young, sunlike star in the Taurus molecular cloud, 450 light years from Earth. In 2014, radio telescope images from the Atacama Large Millimeter/submillimeter Array (ALMA) revealed what appears to be a protoplanetary disk: a set of bright rings of material surrounding the star.

The star is very young—only about one million years old—and scientists were surprised to discover a disk surrounding such a young star.

Collaborate Conduct research to find out more about the HL Tauri system. How is it similar to and different from our solar system? Assuming it is forming according to the nebular theory, at what stage of formation is it currently? What technology has been used to image HL Tauri, and what types of data do these forms of technology help us collect or analyze?

MODELING IMPACT CRATERS | THE OORT CLOUD | Go online to choose one of these other paths.



eBook includes:
Audio,
Notes/Bookmarking,
Easy Navigation

Thing Explainer

UNIT 4

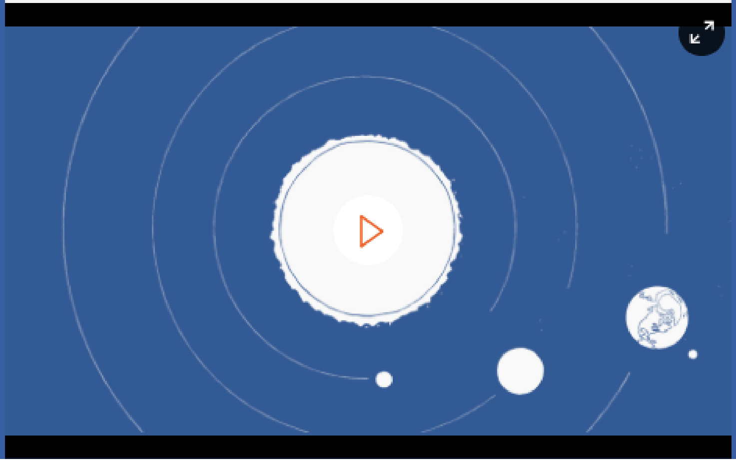
THING EXPLAINER BY RANDALL MUNROE

WORLDS AROUND THE SUN

The system is made up of the sun and the bodies that travel around it.

Understanding the formation and characteristics of our solar system and its planets can help scientists plan investigations to study solar systems around other stars in the universe. Here's a look at our solar system.

THE STORY OF OUR WORLD AND BEYOND



You must be able to teach all topics competently

- Did your college and additional training include geology, meteorology, astronomy, environmental science, and other essential areas?
- If not, what do you need to do to strengthen your knowledge and ‘bag of tricks’?

- Even if you feel comfortable now, how will you continue to learn about new advances in understanding our Planet?

- Earth Science demands never-ending professional development
  – ‘Of course it’s hard—if it weren’t everyone could do it’
  – But that’s what makes it fun!

Remember…

- Nobody, when they begin teaching, really knows everything that needs to be taught, not how to teach it efficiently
- Even many years later, there are always new things to learn

- It’s essential, therefore, to be willing and wanting to keep learning

Read/watch/do/ask/repeat

Lab activities and suggested “hands-on” equipment

- Safety
- General Uses/Needs
- What’s necessary for essential ES activities
- What’s optional/desirable
- What’s special/ “fun to have”

- No “standard set of labs”
- Examples available at:
  – https://earth2class.org/site/?page_id=14905

Suggested Lab Equipment

"So You Are Teaching Earth Science Now – What You Need to Know to Be Prepared"
Dr. Mike Passow
Consulting Author, Earth & Space Science
HMH Science Dimensions

Suggested Lab Equipment

Safety:
First Aid Kit
Gloves
Safety glasses
Lab aprons
Emergency eye wash (required) & safety shower (optional)

Introductory Lessons and General Equipment
Internet access so students can work in groups of 2 – 3

Meter sticks and rulers
Balance scales
Beakers (25 mL, 50 mL, 100 mL, 250 mL, 500 mL, 1000 mL)
Cylinders (10 mL, 25 mL, 100 mL, 1000 mL)
String
Globes
Globe kits (plastic domes, globes, external protractor)
Maps
- World Ocean Floor wall map
- Hubbard ocean floor maps
- World outline maps
- Local maps

Crayons & colored pencils
Drawing compasses
Protractors

Matter and Energy
Heat lamps and support structures

Minerals (suggested hand samples)
Quartz, feldspars, micas, calcite, pyrite, hornblende, olivine, magnetite, hematite, sulphur, halite, gypsum; other locally abundant minerals)

Rocks (suggested hand samples)
Granite, basalt, gabbro, obsidian, pumice, conglomerate, sandstone, shale, limestone, rock salt, slate, schist, gneiss, marble, coal

Using Models: Bring “The Earth” into Your Classroom

Hands-On Labs

Don’t be afraid to modify activities for your students

HANDS-ON LAB

Modeling Impact Craters

BACKGROUND

When scientists observed the collision of comet Shoemaker-Levy 9 (SL9) with Jupiter in 1994, they witnessed a rare event—a comet 8 km in diameter hits Jupiter about once every 2,000 years! Comets are loosely assembled balls of ice and rock. When their orbits take them too close to a celestial body, the body’s gravitational pull begins to gradually alter the comets’ orbits. When SL9 wandered too close to Jupiter, Jupiter’s gravitational pull "captured" the comet and pulled it closer and closer to Jupiter, until the inevitable happened—SL9 was ripped into more than 20 comet chunks, all of which slammed into the giant, gaseous planet.

What happens when a comet or a meteor hits a rocky object such as Earth, Mars, or the moon? You’ve seen the resulting craters when you look at a close-up photograph of the moon. In this lab, you will be able to see firsthand what happens when a comet or meteor collides with a planet.

MATERIALS

- balance, metric
- flour
- graph paper
- marbles of different masses, 4
- meterstick
- pan, aluminum, 23 cm × 33 cm × 7.5 cm or larger
- ruler
- sieve or flour sifter
- tempera paint powder, dry

PREDICT

ASK A QUESTION

1. How do you think mass affects the characteristics of an impact crater?

____

FORM A HYPOTHESIS

2. Form a hypothesis that answers the question. Explain your answer.

____

____

____

____

PROCEDURE

TEST THE HYPOTHESIS

3. To create your model of the surface of a planet, fill the aluminum pan with flour to a depth of about 3 cm. Smooth the surface with a ruler, and then tap the pan lightly to make sure that all materials have settled evenly.

Using Web-based and Online Resources

- Integrating web-based resources to support ES learning
- Designing/enhancing lesson plans
- Support your PD

- Selected examples available at:
  – https://earth2class.org/site/?page_id=14859

- Earth2Class resources
- Selected Professional Societies and organizations
- Selected Federal agencies supporting education
- Implementing the NGSS

Web Resources

So You Are Teaching Earth Science Now—
What You Need to Know to Be Prepared

Dr. Mike Passow

USEFUL WEB RESOURCES AND OTHER IDEAS

There now exist a vast array of web-base resources that will be helpful as you teach Earth Science. List below is an annotated list of selected websites to help get you started with your own collection.

➢ Earth2Class https://earth2class.org/site

This is my website where I share archived versions of workshops presented by research scientists at the Lamont-Doherty Earth Observatory of Columbia University to teachers and students, together with a large collection of resources useful for K – 12 learners and educators.
These include:

- Earth Science Curriculum Units and Teaching Tips
  https://earth2class.org/site/?page_id=3912
- Selected Resources Created by Dr. Mike Passow
  https://earth2class.org/site/?page_id=4969
- Other Educational Resources
  https://earth2class.org/site/?page_id=2942
- Improving Spatial Thinking of Earth Science Teachers and Students
  https://earth2class.org/site/?page_id=2957
- Integrating Educational Technologies
  https://earth2class.org/site/?page_id=3923
- Calendar of Events and Links to ES Ed Organizations
  https://earth2class.org/site/?page_id=3934
- Science Education Standards, Exams, and Safety Guidelines
  https://earth2class.org/site/?page_id=3939

➢ National Earth Science Teachers Association/Windows to the Universe

NESTA is the main organization with its focus on supporting K-12 Earth Science Education. https://serc.carleton.edu/nesta/index.html
Associated with NESTA is Windows to the Universe https://www.windows2universe.org/
WttU provides a large collection of resources useful to students and teachers. Many of these are available in both English and Spanish, and at Elementary-Intermediate-High School levels.

➢ National Association of Geoscience Teachers (NAGT) https://nagt.org/index.html
NAGT also supports geoscience education, with a focus on undergraduate and graduate levels, two-year colleges, teacher education, and geoscience education resources. NAGT Sections provide local field experiences. NAGT presents Outstanding Earth Science Teacher Awards.

Web Resources

- American Geoscience Institute (AGI) Education and Outreach
  https://www.americangeosciences.org/education
  The AGI Education Program provides many curricular resources, especially materials created for the annual Earth Science Week each October. AGI presented the Edward C Roy Award for Outstanding K-8 Science Teaching.

- Geological Society of America (GSA)
  http://geosociety.org/GSA/Education_Careers/GeoTeachers/GSA/GeoTeachers/home.aspx
  The GSA Education Program supports K-12 teachers through a variety of workshops, field experiences, online and print resources.
  Earth Science Week "Big Ideas" activities and videos
  http://www.earthsciweek.org/big-ideas
  Indicators of Earth Science Nationally/Each State
  https://www.americangeosciences.org/education/indicators-k-12-geoscience-education

- Mineral Education Coalition (MEC) https://mineralseducationcoalition.org/
  The Mineral Educational Coalition (previously known as the Mineral Information Institute) provides many online resources, as well as print materials that can be ordered. They give away free mineral sets at NSTA and other conferences.

- Earth Learning Idea www.earthlearningidea.com
  Earth Learning Idea provides a large online collection of blogs and resources on a wide range of topics to assist and excite students and teachers. They are available in many languages and have attracted a worldwide following.

- DLESE (Digital Library for Earth System Education) http://www.dlese.org/lib/index.html
  DLESE is free, searchable collection of resources. Funded by the National Science Foundation, it continues to be built by a community of educators, students, and scientists to support Earth system education at all levels.

- NSTA (National Science Teacher Association) www.nsta.org
  NSTA is the largest science educational organization focuses on k – 12 education. NSTA provides national and area conferences. NESTA offers Share-a-Thons and other programs at NSTA conferences. NSTA Press offers many useful books. Online resources to support implementation of the NGSS are available at http://ngss.nsta.org/.

Government Agencies Supporting Earth Science Education

NOAA Education http://www.noaa.gov/education
  National Weather Service Education http://www.weather.gov/owlie/
  Weather-Ready Nation Ambassadors https://www.weather.gov/wrn/ambassadors
  Teaching Climate https://www.climate.gov/teaching
  Jet Stream – Online School for Weather https://www.weather.gov/jetstream/
  National Ocean Service Education https://oceanservice.noaa.gov/education/

US Geological Survey https://www.usgs.gov/
  Access to recent earthquakes and other natural hazards, news stories, images, videos, and other resources

Web Resources

NASA Education https://www.nasa.gov/offices/education/about/index.html
Many images and other informational resources, but not easy to navigate at times.

Past Exams
For many decades, the New York State Education Department has produced "Regents Exams" in Earth Science and other subjects. These are excellent sources for questions and other support materials, and are copyright-free

Archived versions are available at http://www.nysedregents.org/EarthScience/.

For each exam, students are provided with a copy of the "ES Reference Tables"
http://www.p12.nysed.gov/assessment/reftable/earthscience-rt/esrt2011-engr.pdf
These provide diagrams, tables, charts, and other information that foster higher-level thinking skills. Even if you are not teaching Regents ES, you should utilize these.

More information and links to other NYSED exams and resources are available at
https://earth2class.org/site/?page_id=6298

Implementing the NGSS – Selected Resources
Here selected resources to learn more about the NGSS.

NGSS @ NSTA http://ngss.nsta.org/

AGI Center for Geoscience & Society and NAGT
https://nagt.org/nagt/profdev/workshops/ngss_summit/index.html

Achieve.org Resources https://achieve.org/resources

"A Framework for K-12 Science Education"
https://www.nap.edu/catalog/13165/a-framework-for-k-12-science-education-practices-crosscutting-concepts

"Next Generation Science Standards" http://www.nextgenscience.org/

"Design, Selection, and Implementation of Materials for the Next Generation Science Standards"
https://www.nap.edu/catalog/25001/design-selection-and-implementation-of-instructional-materials-for-the-next-generation-science-standards-ngss

If you work in one of the NGSS-adopting/adapting States, find out more about what you will be expected to implement.
For example, here is a link to the New York State P – 12 Learning Standards
https://earth2class.org/site/wp-content/uploads/2016/12/p-12-science-learning-standards.pdf

The New Jersey Department of Education worked with teachers to create "Model Curricula: Science" http://www.state.nj.us/education/modelcurriculum/sci/

Print books and magazines can also be useful

SELECTED RESOURCES C × Books-1.pdf ×

Secure | https://earth2class.org/site/wp-content/uploads/2018/03/Books-1.pdf

"So You Are Teaching Earth Science Now – What You Need to Know to Be Prepared"
Dr. Mike Passow
Consulting Author, Earth & Space Science
HMH Science Dimensions

Selected Books for Expanding Your Knowledge/Challenging Students

Moore, Peter (2015) *The Weather Experiment: The Pioneers Who Sought to See the Future.* Farrar, Strauss, and Giroux (ISBN 978-0-86547-809-1)

Smith, Mike (2010) *Warnings: The True Story of How Science Tamed the Weather.* Greenleaf Book Group Press. (ISBN 978-1-60832-034-9)

Sobel, Adam (2014) *Storm Surge: Hurricane Sandy, Our Changing Climate. And Extreme Weather of the Past and Future.* Harper Wave. ISBN 978*0*06*230476-6)

Felt, Hali (2012) *Soundings: The Story of the Remarkable Woman Who Mapped the Ocean Floor.* Henry Holt & Co. (ISBN 978-0-8050-9215-8)

Kolbert, Elizabeth (2015) *The Sixth Extinction: An Unnatural History.* Picador/Henry Holt & Co. (ISBN 978-0-8050-9299-8)

Andrews, Sarah (2007) *In Cold Pursuit: A Mystery from the Last Continent.* St. Martin's Press. (ISBN 978-0-312-34253-1)

Sykes, Lynn R. (2017) *Silencing the Bomb: One Scientist's Quest to Halt Nuclear Testing.* Columbia University Press (ISBN 978-0-23118-248-5)

Selected Periodicals

NSTA "The Science Teacher"

NESTA "The Earth Scientist"

AGI "Earth"

AIP "Physics Today"

Taylor & Francis "Weatherwise"

"National Geographic Magazine"

Museum magazines (ex. AMNH "Rotunda", Smithsonian Magazine)

Additional suggestions:

Using Videos, Animations, and Webinars

- Today’s students learn more efficiently through visualizations

- Videos can be helpful, but you **must**:
  - Prescreen to be certain of quality and alignment to course goals
  - Utilize efficiently within limited class time
  - Be able to handle technical glitches and avoid other problems

- You also can benefit from viewing webinars and online resources

Incorporating Videos into Your Lessons

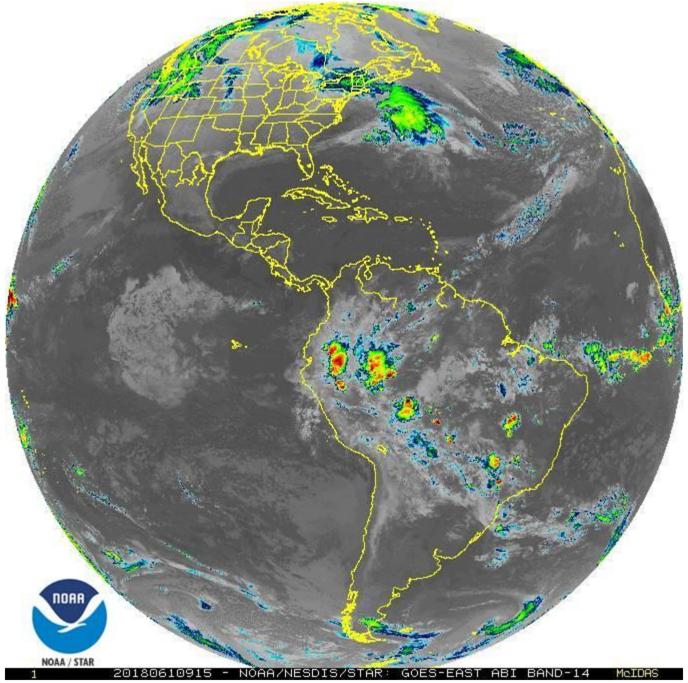
- Many available through YouTube and other sources
  – Quality varies – you must prescreen

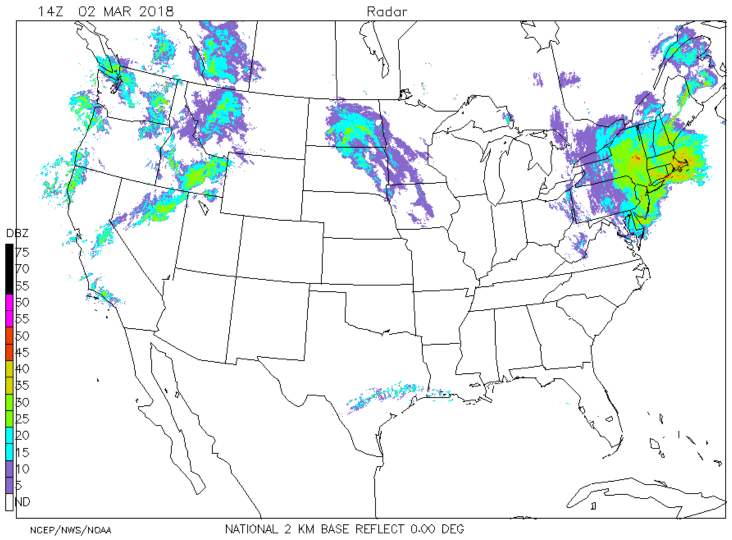
- Teachers have created/collated excellent resources
  – One example: Tom Gazda (Ichabod Crane HS, Valatie, NY)
  – https://www.gazdonianproductions.com/rocks--minerals.html

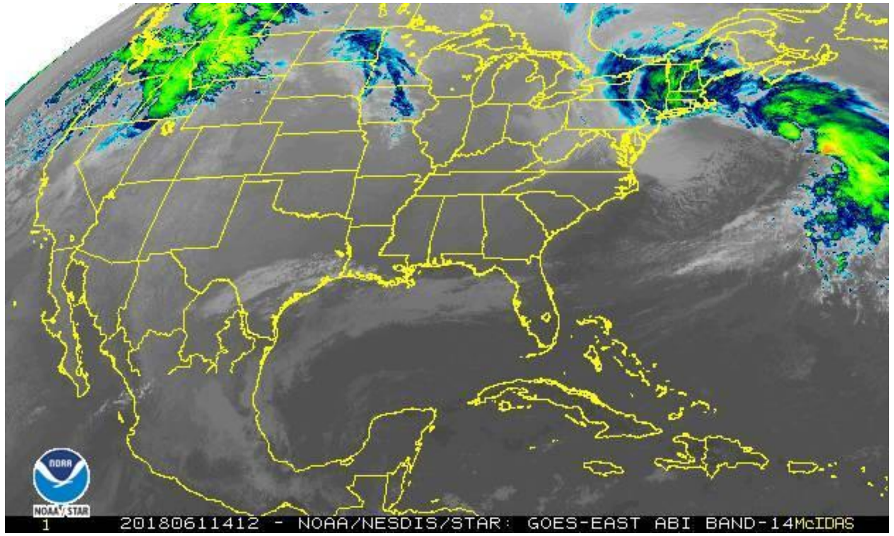
  - Student-produced videos and animations
    Graphic novels

Using Visualizations

- Radar and satellites – ‘real-time weather’
  - AMS “Real-Time Weather Portal”
  - http://www.ametsoc.org/amsedu/dstreme/







Videos

Contents

Unit Connections

UNIT CONNECTIONS

Physics Connection

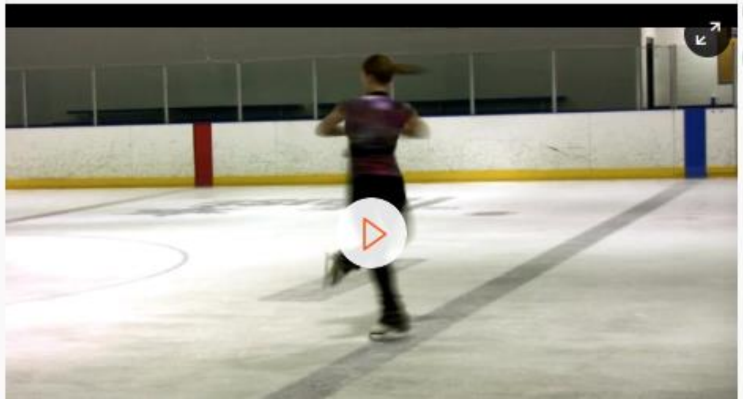
Social Studies Connection

Art Connection

Physics Connection

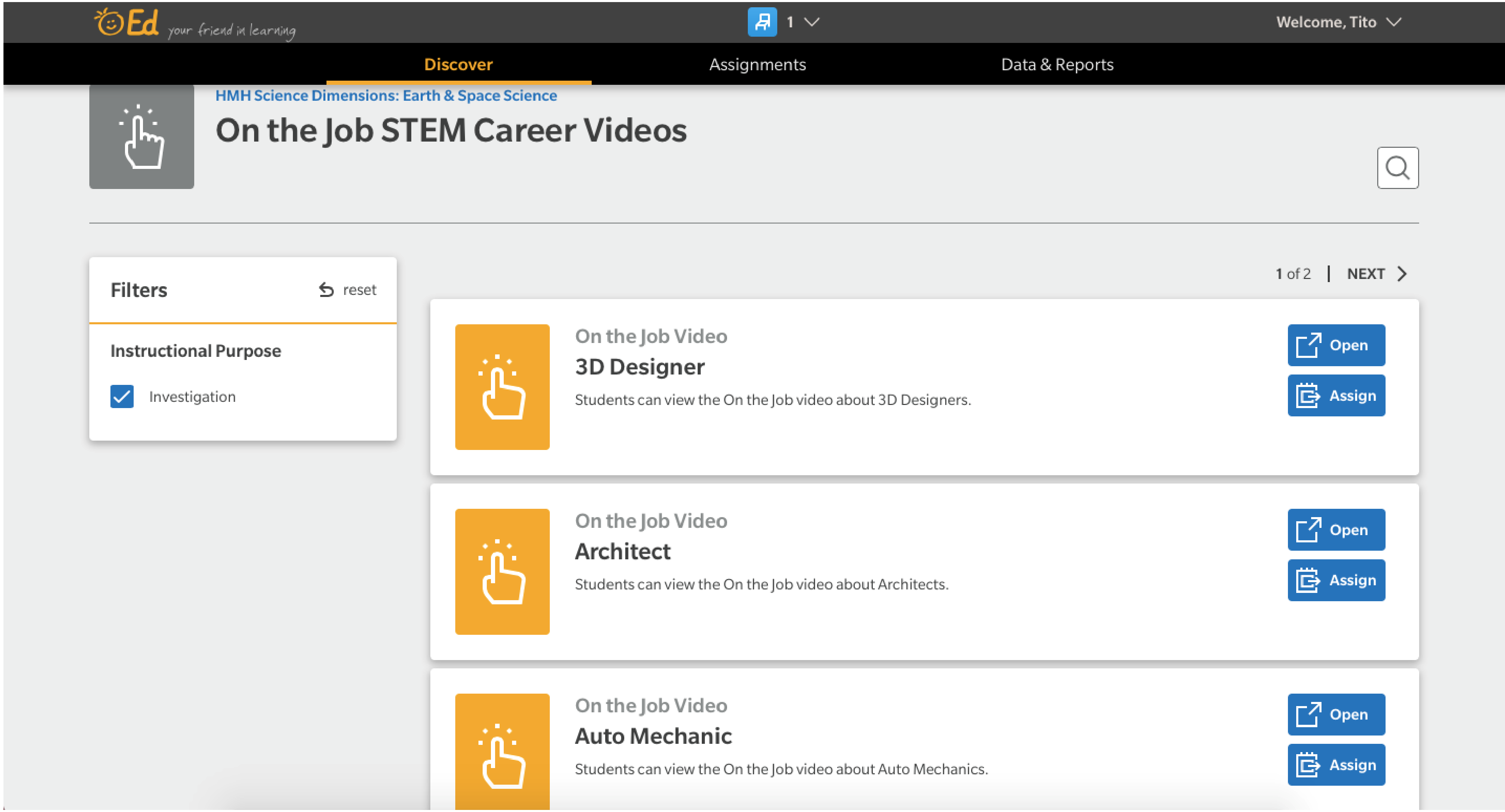
Exploring Rotational Motion An object that spins about its center of mass is said to be in rotational motion. The sun, planets, and moons of the solar system all exhibit rotational motion. Everyday examples of rotational motion include the spinning of a football as it flies through the air or a figure skater as she executes a spin. As a skater draws her hands closer to her body, more of her mass is near the axis of rotation. As a result, the speed of rotation increases.

A spinning ice skater is a familiar example of rotational motion.

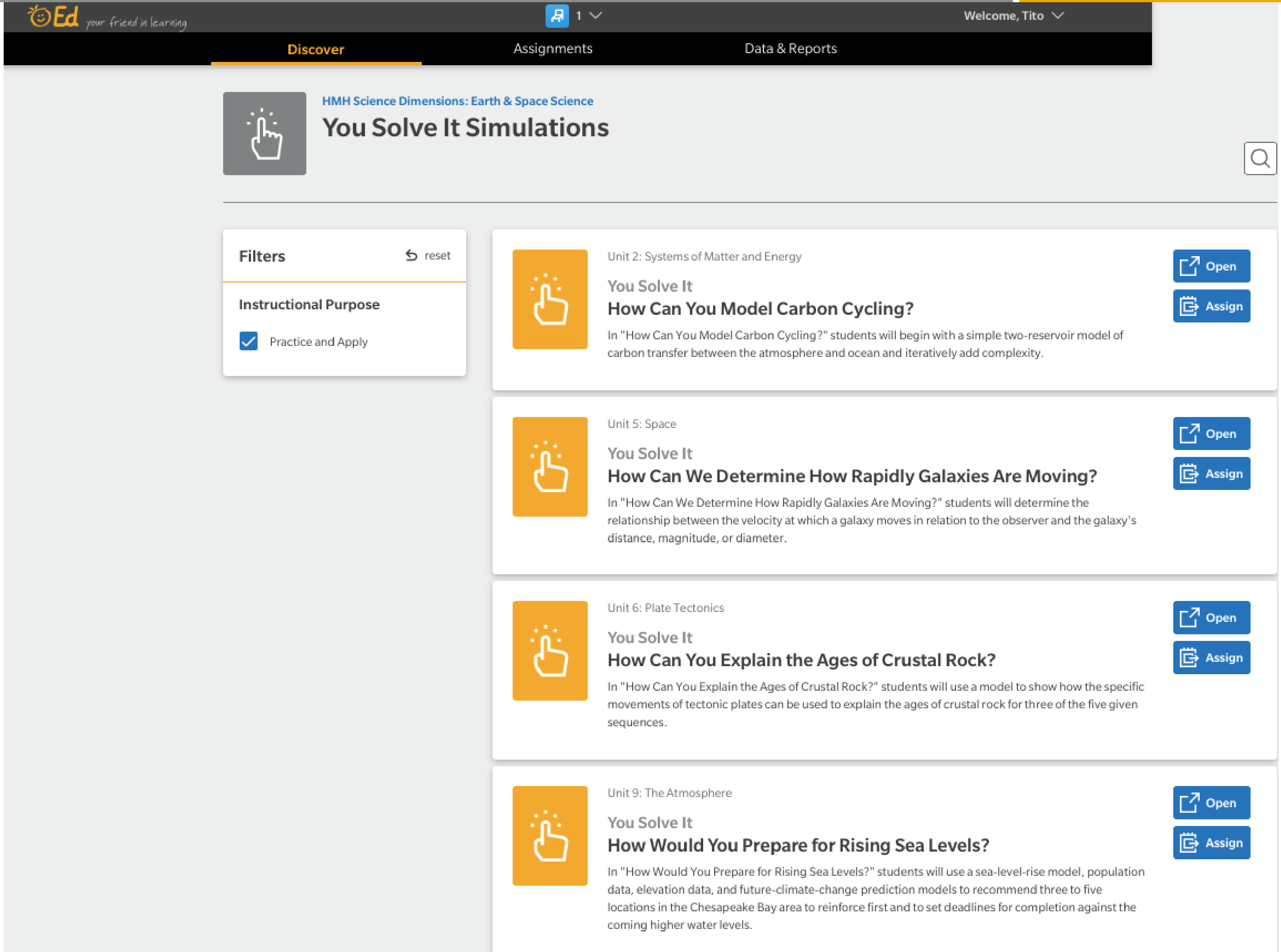


Houghton Mifflin Harcourt

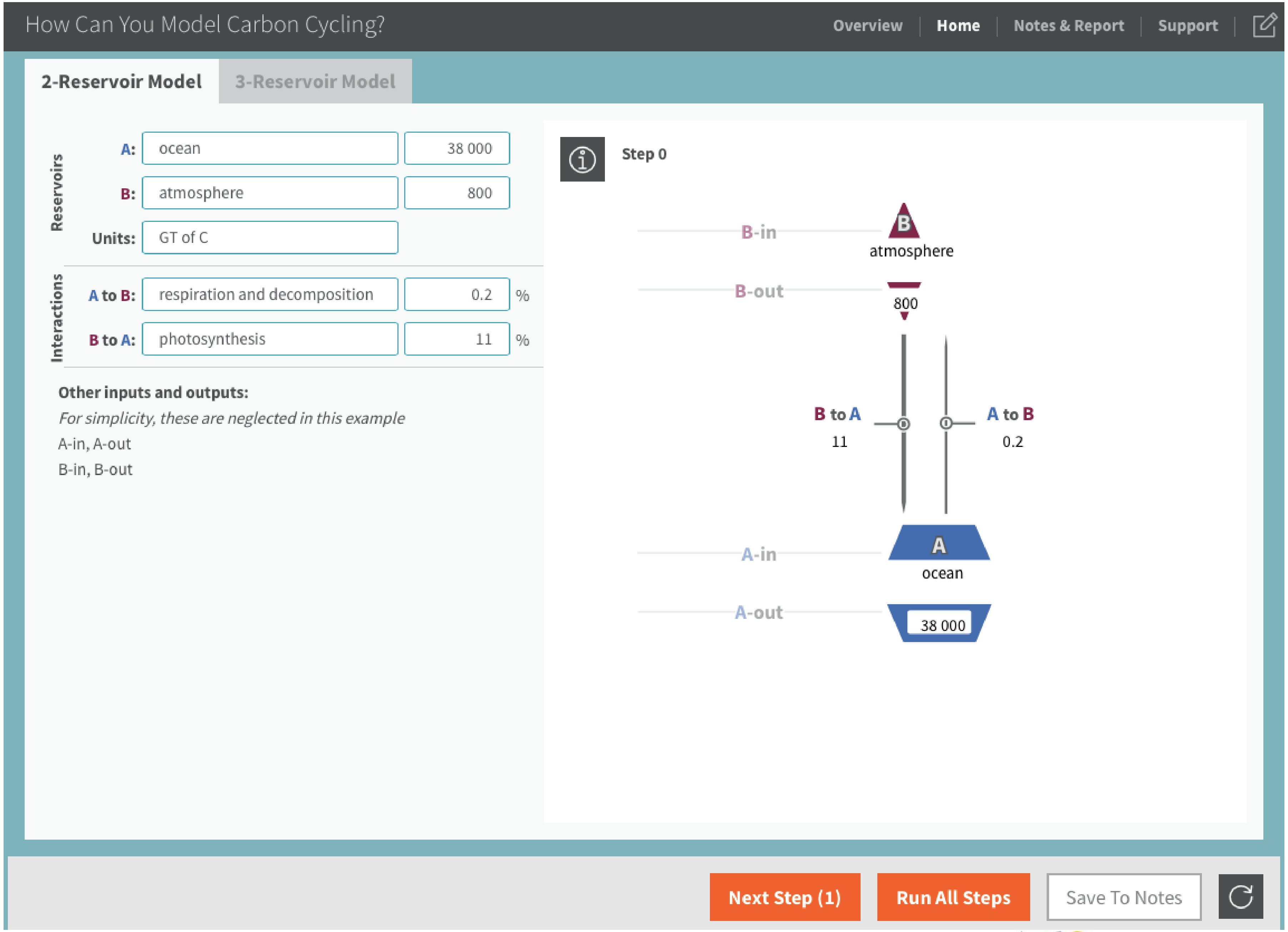
Videos


Ed your friend in learning
1
Welcome, Tito
Discover
Assignments
Data & Reports
HMH Science Dimensions: Earth & Space Science
On the Job STEM Career Videos
Filters
reset
Instructional Purpose
Investigation
1 of 2
NEXT
On the Job Video
3D Designer
Students can view the On the Job video about 3D Designers.
Open
Assign
On the Job Video
Architect
Students can view the On the Job video about Architects.
Open
Assign
On the Job Video
Auto Mechanic
Students can view the On the Job video about Auto Mechanics.
Open
Assign

You Solve It Simulations



You Solve It Simulations



Houghton Mifflin Harcourt

Discussion Break 1:
Examples of Curriculum and Activities

"Making Daily Weather and Sun/Moon Observations"
https://earth2class.org/site/wp-content/uploads/2016/10/Wx_climate_data.pdf

"Using Weather Maps and Other Representations of the Atmosphere"
https://earth2class.org/site/wp-content/uploads/2016/09/Weather-Maps.pdf

"Density of Minerals and Rocks"
https://earth2class.org/site/wp-content/uploads/2015/06/Density-of-minerals-and-rocks.pdf

"Modeling a Scale Model of the Solar System"
https://earth2class.org/site/wp-content/uploads/2018/02/scale-model-solar-system.docx.pdf

Field Experiences

- "The Real Classroom Is Outside—Get into It!"

- Opportunities vary widely depending on your location, resources, and school policies

- At its simplest: Do a Campus Walking Tour
  - What materials were used to create buildings, sidewalks, etc.?
  - How are these related to what you study in ES?
  - Will you enhance student connection with ES when you "bring it into their home"?

Experiences that Require More Planning & Resources

Museums and Nature Centers

Fields trips,
outcrops, landscapes

Caverns, quarries, mines

http://www.rci.rutgers.edu/~schlisch/structureslides/VFT1.html

Houghton Mifflin Harcourt

EXHIBITIONS
Permanent Exhibitions

Collect SHARE:

Fossil Halls

Paul and Irma Milstein Hall of Advanced Mammals

Hall of Ornithischian Dinosaurs

Hall of Primitive Mammals

Hall of Saurischian Dinosaurs

Hall of Vertebrate Origins

Miriam and Ira D. Wallach Orientation Center


Hall of Ornithischian Dinosaurs

Fossil Halls

- Paul and Irma Milstein Hall of Advanced Mammals
- Hall of Ornithischian Dinosaurs
- Hall of Primitive Mammals
- Hall of Saurischian Dinosaurs
- Hall of Vertebrate Origins
- Miriam and Ira D. Wallach Orientation Center

PLAN YOUR VISIT

School or Camp Field Trips
- Things to Know for Your Visit
- Pricing and Payment
- Exhibitions and Educator Resources
- Programs For School Groups
- Book Your School Field Trip
- Book Your Camp Field Trip

Collect
SHARE:

School or Camp Field Trips

There's a reason we're a top field trip destination in New York City: amazing new exhibits, over 34 million objects in our permanent collections, and exceptional programs, resources and classes for students and teachers! All of our programs and offerings are designed to support the NYC Scope and Sequence for Science and Social Studies.

Follow these simple steps to plan an unforgettable museum learning experience for your school or camp group. To ensure availability, you must plan your field trip at least **5 weeks in advance.**

School Tours

Our school field trip program gives children hands-on lessons in geology, our local economy, and how businesses function. This engaging and interactive tour typically lasts about 1 hour, and we'll work with teachers and school administrators to tailor tours to **meet specific SOL requirements or other educational needs for the grade level of the students**. If you're interested in a field trip for your school or class, please **let us know.**

A basic tour consists of:

- The tour begins at the office of Frazier Quarry's **Waterman Drive** location.
- Students ride the bus up to the Retail Stone Yard where they are allowed to explore and touch many of the stone and sand products while learning the economics of how products are bought and sold.
- The bus takes the tour down into the depths of the quarry as students learn the geological history of Frazier Quarry's Stonewall Grey limestone.
- Students then have the opportunity to see some of the large vehicles and tools used inside the quarry to extract and process stone.
- The tour concludes back at the office where students receive a special Frazier Quarry gift.

CONTACT US

TO LEARN MORE ABOUT **SCIENCE SOL REQUIREMENTS** THAT MAY BE INCLUDED DURING A TOUR AT FRAZIER QUARRY.

Incorporating Field Experiences

So You Are Teaching Earth Science Now—
What You Need to Know to Be Prepared

Dr. Mike Passow

INCORPORATING FIELD EXPERIENCES

"The Real Classroom Is Outside—Get into It!"

This has been one of my favorite guidelines since I started learning and teaching about 50 years ago. I still enjoy exploring new venues and bringing others to places I have seen.

Museums and Nature Centers

You don't have to amass everything by yourself. Like libraries, museums serve as common learning centers where excellent examples are displayed for students and the general public. Discover what's available in museums near you and utilize their resources in your teaching.

I will use examples from the American Museum of Natural History in New York City, where I am an Adjunct Instructor. Museums across the country—such as the Smithsonian Institution museums in Washington, D.C., the Field Museum in Chicago, the Franklin Institute in Philadelphia, and many others—provide similar resources and support for students, teachers, families, and visitors from everywhere.

There are several ways you can take advantage of museums. One is a scheduled field trip for your classes. It's very helpful to find out the institution's suggestions, guidelines, reservation and lunch policies, and estimated expenses. (https://www.amnh.org/plan-your-visit/school-or-camp-field-trips) Often, bus transportation is one of the largest expenses, so you should ascertain your District rules, and sources of support (such as the PTA and local grants.)

Museums have staff educators who offer custom programs and/or have created guides for using the displays. One example is https://www.amnh.org/exhibitions/permanent-exhibitions/rose-center-for-earth-and-space/david-s.-and-ruth-l.-gottesman-hall-of-planet-earth/promos/hall-of-planet-earth-for-educators. You should use these combined with scouting visits to decide what you want your students to focus on during their visit. Both permanent and temporary exhibits can provide memorable learning experiences.

Another approach, especially if full-group trips are impractical, involves creating problem sets for students to complete during a visit. This helps them focus on aspects of exhibits most pertinent to your curriculum. These can be used during class or individual (family) visits, depending on your school's situation.

Nature centers can serve similar purposes, and often have a focus on the local environment. They may be easier to visit than a museum, depending on your situation. Find out if there is a nature center near you that may be useful for enhancing student interest and experiences. You may also find that some welcome student volunteers.

Depending on your local environment, your community, County, and State Park and Recreation Departments may have facilities that can use helpful in your curriculum.

Helping Students Learn—
Spatial Thinking and Differentiated Instruction

- Each student brings a unique collection of experiences and knowledge
- Each student learns in a unique style

- So what must you be aware of to help each student learn?

- Focus here:
  - Spatial Thinking
  - Differentiate Instruction

Spatial Thinking

So You Are Teaching Earth Science Now—What You Need to Know to Be Prepared

Dr. Mike Passow

HELPING STUDENTS (AND TEACHER) LEARN ABOUT OUR PLANET

Effective teaching demands that you understand to your best ability whether or not your students are comprehending the matter presented or merely acting as if they do. In other words, you are expected to tell from external signs if your students are incorporating the lesson into their internal 'knowledge bank.' Of course, no teacher is ever completely proficient at this aspect of our challenges. But there are some ways to try to improve your skills.

Let's focus on two: Spatial Thinking and Differentiated Instruction. Here, we will simply provide a simplified introduction because to be thoroughly conversant with these takes much more than we can accomplish here. Hopefully, now that you are aware of the important of these, you will seek more information and develop strategies to incorporate them into your teaching style and 'bag of tricks.'

1) SPATIAL THINKING

"Spatial Thinking" is formally defined as "thinking that finds meaning in the shape, size, orientation, location, direction, or trajectory of objects, processes, or phenomena, or the relative positions in space of multiple objects, processes, or phenomena."

Some examples of Spatial Thinking in the Earth Sciences are:

- Recalling locations of previously observed geological phenomena
- Mentally manipulating a volume by folding, faulting, and eroding
- Envisioning the motion of objects or materials through space in three dimensions
- Making and interpreting spatial representations (including maps
- Using spatial thinking to think about time
- Using spatial thinking to think about non-spatial properties

Spatial Thinking

Professional Development to Improve the Spatial Thinking of Earth Science Teachers and Students

Supported by National Science Foundation GEO-1034994

Dr. Kim A. Kastens, Principal Investigator

Dr. Michael J. Passow, Co-Principal Investigator

Linda Pistolesi

The goal of this project is to create and test a professional development program for Earth Science teachers, targeted at improving the *spatial thinking* of Earth Science students. Research has shown that spatial thinking is important in science in general, and Earth Science in particular, and that performance on spatially-demanding tasks can be fostered through instruction. Teachers of the New York State Regents course in "Physical Setting/Earth Science" and others will serve as co-developers/participants in the pilot test of the program, which is offered in association with the well-established Earth2Class workshop series at Lamont-Doherty Earth Observatory.

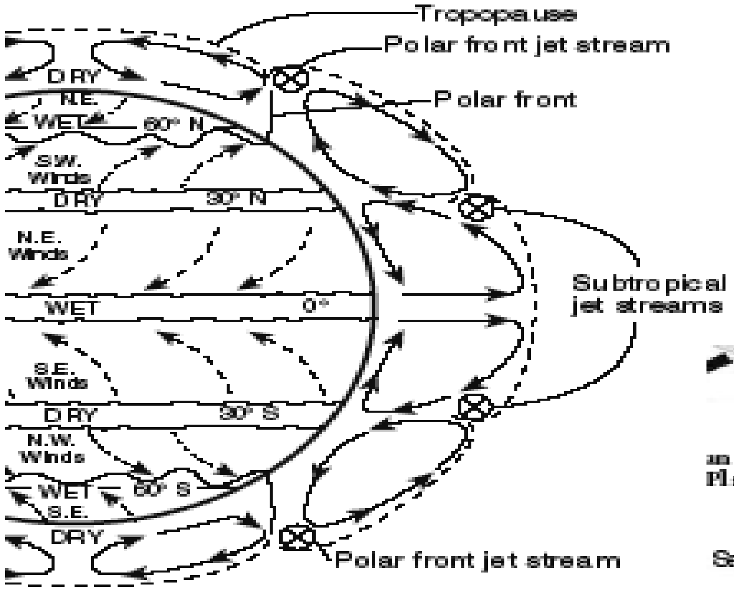
Teachers are learning to diagnose students' difficulties with spatial thinking and to support students in learning to think spatially. If this pilot project is successful, our long term vision is that school districts committed to data-driven professional development will be able to identify teachers whose students are struggling with spatially-demanding items on standardized tests such as the Earth Science Regents, and use our spatial thinking professional development techniques to help those teachers improve their practice. The work taps into basic and applied research on how humans perceive and reason with spatial information, and leverage these insights in serve of Earth Science education.

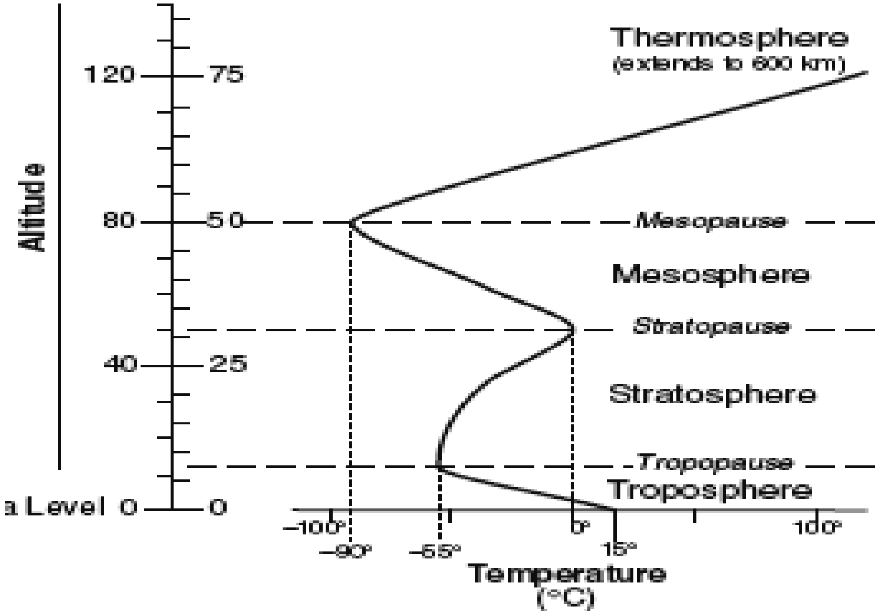
Spatial Thinking

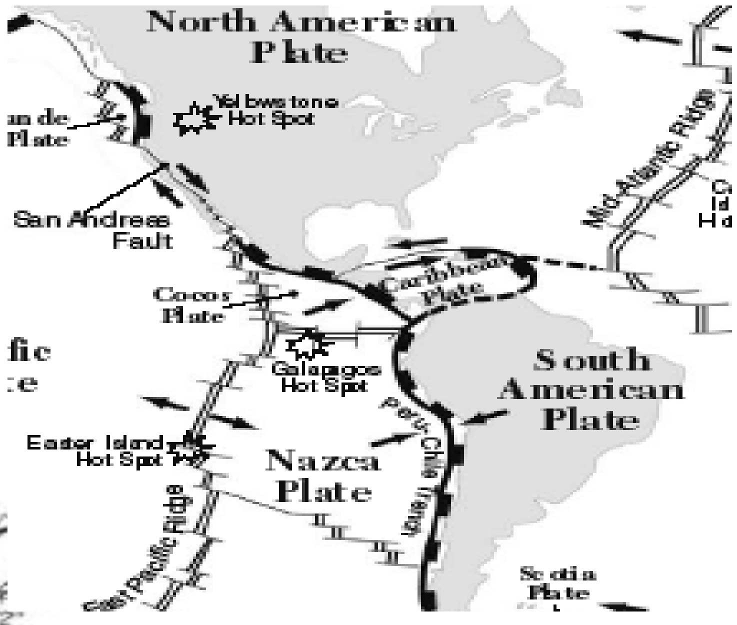
- Making sense of images – 2D & 3D
- Very important in the geosciences
- Abilities vary widely among students and teachers
- Not well recognized nor incorporated into instruction
- Can improve with scaffolding and practice

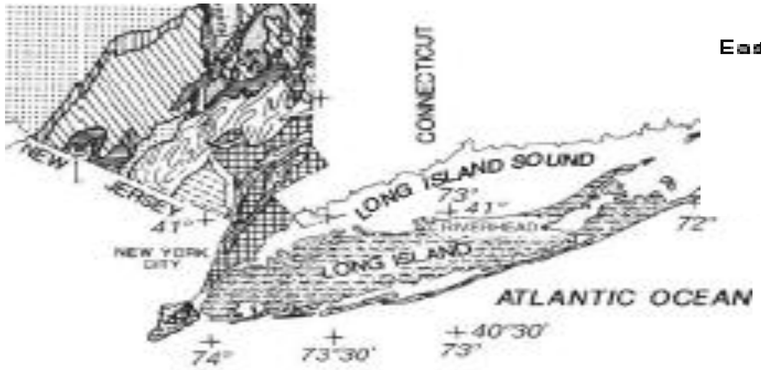
- Frequently tested (especially in NYS Regents Exams)
- Supported by the Earth Science Reference Tables

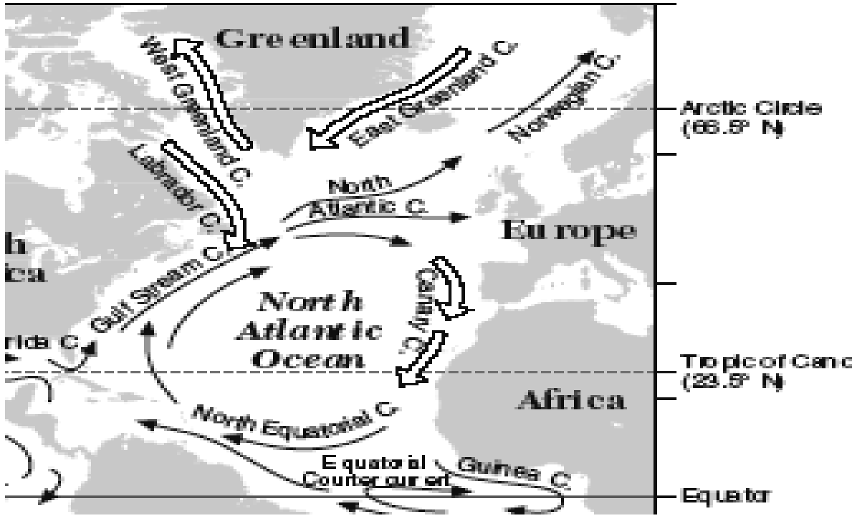
New York Earth Science Reference Tables





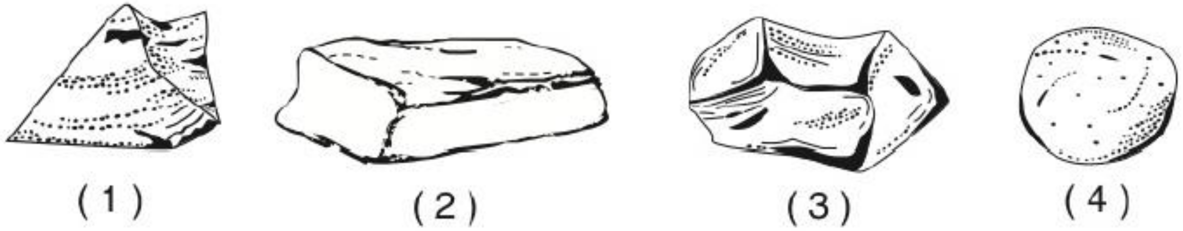


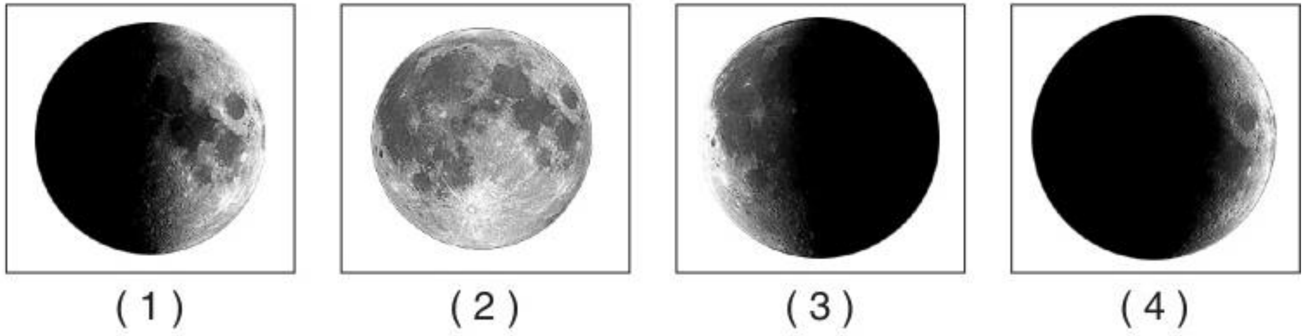


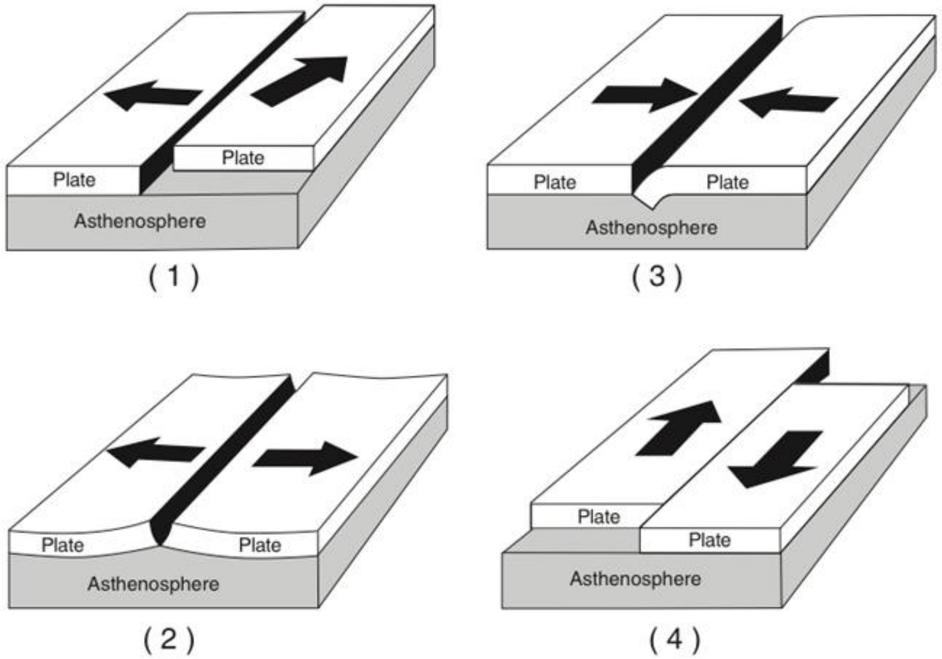


16 page booklet

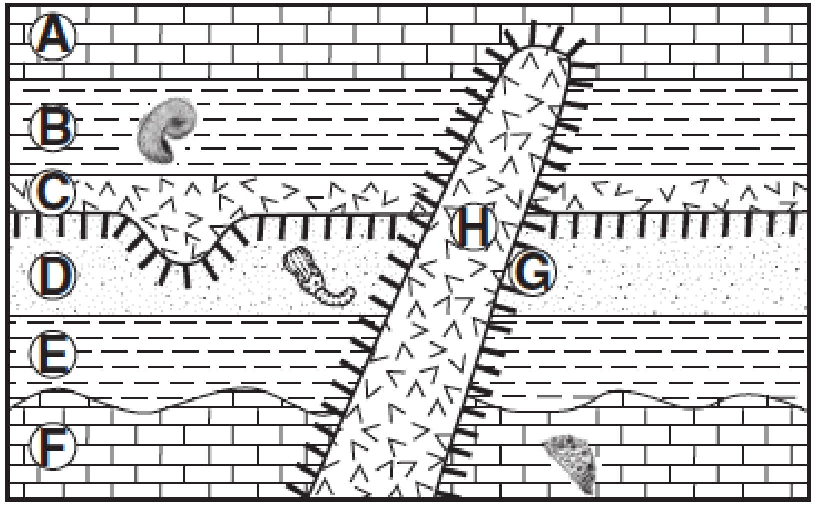
Representational Correspondence

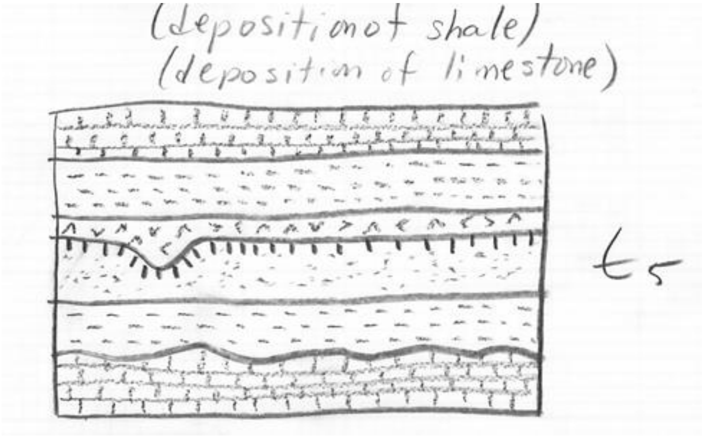


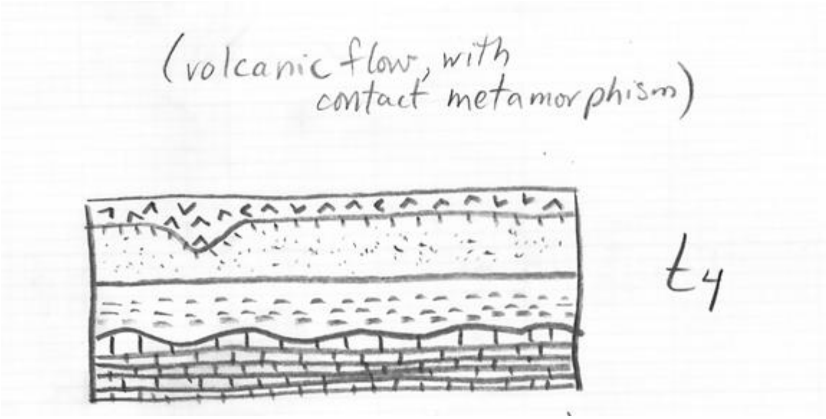


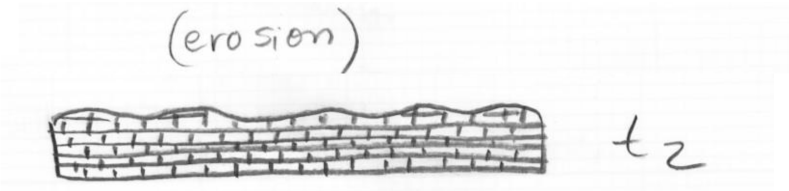


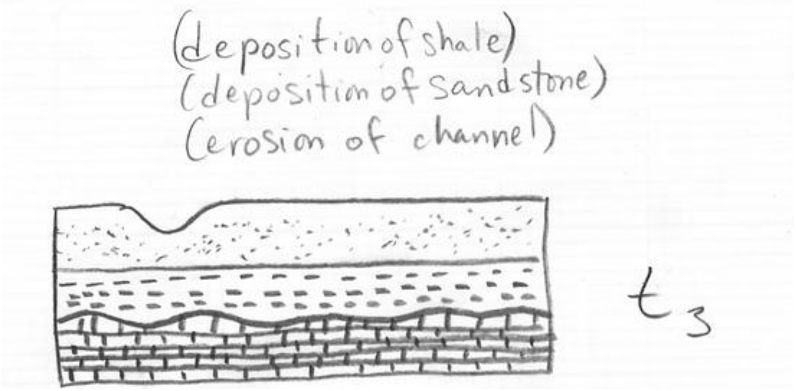
Interpreting Block Diagrams – Sequencing

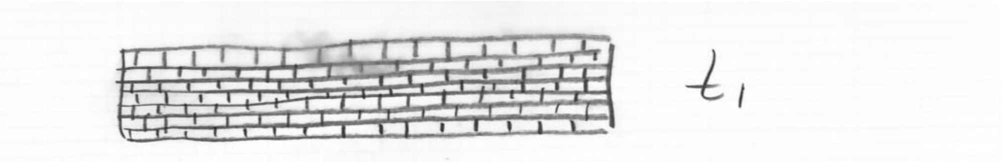








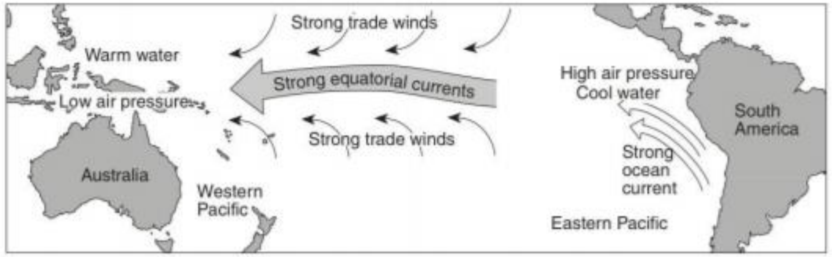




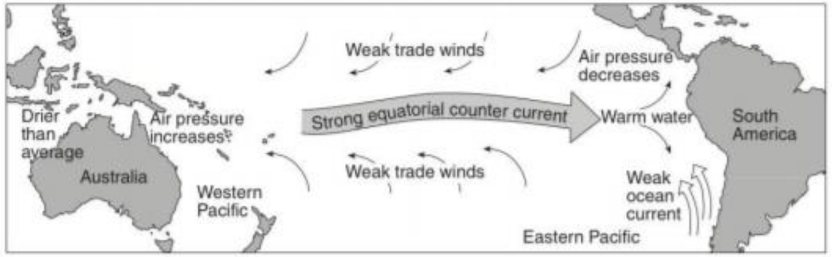
(2) Question ID: 2010-06-44 **Percent Correct: 41.7%**

Base your answers to questions 44 through 47 on the maps and the passage below. The maps show differences in trade wind strength, ocean current direction, and water temperature associated with air-pressure changes from normal climate conditions to El Niño conditions.

Normal Climate Conditions



El Niño Conditions



El Niño Conditions

El Niño conditions occur with a buildup of warm water in the equatorial Pacific Ocean off the coast of South America. The immediate cause of this buildup is a change in air pressure that weakens the southern trade winds. These are the planetary winds that move air from 30° S to the equator. Normally, these strong, steady winds, with the help of their counterparts in the Northern Hemisphere, push equatorial water westward away from South America. But, at intervals of two to seven years, these winds weaken, causing the westward water flow to reverse. This results in an accumulation of unusually warm water on the east side of the equatorial Pacific Ocean. This warm water not only changes the characteristics of the air above it, but also is thought to be the cause of weather changes around the world. El Niño conditions may last only a few months, but often last a year or two.

44 The trade winds between 30° S and the equator usually blow from the

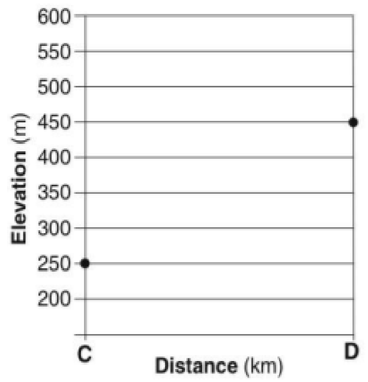
(1) northeast
(2) southeast
(3) northwest
(4) southwest

Spatial Concepts: Po, Dr, Mo
Spatial Representations: Mp
Spatial Skills:

(8) Question ID: 2010-06-69 (continued)

Student Answer Booklet (continued):

69

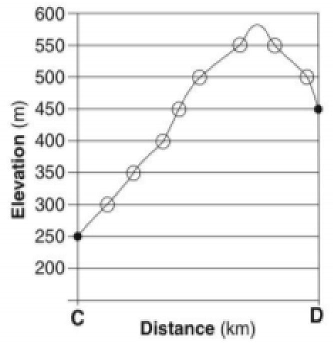


Teacher's Grading Booklet Instruction:

69 [1] Allow 1 credit if the centers of all student-plotted **X**s are located within the circles shown below and are correctly connected with a line that passes within the circles. The line must have the highest elevation between 550 and 600 meters.

Note: It is recommended that an overlay be used to ensure reliability in rating. Allow credit if a symbol other than an **X** is used.

Example of a 1-credit response:



Differentiated Instruction

- "…framework or philosophy for effective teaching that involves providing different students with different avenues to learning (often in the same classroom) in terms of: acquiring content; processing, constructing, or making sense of ideas; and developing teaching materials and assessment measures so that all students within a classroom can learn effectively, regardless of differences in ability…" – ASCD

- Both desired and required -- IEPs
  – Work with teacher aids, guidance counselors, other specialists

  – Vitally important to try constantly and consistently to help all students to learn

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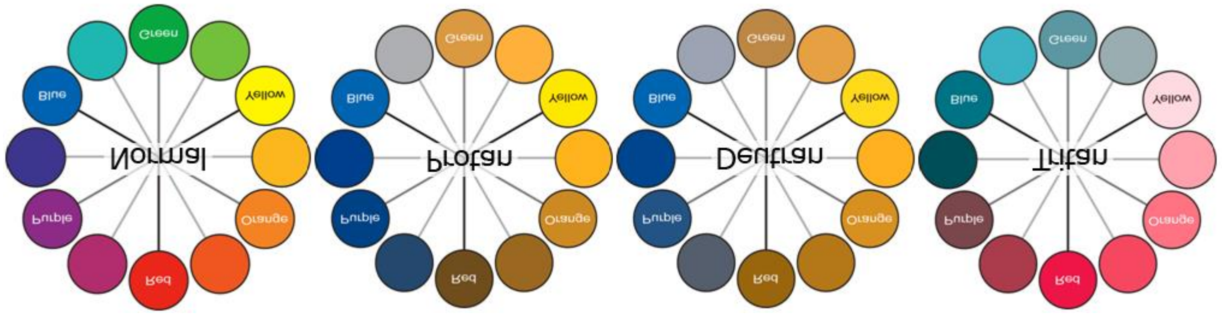
Expanding Inclusion

- Providing opportunities to learn for all students
  - Visually- and hearing-impaired
  - Mobility challenged
  - Other disabilities

- International Association for Geoscience Diversity
  - https://theiagd.org/



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Learn to Combine ‘Ideals’ with What You Assess

- “Backward design”
  - Based on what you want your students to know and do
  - Create lessons that foster mastering on content knowledge and skills

- “I hear and I forget. I see and I remember. I do and I understand.”
  - Whenever possible, have students engage in ‘active learning’
  - Integrate engineering, technology, art, kinesthetics, etc.

- Constantly “formative”
  - External emphasis on “Cumulative”

Networking—Key to Your Continuing PD Learning

- Conferences are good, but infrequent
- Sign up for the ES teachers list-serv
  - http://external.oneonta.edu/mentor/listserv.html
- Participate in webinars – NSTA, HMH, NAGT, NASA, others
- Become a member of professional organizations
  - NESTA
  - Your State Science Association/State ESTA
  - Your NAGT Section
  - NSTA

Take-Aways

1. Know your subject matter
   - Strive to master your curriculum, and then go far beyond it
2. Know what will be assessed and how to help your students prepare
   - Don’t ‘teach to the test,’ but help them get ready
3. Incorporate hands-on and field experiences, web-based resources
   - Make ES ‘real’ and ‘fun’
4. Keep learning through networking, reading, webinars, getting out
   - Remember what excited you in the first place
5. Find reliable and supported print/online resources
   - What can HMH and other sources do for you?

Final Questions and Comments?

Thank you for participating!

- More information available at:
  - https://earth2class.org/site/?p=14856
    - Earth2Class → Michael J Passow Resources → Courses

- Contact me: michael@earth2class.org