Smithsonian
Science Education Center

STC
SCIENCE AND TECHNOLOGY CONCEPTS™
MIDDLE SCHOOL

LEARNING PROGRESSIONS

Lesson Summaries for STC Middle School™

Extraordinary
Inquiry Science
for Middle School

CAROLINA®
www.carolina.com

The Smithsonian Has Done It Again— Extraordinary Inquiry Science for Middle School

NEW Smithsonian's STCMS™ empowers students and teachers for success in middle school science and beyond!

With instruction that goes beyond meeting the NGSS*, STCMS™ steps up to the challenge of meeting the 5 innovations of the NGSS:

- Three-dimensional learning
- Students engaging with phenomena and design solutions
- Math and literacy connected with science content
- Coherent learning progressions
- Integrated engineering and the nature of science

STCMS™ Learning Framework

	LIFE *Sciences*	**EARTH** *Sciences*	**PHYSICAL** *Sciences*
Grades 6–8	Ecosystems and Their Interactions	Weather and Climate Systems	Energy, Forces, and Motion
	Structure and Function	Earth's Dynamic Systems	Matter and Its Interactions
	Genes and Molecular Machines	Space Systems Exploration	Electricity, Waves, and Information Transfer

Three-dimensional learning is the signature innovation of the Next Generation Science Standards. STCMS™ supports teachers and students by weaving together Disciplinary Core Ideas, Science and Engineering Practices, and Crosscutting Concepts to address Performance Expectations over time.

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Smithsonian's STCMS offers 9 units grounded in NGSS three-dimensional learning:

- Research-based curriculum proven to **raise test scores in science, math, and reading**
- **Engineering design challenges** and science **investigations** to **integrate** seamlessly the **Science and Engineering Practices**
- Real-world phenomena that anchor practices-based instruction
- **Coherent learning progressions** that revisit and expand student understandings

The NGSS Are Clear: Students Need Hands-On Experiences

With STCMS™, there's no need to purchase lab equipment separately. Everything you need—print, digital, and lab materials—is in one package.

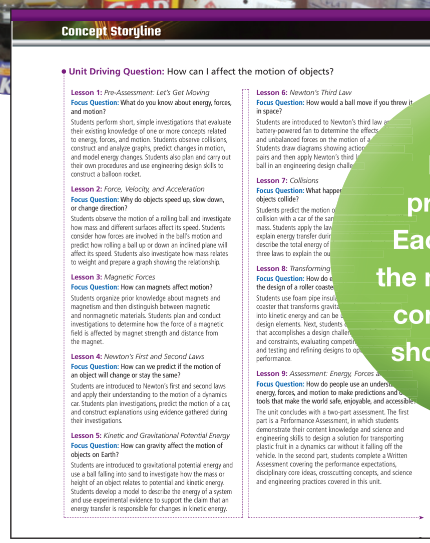
No extra purchases—equipment is included!

Electricity, Waves, and Information Transfer
1-Class Unit Kit

Each STCMS unit features:

- **Teacher Edition** (print and digital) that offers support for educators transitioning to NGSS
- **Access to Carolina Science Online®**
  - Teacher edition eBook access
  - Student sheets and lesson masters, including Spanish
  - Student guide eBook access
- **16 Hardbound Student Guides**
- **Hands-On Materials Kit of Choice:**
  - **1-Class Kit** (with enough materials for up to 32 students)
  - **5-Class Kit** (with enough materials for up to 160 students)

No "Random Acts of Science" When You Have the Smithsonian's STCMS™ in Your Classroom


Concept Storyline

• **Unit Driving Question:** How can I affect the motion of objects?

Lesson 1: *Pre-Assessment: Let's Get Moving*
Focus Question: What do you know about energy, forces, and motion?
Students perform short, simple investigations that evaluate their existing knowledge of one or more concepts related to energy, forces, and motion. Students observe collisions, construct and analyze graphs, predict changes in motion, and model energy changes. Students also plan and carry out their own procedures and use engineering design skills to construct a balloon rocket.

Lesson 2: *Force, Velocity, and Acceleration*
Focus Question: Why do objects speed up, slow down, or change direction?
Students observe the motion of a rolling ball and investigate how mass and different surfaces affect its speed. Students consider how forces are involved in the ball's motion and predict how rolling a ball up or down an inclined plane will affect its speed. Students also investigate how mass relates to weight and prepare a graph showing the relationship.

Lesson 3: *Magnetic Forces*
Focus Question: How can magnets affect motion?
Students organize prior knowledge about magnets and magnetism and then distinguish between magnetic and nonmagnetic materials. Students plan and conduct investigations to determine how the force of a magnetic field is affected by magnet strength and distance from the magnet.

Lesson 4: *Newton's First and Second Laws*
Focus Question: How can we predict if the motion of an object will change or stay the same?
Students are introduced to Newton's first and second laws and apply their understanding to the motion of a dynamics car. Students plan investigations, predict the motion of a car, and construct explanations using evidence gathered during their investigations.

Lesson 5: *Kinetic and Gravitational Potential Energy*
Focus Question: How can gravity affect the motion of objects on Earth?
Students are introduced to gravitational potential energy and use a ball falling into sand to investigate how the mass or height of an object relates to potential and kinetic energy. Students develop a model to describe the energy of a system and use experimental evidence to support the claim that an energy transfer is responsible for changes in kinetic energy.

Lesson 6: *Newton's Third Law*
Focus Question: How would a ball move if you threw it in space?
Students are introduced to Newton's third law a
battery-powered fan to determine the effects
and unbalanced forces on the motion of a
Students draw diagrams showing action
pairs and then apply Newton's third l
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Lesson 7: *Collisions*
Focus Question: What happe
objects collide?
Students predict the motion o
collision with a car of the sa
mass. Students apply the law
explain energy transfer duri
describe the total energy of
three laws to explain the ou

Lesson 8: *Transforming*
Focus Question: How do e
the design of a roller coaste
Students use foam pipe insula
coaster that transforms gravita
into kinetic energy and can be
design elements. Next, students
that accomplishes a design challen
and constraints, evaluating competin
and testing and refining designs to op
performance.

Lesson 9: *Assessment: Energy, Forces a*
Focus Question: How do people use an underst
energy, forces, and motion to make predictions and
tools that make the world safe, enjoyable, and accessible
The unit concludes with a two-part assessment. The first part is a Performance Assessment, in which students demonstrate their content knowledge and science and engineering skills to design a solution for transporting plastic fruit in a dynamics car without it falling off the vehicle. In the second part, students complete a Written Assessment covering the performance expectations, disciplinary core ideas, crosscutting concepts, and science and engineering practices covered in this unit.

Every lesson builds on the previous lesson. Each unit builds to the next unit. STCMS concept storylines show the pathway.

In need of instruction with a coherent learning progression? Look no further.

For more than 30 years, the Smithsonian Science Education Center has built inquiry science programs that work. What's the secret to their success? Concept storylines that use authentic STEM experiences to help students construct learning.

With the STCMS program:

- Each unit provides a unit driving question to focus the entire unit.
- Each lesson builds on the previous lesson. This sequence allows students to answer the unit driving question by the end of the unit.

What can you expect from every lesson?

- To ignite learning through the introduction of **phenomena**
- To **integrate literacy and math**, which will create deep understanding and provide key tools for success in science
- To engage students in **investigative experiences**, during which they **study, model, and explain phenomena**

Why Phenomena? How Do You Teach It?

The Why: "Phenomena" appears in the middle school Next Generation Science Standards 40 times!

Phenomena are a big part of the new standards and the link between all three dimensions of the NGSS. Connecting phenomena to science provides concrete experiences that ignite students' interest in learning more.

The How: There's a right way to teach phenomena.

Building students' understanding of phenomena requires instruction that is rooted in hands-on experiences rather than students reading about phenomena and "experiencing" them through computer simulations.

The Smithsonian's STCMS™ puts real-world and experiential phenomena in students' hands every day.

To teach phenomena, present events for students to study, model, and explain.

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How Do You Know Students Understand?

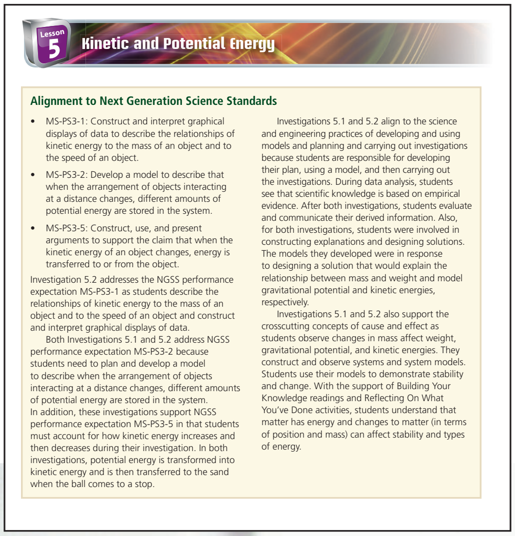
STCMS™ provides powerful assessment every step of the way.

A good assessment system positions students for success on any external assessment that is well aligned to NGSS standards. **A great assessment system goes further**, providing a coherent structure of classroom-based assessments that give powerful information to inform not only teacher instruction, but also student learning.

The Smithsonian's STCMS system includes:

- **Pre-assessment**
- Multiple forms of **formative assessment** in each lesson, including **Exit Slips**
- Powerful **self-assessment** for students
- **Summative assessment**—performance and written components targeting the full range of the unit's concepts and practices
- Unit-specific **NGSS rubrics** to assess three-dimensional learning

STCMS provides NGSS rubrics for every unit.



Lesson 5 Kinetic and Potential Energy

Alignment to Next Generation Science Standards

- MS-PS3-1: Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object.
- MS-PS3-2: Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system.
- MS-PS3-5: Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.

Investigation 5.2 addresses the NGSS performance expectation MS-PS3-1 as students describe the relationships of kinetic energy to the mass of an object and to the speed of an object and construct and interpret graphical displays of data.

Both Investigations 5.1 and 5.2 address NGSS performance expectation MS-PS3-2 because students need to plan and develop a model to describe when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system. In addition, these investigations support NGSS performance expectation MS-PS3-5 in that students must account for how kinetic energy increases and then decreases during their investigation. In both investigations, potential energy is transformed into kinetic energy and is then transferred to the sand when the ball comes to a stop.

Investigations 5.1 and 5.2 align to the science and engineering practices of developing and using models and planning and carrying out investigations because students are responsible for developing their plan, using a model, and then carrying out the investigations. During data analysis, students see that scientific knowledge is based on empirical evidence. After both investigations, students evaluate and communicate their derived information. Also, for both investigations, students were involved in constructing explanations and designing solutions. The models they developed were in response to designing a solution that would explain the relationship between mass and weight and model gravitational potential and kinetic energies, respectively.

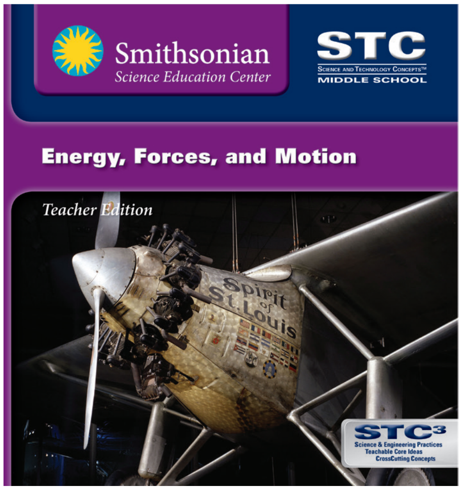
Investigations 5.1 and 5.2 also support the crosscutting concepts of cause and effect as students observe changes in mass affect weight, gravitational potential, and kinetic energies. They construct and observe systems and system models. Students use their models to demonstrate stability and change. With the support of Building Your Knowledge readings and Reflecting On What You've Done activities, students understand that matter has energy and changes to matter (in terms of position and mass) can affect stability and types of energy.

Support for Teachers Transitioning to the New Standards

Three-dimensional learning calls for building to Performance Expectations over time with Science and Engineering Practices, Crosscutting Concepts, and Disciplinary Core Ideas. STCMS™ provides educators with support for this new teaching innovation every step of the way.

STCMS truly supports the new NGSS standards and three-dimensional learning.

Energy, Forces, and Motion



Unit Driving Question:

How can I affect the motion of objects?

Performance Expectations: MS-PS2-1, MS-PS2-2, MS-PS2-3, MS-PS2-5, MS-PS3-1, MS-PS3-2, MS-PS3-5, ETS1-1, ETS1-2, ETS1-3, ETS1-4

Unit Highlight: Students design, refine, and redesign a roller coaster for optimal performance. As part of the unit assessment, students are challenged to apply their content knowledge and science and engineering practice skills to design a solution for safely transporting fruit in a dynamics car.

Lesson 1 *Pre-Assessment: Let's Get Moving*

Focus Question: What do you know about energy, forces, and motion?

Students perform short, simple **investigations** that evaluate their existing knowledge of one or more concepts related to energy, forces, and motion. Students observe collisions, **construct and analyze** graphs, **predict** changes in motion, and **model** energy changes. Students also **plan and carry out** their own procedures and use **engineering design skills** to **construct a balloon rocket**.

Lesson 2 *Force, Velocity, and Acceleration*

Focus Question: Why do objects speed up, slow down, or change direction?

Students observe the motion of a rolling ball and **investigate** how mass and different surfaces affect its speed. Students consider how forces are involved in the ball's motion and **predict** how rolling a ball up or down an inclined plane will affect its speed. Students also **investigate** how mass relates to weight and **prepare a graph** showing the relationship.

Lesson 3 *Magnetic Forces*

Focus Question: How can magnets affect motion?

Students organize prior knowledge about magnets and magnetism and then distinguish between magnetic and nonmagnetic materials. Students **plan and conduct investigations** to determine how the force of a magnetic field is affected by magnet strength and distance from the magnet.

Lesson 4 *Newton's First and Second Laws*

Focus Question: How can we predict if the motion of an object will change or stay the same?

Students are introduced to Newton's first and second laws and **apply their understanding** to the motion of a dynamics car. Students **plan investigations**, **predict** the motion of a car, and **construct explanations using evidence** gathered during their **investigations**.

Lesson 5 *Kinetic and Gravitational Potential Energy*

Focus Question: How can gravity affect the motion of objects on Earth?

Students are introduced to gravitational potential energy and use a ball falling into sand to **investigate** how the mass or height of an object relates to potential and kinetic energy. Students **develop a model** to describe the energy of a system and use experimental **evidence to support the claim** that an energy transfer is responsible for changes in kinetic energy.

Lesson 6 *Newton's Third Law*

Focus Question: How would a ball move if you threw it in space?

Students are introduced to Newton's third law and use a battery-powered fan to determine the effects of balanced and unbalanced forces on the motion of a (dynamics) car. Students **draw diagrams** showing action-reaction force pairs and then apply Newton's third law to move a tennis ball in an **engineering design challenge.**

Lesson 7 *Collisions*

Focus Question: What happens to energy when two objects collide?

Students **predict** the motion of a dynamics car following a collision with a car of the same mass and a car of a different mass. Students **apply** the law of conservation of energy to explain energy transfer during a collision, **develop a model** to describe the total energy of the system, and apply Newton's three laws to explain the outcome of a collision.

Lesson 8 *Transforming Energy*

Focus Question: How do energy transformations inform the design of a roller coaster?

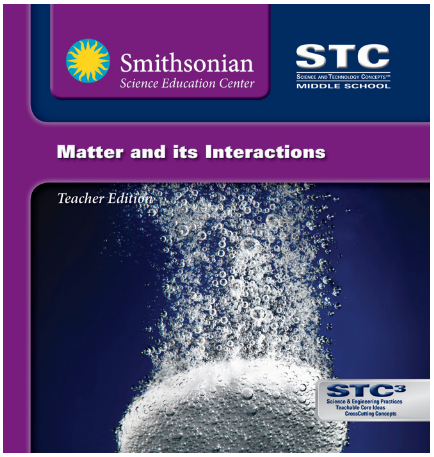
Students use foam pipe insulation to **build a basic roller coaster** that transforms gravitational potential energy into kinetic energy and can be used to test roller coaster design elements. Next, students **construct a roller coaster** that accomplishes a **design challenge** by defining criteria and constraints, evaluating competing design solutions, and **testing and refining designs** to optimize roller coaster performance.

Lesson 9 *Assessment*

Focus Question: How do people use an understanding of energy, forces, and motion to make predictions and design tools that make the world safe, enjoyable, and accessible?

The unit concludes with a two-part assessment. The first part is a performance assessment, in which students demonstrate their content knowledge and science and engineering skills to **design a solution** for transporting plastic fruit in a dynamics car without it falling off the vehicle. In the second part, students complete a written assessment that covers the performance expectations, disciplinary core ideas, crosscutting concepts, and science and engineering practices incorporated in this unit.

Matter and Its Interactions



Unit Driving Question:

How does matter and its interactions affect everyday life?

Performance Expectations: PS1-1, PS1-2, PS1-3, PS1-4, PS1-5, PS1-6, MS-PS3-4, MS-ETS1-1, MS-ETS1-2, MS-ETS1-3, MS-ETS1-4

Unit Highlight: Students utilize content knowledge to design a method to remove impurities from rock salt, a practice that allows us to have salt for our food. As part of the unit assessment, students demonstrate content knowledge and science and engineering practices to design an eco- and pet-friendly cold pack.

Lesson 1 *Pre-Assessment*

Focus Question: What do you know about matter?

Students perform short, simple **investigations** that evaluate their existing knowledge of one or more concepts related to matter and its interactions. Students make observations of pure substances and mixtures, and determine if new substances are formed. Students also **evaluate predictions**, use **evidence to support claims**, and infer **cause and effect** relationships.

Lesson 2 *The Nature of Matter*

Focus Question: What can properties of matter help you determine?

Students **observe and describe** samples of matter based on their physical and chemical properties (including solubility and reactivity). Students also identify mystery samples on the basis of their physical and chemical properties.

Lesson 3 *Density Makes a Difference*

Focus Question: How can density be used to identify a substance and predict how it will behave under different conditions?

Students compare the densities of different substances, including liquids and irregularly-shaped objects. Students also **make and test predictions** about the floating of solids in liquids and use their findings to recreate the density bottle they explored in the pre-assessment.

Lesson 4 *Just a Phase*

Focus Question: How is energy related to physical changes in matter?

Students record the temperature of water as it melts, warms, and boils and then make connections with molecular-level observations in a computer simulation of the same experiment. Students also **apply their understanding** of the law of conservation of mass to **plan and carry out investigations** of the mass of water as it melts or freezes in a sealed container.

Lesson 5 *Building Blocks of Matter*

Focus Question: How can you use a model to describe the composition of matter?

Students rotate through stations to collect information about 16 different element samples. Next, students combine elements to **create models** of simple molecules using plastic atoms and computer simulations.

Lesson 6 *Pure Substances and Mixtures*

Focus Question: How can mixtures be separated?

Students observe and describe samples of pure substances and mixtures. Students use chromatography to separate inks, and distill favoring from a carbonated beverage. Students **apply engineering skills to design a method** for removing impurities from rock salt.

Lesson 7 *Reacting Chemically*

Focus Question: How can the properties of matter be used to determine if a chemical reaction has occurred?

Students **analyze and interpret data** on the properties of substances before and after different chemical reactions. Students also use their **data to support the claim** that a new substance has been formed. Chemical reactions include: the electrolysis of water; formation of precipitates; and combination of sodium bicarbonate, calcium chloride, and phenol red.

Lesson 8 *Releasing Energy*

Focus Question: What is the relationship between changes in substances and changes in thermal energy?

Students **plan and conduct an investigation** to study temperature change that accompanies the oxidation of iron in steel wool. Students also **apply their engineering skills to design** a hot pack that utilizes the exothermic reaction between calcium chloride and water.

Lesson 9 *Conservation of Matter*

Focus Question: What happens to the total mass of matter in a chemical reaction?

Students will **apply their understanding** of the law of conservation of matter to **create models** that explain situations in which matter seems to appear or disappear. Chemical reactions include dissolving an effervescent tablet in water and burning steel wool.

Lesson 10 *Compounds from Natural Resources*

Focus Question: How are synthetic compounds made and used?

Students read about and **investigate** natural resources that undergo chemical reactions to produce synthetic materials. Students **plan and conduct an investigation** to determine which solutions can be combined with sodium alginate to form a gelatinous product.

Lesson 11 *Assessment*

Focus Question: How can we use our knowledge of matter and its interactions to solve problems?

The unit concludes with a two-part assessment. The first part is a performance assessment, in which students demonstrate their content knowledge and **science and engineering skills to design a cold pack** using one of six chemical compounds. Students must set up their own experiments and justify their selection based on safety for humans, safety for the environment, and cost of material per gram. In the second part, students complete a written assessment that covers the performance expectations, disciplinary core ideas, crosscutting concepts, and science and engineering practices incorporated in this unit.

Electricity, Waves, and Information Transfer

Unit Driving Question:

How do the properties of electricity and waves influence the technology of information transfer?

Performance Expectations: MS-LS1-8, MS-PS2-3, MS-PS3-3, MS-PS3-5, MS-PS4-1, MS-PS4-2, MS-PS4-3, MS-ETS1-1, MS-ETS1-2, MS-ETS1-3, MS-ETS1-4

Unit Highlight: Applying what they learn as they explore the technology behind touch screen devices, students design a stylus. As part of the unit assessment, students design a remote medical system for assessing and transporting patients from a natural disaster area.

Pre-Assessment *Electricity and Waves Help Us Communicate*

Focus Question: What do you know about electricity, waves, and information transfer?

Students **observe and investigate** electric devices, sources of waves, and simple examples of energy transfer. They also **construct explanations** and explore the use of a waterwheel as an analogy to **model** electricity.

Lesson 1 *Battery Powered: Electricity Basics*

Focus Question: What is electricity and how is it measured?

Students **investigate** the **structure and function** of batteries as applied to energy transformation in circuits. Students measure voltage and current in open and closed circuits with batteries and lightbulbs, **using evidence** from their observations to construct explanations about how different batteries and battery arrangements affect the voltage and current in a circuit.

Lesson 2 *Resistance and Capacitance*

Focus Question: How can components in an electric circuit affect current and voltage?

Students apply Ohm's law to **investigate** resistance values for different resistors and wires. Students **investigate** capacitors and discover that batteries are not the only method of energy storage. Students **generate a hypothesis** on how a capacitor affects voltage and current, **plan an investigation to test**, and **argue their claim using evidence**.

Lesson 3 *Transforming and Transferring Electrical Energy*

Focus Question: How is the transfer of thermal energy from electric devices regulated?

Students **analyze** thermal energy transformation and transfer in lightbulbs and resistors. Applying what they learn, they **design** an electrical system that maximizes or minimizes thermal energy transfer.

Lesson 4 *Electricity in Motion*

Focus Question: How do components in an electrical system transform electrical energy into kinetic energy?

Students build a spinning coil motor to **investigate** relationships between current and electrical energy, gathering and **using evidence to construct arguments** about the source of kinetic energy in their motors. Students then disassemble and reassemble a manufactured electric motor to examine how the parts work together to transform electrical energy into kinetic energy.

Lesson 5 *Detecting Waves*

Focus Question: How can we use models to understand wave properties?

Students use **models** to **investigate** the properties of transverse and longitudinal waves, including wavelength, frequency, and amplitude.

Lesson 6 *Wave Transmission: Traveling through Media*

Focus Question: How do waves behave when they interact with matter?

Students observe light and sound waves interacting with different types of matter and **create models** describing absorption, transmission, reflection, and refraction. Students **apply their knowledge** of electromagnetic waves to **construct an explanation** about whether light waves always travel in straight lines. Students **construct an explanation** about how sound waves move through different states of matter.

Lesson 7 *Communicating and Storing Information with Waves*

Focus Question: How do we use waves to encode and transmit information?

Students read about differences in analog and digital information technologies and decide what information would be necessary to **construct a scientific argument** about perceived differences between analog and digital sound. Students then **investigate** how wave properties and interactions can be used to communicate information.

Exploration Activity *Designing an Information Communication System*

Focus Question: How can electricity and waves be used to communicate information from one place to another?

Students **design, build, and test prototypes** of technological systems that utilize electricity and waves to communicate information. Students **relate what they learn** in this exploration activity to **real-world technologies**, including fiber-optic communications and encoding information into electronic formats.

Lesson 8 *Waves and Information Transfer: The Global Positioning System*

Focus Question: How are the properties of electromagnetic waves useful for human communication systems, such as the Global Positioning System?

Students **model** the transfer of information via electromagnetic waves, and how the Global Positioning System works to determine a receiver's location.

Lesson 9 *The Electric Body*

Focus Question: How does your body use electrical signals to detect and respond to information in your environment?

Students **investigate** and **model** how neurons use electrical signals to transmit information from the sense organs to the brain and from the brain to muscles and organs. Students reflect on how the structures of the nervous system support the functions of transmitting and storing information.

Lesson 10 *Animal Communication and Navigation Systems*

Focus Question: How do animals use waves to communicate and navigate in their environments?

Students continue investigating biological applications of electricity as they **model** animal communication and navigation systems. Students **apply prior knowledge** of the transmission and reflection of sound waves and the transmittal of information from the environment to the brain to understand how the different components of echolocation work together in a system.

Lesson 11 *Electricity and Waves in Medical Technologies*

Focus Question: How are electricity and waves used to diagnose and treat medical conditions?

Students read about the use of waves in medical imaging technologies and **apply their understanding** of benefits, risks, and cost to develop a medical imaging protocol for a health clinic and make recommendations for medical imaging purchases.

Lesson 12 *Exploring and Designing Touch Screen Devices*

Focus Question: How are electrical components used to design touch screen devices?

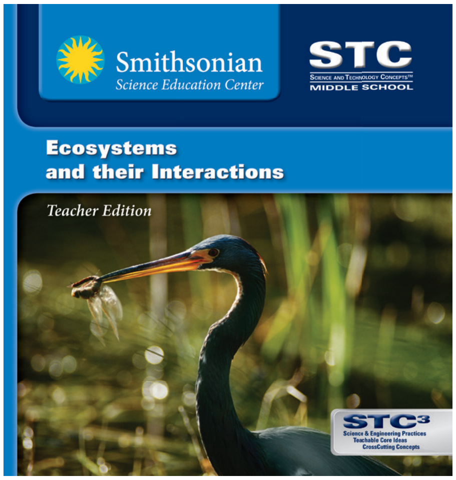
Students **apply the content knowledge and engineering skills** they have acquired during the unit to a real-world technology: touch screens. Students learn about the structure and function of different touch screen designs and then design an adaptive technology that allows people to operate a touch screen without the use of fingers. Students **evaluate their designs** and **consider the impact of technology on society.**

Assessment

Focus Question: What have you learned about electricity, waves, and information transfer?

The unit concludes with a two-part assessment. In a performance assessment, students **demonstrate their content knowledge and science and engineering skills as they design a remote medical system** for assessing and transporting patients from a natural disaster area. Students then complete a written assessment that covers the performance expectations, disciplinary core ideas, crosscutting concepts, and science and engineering practices incorporated in the unit.

Ecosystems and Their Interactions



Unit Driving Question:

How do organisms interact with one another and their environments?

Performance Expectations: MS-LS1-5, MS-LS1-6, MS-LS1-7, MS-LS2-1, MS-LS2-2, MS-LS2-3, MS-LS2-4, MS-LS2-5, MS-LS4-4, MS-LS4-6, MS-ESS3-3, MS-ETS1-1, MS-ETS1-2

Unit Highlight: As the unit opens, pond ecosystems and butterfly ecosystems provide the launching pad for learning how various elements of systems interact. Students build models and work with simulations to learn how the food web, predation, genetics, and the energy pyramid effect ecosystems. By the end of the unit, students apply their learning to timely issues such as invasive species, runoff and its impact on drinking water, and landslides.

Lesson 1 *Pre-Assessment: Ecosystems and Their Interactions*

Focus Question: What do you already know about ecosystems and their interactions?

Students perform short, simple **investigations** that evaluate their existing knowledge of one or more concepts related to ecosystems and the interactions that occur within them. Students **engineer a model** pond that they will use throughout the unit to investigate different aspects of ecosystems. Students also create concept maps and KWL charts to explore their existing knowledge.

Lesson 2 *Ecosystem Organization*

Focus Question: How are ecosystems organized?

Students investigate the organization of ecosystems and begin laying the framework for further studies of ecosystems. They begin learning about **engineering** and its relationship to ecology as they discuss the criteria and constraints that would have to be met to create an artificial habitat for an organism. Students conclude the lesson by **applying their understanding** of ecosystem organization **to their model** pond ecosystem.

Lesson 3 *Resources*

Focus Question: How does the availability of resources affect a population of organisms?

Students **design and carry out an investigation** to determine how the availability of resources affects plant growth and extrapolate that to the environment. Students also **analyze data** based on a model of an ecosystem showing carrying capacity. In the final investigation of the lesson, students consider the resources available in their ponds. Then, they **apply their understanding** of resources **to their model** pond ecosystem.

Lesson 4 *Matter Cycles*

Focus Question: How do organisms get matter to grow and repair their bodies?

After reading about the water cycle, students **design a model** to show the movement of water in an ecosystem. Then, they conduct an experiment using algae and yeast, and construct an explanation for the flow of carbon in an ecosystem. Students also take the role of a nitrogen atom as they **model** the flow of nitrogen through an ecosystem. Based on the information gathered in this lesson and the **data** they have collected from their ponds, students **explain** how matter is flowing through their model ponds.

Lesson 5 *Energy Flow*

Focus Question: How do organisms get energy to live and grow?

Students **model** the flow of energy through an ecosystem to develop an understanding of energy transfer, trophic levels, food chains, and food webs. Students begin to grow *Brassica* to observe the relationship between *Brassica* and the cabbage white butterfly throughout its life cycle. The lesson concludes as students use the **data** they have collected about their **model** ponds to construct food chains for the organisms in the pond.

Lesson 6 *Relationships Among Organisms*

Focus Question: How do organisms interact with one another?

Students **model** predation and competition. They also **analyze** presented information to **determine the relationships** that exist between different sets of organisms. Students begin to **ask questions** that will be answered in a later lesson as they **carry out investigations** on natural selection. Using their **model** ponds, students **cite evidence** to identify relationships that exist between different organisms.

Lesson 7 *Population Changes*

Focus Question: How do changes to the physical or biological components of an ecosystem affect a population?

Students continue to explore how changes to an ecosystem can affect the populations of organisms that live within it by **modeling** the introduction of a nonnative species to an ecosystem. Students also examine the different types of succession that occur in an ecosystem and consider the importance of natural disturbances. Students **plan and carry out an investigation** to see how a change to a biotic or abiotic component of their model ponds will affect the ecosystem.

Lesson 8 *Natural Selection*

Focus Question: How does natural selection change a population over time?

Students **construct explanations** about the importance of variation in a population after conducting several investigations. Students examine sunflower seeds to observe the variation that occurs between them. Students then **model** sea turtle survival to begin understanding natural selection. Next, students **model** natural selection in a population. They again revisit their ponds and sample ponds, and discuss how changing conditions can lead to selection within their models.

Lesson 9 *Biodiversity*

Focus Question: What is biodiversity and why is it important?

Students **model** ways in which scientists measure biodiversity and then use mathematics to approximate the number of organisms in their ecosystem. Students explore ecological engineering as they **obtain, evaluate, and communicate information** about the reintroduction of a species. They **engage in argument from evidence** as they determine whether a species should be reintroduced to an area in which it no longer exists. Students use their newly learned techniques for measuring biodiversity to measure the biodiversity in their model ponds.

Lesson 10 *Human Impact*

Focus Question: How can human impact on the environment be monitored and minimized?

Students **plan and carry out an investigation** to determine how human activities affect plant growth. They also **research** the impact that a human activity is having on the ecosystem. Then, students take on a community stakeholder role and work to **design a solution** to mediate the impact that human activity is having on the ecosystem.

Lesson 11 *Assessment*

Focus Question: What have you learned about ecosystems and their interactions?

This unit concludes with a two-part assessment. The first part is a performance assessment, in which students **apply the knowledge and skills** they have acquired during the unit to **obtain, evaluate, and communicate information** about ecosystem services. Students will be presented with a threat to an ecosystem service and must **design a solution to the problem**. In the second part, students complete a written assessment that covers the performance expectations, disciplinary core ideas, crosscutting concepts, and science and engineering practices incorporated in this unit.

Structure and Function

Unit Driving Question:

How do the structure and function of organisms contribute to their survival?

Performance Expectations: MS-LS1-1, MS-LS1-2, MS-LS1-3, MS-LS1-6, MS-LS1-7, MS-LS1-8, MS-LS4-2, MS-LS4-3

Unit Highlight: Whether it's the deadly leaves of a Venus flytrap or the startling camouflage techniques of a brilliant octopus, Earth's diverse array of creatures and plants have unique structures that assist our common quest for survival. Starting at the cellular level for plants and animals, students learn about cells and how those cells work in systems to contribute to survival. Students investigate how photosynthesis and cellular respiration drive the flow of energy and matter in an organism. A close investigation of the nervous system and a frog dissection show the interdependence of organs and their systems. At the end of the unit, students research unique systems of organisms—who knew hippos can sweat their own sunscreen?

Lesson 1 *Pre-Assessment*

Focus Question: What do we already know about how living things survive in their environment and how can we learn more?

Students build on their understanding of life by observing various cellular structures, predicting their function, and then relating those structures to a living thing's survival. They will think about what they already know about how living things survive in their environment. The observations they make and the ideas they discuss in this lesson will prepare them for future investigations.

Lesson 2 *Cells*

Focus Question: What roles can cells play in the development and survival of organisms?

Students will explore various microorganisms, **investigating** the structures found in their bodies and determining how these structures allow them to function and ultimately survive. They will then **investigate** the diversity of cells found in macroorganisms and attempt to determine their function for survival. Finally, students will explore how cells become "different" from one another during the development of a new organism.

Lesson 3 *Cell Organelles*

Focus Question: What structures does a cell need in order to survive?

Students will **investigate** the organelles found inside of cells and examine the interrelatedness of these structures. They will also **observe** how organelles have particular functions within the cell that work together to help the cell survive.

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Lesson 4 *Photosynthesis*

Focus Question: What role do matter and energy play during photosynthesis?

Students will learn about a cellular process known as photosynthesis and investigate how matter and energy flow between the living and nonliving parts of the environment during this process, continuously being recycled by autotrophs such as plants.

Lesson 5 *Cellular Respiration*

Focus Question: Where do cells get the resources they need to aid an organism's survival?

Students will explore an energy producing process known as cellular respiration and determine the role that oxygen plays in it. By the end of the lesson, they will **construct a scientific explanation** about how organisms obtain the energy that they need to survive.

Lesson 6 *Levels of Organization*

Focus Question: How does the organization of an organism's body aid in survival?

Students will **investigate** how a body is a system made up of many smaller subsystems that work together to perform various functions and keep an organism alive. They will begin to understand that the cells in multicellular organisms are organized in a particular way because they rely on each other in order to survive.

Lesson 7 *The Nervous System*

Focus Question: How does the brain send and receive information?

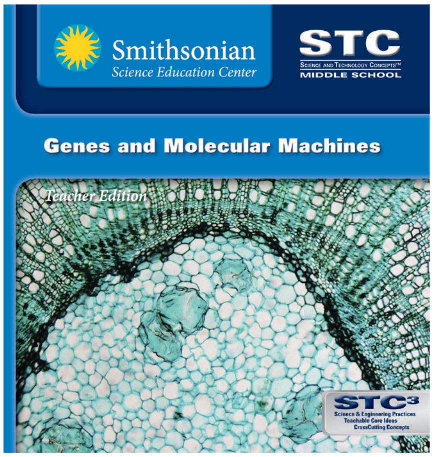
Students will **observe** and explore nerves and nerve cells and evaluate information to gain an understanding of the role these cells in tissue have in sending and receiving information. They will then **conduct several investigations** to gain an understanding of the relationship between the senses and the brain in communicating information.

Lesson 8 *Assessment*

Focus Question: How are different animals specially adapted to survive in their environment?

As a culminating activity, students will work in groups to research an animal with a unique/extreme organ system or structure within an organ system that helps it survive. In its research, each group will **investigate** the purpose of the organ or system involved, all the organs involved in that particular system and how they work together, and describe the specialized cells that are involved in the system and how their organelles may be specially adapted for that system. Each group will **present its research** to the class.

Genes and Molecular Machines



Unit Driving Question:

How has human understanding of inheritance allowed us to influence change in biodiversity?

Performance Expectations: MS-LS1-1, MS-LS1-4, MS-LS3-1, MS-LS3-2, MS-LS4-4, MS-LS4-5

Unit Highlight: Beginning at the cellular level, students explore the different ways that organisms reproduce and what that means for their genetics. Students learn how traits are passed from one generation to the next as they study zebra fish, plants, protists, and humans. By the end of the unit, students create their own "creatures" with unique characteristics and follow those traits to their offspring to learn about inheritance. Using Punnett squares, DNA, and mutations, they predict future generations.

Lesson 1 *Pre-Assessment: Genes and Molecular Machines*

Focus Question: What do you already know about cells, reproduction, and genetics?

Students perform short, simple **investigations** that evaluate their existing knowledge of one or more concepts related to genetics. Students plant Wisconsin Fast Plants® seeds, root a coleus plant, observe variations in zebra fish, examine cells, and look for similarities between parents and offspring. Students are also introduced to **model** organisms and their significance in life science.

Lesson 2 *Cells*

Focus Question: What are the building blocks of life?

Students **carry out investigations** relating to cells by creating wet-mount slides of various organisms that allow them to distinguish between unicellular and multicellular organisms. Next, students analyze prepared slides and attempt to interpret cell **function** within a multicellular organism. Finally, students consider the **function** of bones in an animal and **design a cell** whose structure would adequately meet that function.

Lesson 3 *Organism Reproduction*

Focus Question: What can cells tell us about how organisms reproduce?

Students cross-pollinate the flowers of their Wisconsin Fast Plants®, simulating sexual reproduction. Students then **investigate** various asexual methods of reproduction under the microscope by observing paramecium undergoing fission and hydras undergoing budding. Students continue to explore asexual reproduction by regenerating a blackworm segment and **analyzing** the results of their coleus clipping. Students then **consider the advantages and disadvantages** of sexual and asexual reproduction and the offspring that are created as a result.

Lesson 4 *Cellular Reproduction*

Focus Question: Where do cells come from?

Students explore cell division and how it relates to reproduction. Students prepare and stain a wet-mount slide of onion root cells undergoing mitosis. Students then **design and construct a model** of a cell and **predict** the behaviors of the cell during mitosis. Next, students explore plant reproductive cells undergoing meiosis. Students use their **observations to design and construct a model of a cell** and **predict** the cell behaviors that occur during meiosis. Students compare and contrast these two cellular divisions and how they both relate to reproduction.

Lesson 5 *Genetics*

Focus Question: Why do family members look similar but not identical to one another?

Students begin to **investigate** variation by observing a lady beetle population. Students then explore complete dominance by using probability to determine genotypes and phenotypes in a newly created creature. Next, students take those creatures and demonstrate heredity by using a die to randomly pass on genes to an offspring. Students then create Punnett square **models** that allow them to **analyze and interpret** the passing of traits from parents to offspring.

Lesson 6 *DNA to Trait*

Focus Question: How does DNA determine the traits that organisms have?

Students **analyze** the structure of DNA and **determine the patterns** that exist in the structure. Students then **carry out an investigation** to extract DNA from strawberries. Next, students use pop beads to **model** DNA transcription into RNA, and then translate the RNA into amino acids, forming proteins. Using their creatures from Lesson 5, students then explore how changes in DNA can lead to changes in a protein which leads to changes in the creature's traits.

Lesson 7 *Successful Reproduction and Offspring*

Focus Question: How do behaviors and structures allow plants and animals to reproduce more successfully and better survive?

Students **analyze** various flowers and pollinators to determine which pair relies on one another for reproductive success. Then, students **plan and carry out an investigation** to determine how various seeds are dispersed. Next, students **plan and carry out an investigation** to explore materials and ideal conditions needed for a seed to germinate. Then, students **develop and present a model** of a new species of flower, its pollinator, seed structure, and method of dispersal. To end the lesson, students determine the reproductive success of some animals based on parenting strategies.

Lesson 8 *Variation*

Focus Question: How do differences within a population help a species survive?

Students harvest and germinate the Wisconsin Fast Plants® seeds from their plants. Students then observe the variations that exist between the plants. Next, students use the phenotypes that they observe to **predict** the genotype of the parents by using Punnett square **models**. Students then use beads to **investigate** genetic diversity within asexual and sexual reproducing organisms.

Lesson 9 *Selection*

Focus Question: How do natural and artificial selection change a population over time?

Students work in groups to **carry out an investigation** relating to natural selection using beads and different types of habitats. Then, students intentionally hunt for certain colors of beads, **modeling the process** of artificial selection. Students then consider the selection pressures of both processes and how they lead to evolution.

Lesson 10 *Human Manipulation*

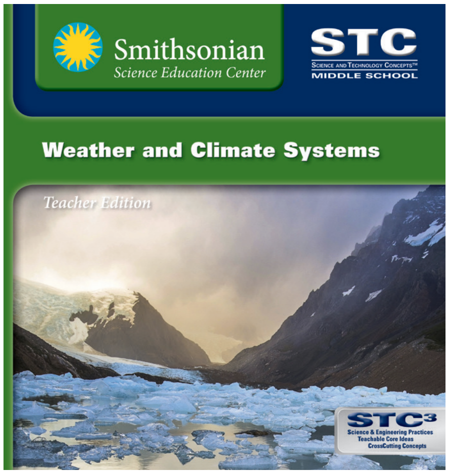
Focus Question: What are some ways that humans have influenced the inheritance of desired traits in organisms?

Students organize **prior knowledge** about genetics to consider reasons why humans would want to manipulate an organism's DNA. Then, students **observe** the different variants of zebra fish in their classroom to **construct an explanation** to how the different kinds of zebra fish were created. Next, students research different types of genetic modification technologies and compile a list of reliable sources of information.

Lesson 11 *Assessment*

The unit concludes with a two-part assessment. The first part is a performance assessment, in which students **apply the knowledge and skills** they have acquired during the unit to **research and report** on human manipulation of organisms' genetics to produce desirable traits. In the second part, students complete a written assessment that covers the performance expectations, disciplinary core ideas, crosscutting concepts, and science and engineering practices incorporated in this unit.

Weather and Climate Systems



Unit Driving Question:

How can data be used to understand weather and climate?

Performance Expectations: MS-ESS2-4, MS-ESS2-5, MS-ESS2-6, MS-ESS3-2, MS-ESS3-4, MS-ESS3-5, MS-PS3-4, MS-ETS1-1, MS-ETS1-2

Unit Highlight: Students apply content knowledge and engineering practices to create a design solution to minimize the impact of a storm surge. As a unit assessment students use provided weather data to determine if they will have a day off from school due to weather conditions.

Lesson 1 *Pre-Assessment: Weather and Climate Systems*

Focus Question: What do you know about weather and climate on Earth?

Students **reflect on what they already know** about weather and climate in a series of activities. Through these activities they reflect on many different parts of weather and climate. Students will ask questions about these topics to set the stage for later lessons.

Lesson 2 *Heating Earth's Surface*

Focus Question: How do different surfaces on Earth warm and cool?

Students **investigate** the unequal heating of Earth's surface by **planning and carrying out an investigation** to **collect data** about how different materials, water and soil, absorb and release heat. Then students will **analyze and interpret their collected data**. Students will consider how these interactions between material and heat relate to weather and climate.

Lesson 3 *Water Cycle, Cloud Formation, and Air Masses*

Focus Question: How do water and air move in the atmosphere?

Students **investigate** the movement of air and water in the atmosphere, which allows them to obtain a foundational knowledge of air masses. In their **investigations** students **model** the atmospheric process of condensation and evaporation. They will **create a model** of the water cycle, allowing them to visualize the flow of water through the atmosphere and land. They will determine the roles that sun and gravity play in this cycle. Using a **model**, students will also **investigate** how surfaces cause the warming and cooling of air above them. Then they continue using their **models** to see how warm and cool air move. Students will then relate this to the formation of clouds and other weather phenomena.

Lesson 4 *Wind and Air Pressure*

Focus Question: How can meteorologists use air pressure measurements to predict changes in weather and different types of cloud formations?

Students **model** the movement of air masses as they **design an investigation** in which they **model** the collision of types of air masses. They conduct an **investigation** to see how different air pressure conditions relate to the formation of clouds. Then they **create a barometer,** which they use as they **plan and carry out an investigation** to determine how air pressure is correlated to weather conditions. Students will recognize the **patterns** that exist between changing air pressure and certain **weather phenomena**, such as clouds.

Lesson 5 *Ocean Currents*

Focus Question: How do temperature, salinity, and wind affect ocean currents?

Students **investigate** the movement of the ocean currents. In separate investigations they **model** how salinity, temperature, and wind affect the movement of water. These activities allow students to view the real-world processes that allow the ocean conveyor belt to move. Students relate the movement of ocean currents to weather and climate.

Lesson 6 *Storms*

Focus Question: What is a vortex and how does it relate to hurricanes and tornados?

Students **model** a vortex and relate it to the movement of tornados and hurricanes. Students learn what conditions are necessary for the formation of thunderstorms, tornados, and hurricanes.

Lesson 7 *Predicting Weather*

Focus Question: How can weather data and patterns be used to predict future weather events?

Students **collect weather data** for five days and then **examine the data for patterns and relationships**. Then they examine weather maps and again look for **patterns and relationships** in the maps. Students will then **analyze and interpret collected data** to **predict** weather events.

Lesson 8 *Tracking Severe Storms*

Focus Question: How can severe storms be tracked in order to predict their impact?

Students examine how severe storms are tracked and **model** it by tracking the path of Hurricane Katrina. They will also **investigate** storm surges and the damage that is caused by them. Students will **design a solution** to minimize the impact of a storm surge and share their designs with their classmates. Students will then get the opportunity to **modify their designs based on feedback** from the class.

Lesson 9 *Introduction to Climate*

Focus Question: What is climate and how is it determined?

Students examine climate and how it differs from weather. Students will **analyze weather data** from several locations and **draw conclusions** about the climate of each region. They will propose the climate classification for a region and **support their argument with evidence** and **present it to the class**.

Lesson 10 *Climate Change Research*

Focus Question: What data have scientists collected and analyzed to support theories about climate change?

Students will learn about climate change through a research **investigation**. Students will **research** climate change and **present their findings to the class**. They will **use the data** that they find to **formulate conclusions** regarding climate change.

Lesson 11 *Impact of Climate Change*

Focus Question: How does climate change impact Earth's systems?

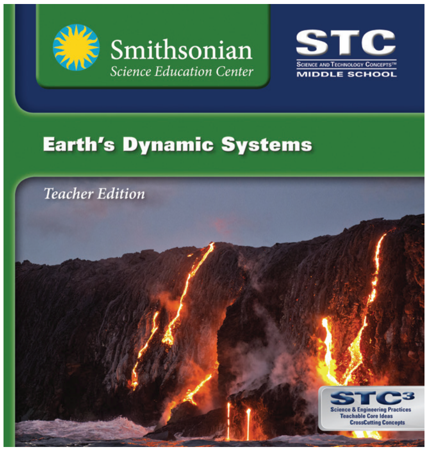
Students will **evaluate** how evidence of climate change can be used **to make projections** of the impacts of climate change on the future. Students will study how scientists **model** climate change and study its potential effects.

Lesson 12 *Assessment*

Focus Question: What have you learned about weather and climate on Earth?

The unit concludes with a two-part assessment. The first part is a performance assessment, in which students **demonstrate their content knowledge and science and engineering skills to analyze** a scenario in which they have to decide whether to close a school due to impending weather conditions. Students will analyze available weather data to formulate an argument based on evidence on whether the conditions will necessitate closing schools in a region. They will present their findings to the class. In the second part, students complete a written assessment that covers the performance expectations, disciplinary core ideas, crosscutting concepts, and science and engineering practices incorporated in this unit.

Earth's Dynamic Systems



Unit Driving Question:

How do the dynamic systems of Earth change its surface?

Performance Expectations: MS-LS4-1, MS-ESS1-4, MS-ESS2-1, MS-ESS2-2, MS-ESS2-3, MS-ESS3-1, MS-ESS3-2, MS-ETS1-1, MS-ETS1-2, MS-ETS1-3, MS-ETS1-4

Unit Highlight: How did that aquatic fossil end up on the top of that mountain? Students learn about gradual processes (erosion, deposition, plate motion, and fossilization) and catastrophic events (earthquakes, volcanoes) and how they contribute to changes on the earth's surface. Students track the transfer of energy, build models, and investigate mineral resources. Students conclude the unit with research on preparedness for catastrophic events. Are we ready for "The Big One"?

Lesson 1 *Pre-Assessment*

Focus Question: What do you know about geological processes?

Students are introduced to two geologic events, the eruption of Krakatau in 1883 and the discovery of the Burgess Shale in 1909, through primary source documents and images. They consider these events, **predict** the way they may have occurred, and **develop questions to explore** about these events during the unit.

Lesson 2 *When the Earth Shakes*

Focus Question: Why are some structures damaged when the earth shakes?

Students **observe** videos of earthquakes and are introduced to shake tables as a way to model earthquakes. They **design and conduct an experiment** to **investigate** the effect of design variables on the way model buildings respond to shaking. Students use experimental data to describe conditions for areas with greatest and least risk for future earthquake damage. Students then use iterative **testing and modification** to **design a model** of an earthquake-resistant house.

Lesson 3 *Analyzing Earthquake Data*

Focus Question: How can we collect data about earthquakes?

Students explore how **data** pertaining to earthquakes can be **collected and analyzed**. They explore wave motion, use seismographs to collect simulated quake data, analyze seismogram readings, and use earthquake data to locate the epicenter of a quake. Through these investigations, students come to understand how earthquake data can show patterns that help in the prediction of future quakes.

Lesson 4 *Investigating Plate Movement*

Focus Question: How do changes in the lithosphere affect Earth's surface?

Students plot earthquake data to **investigate** patterns caused by earthquakes. They also examine the structure of Earth's interior to gain an understanding of the dynamic nature of Earth. Using **models**, students also simulate the movement of tectonic plates and examine the cause and effect of plate movements along faults.

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Lesson 5 *Cycling Matter and Energy*

Focus Question: How do heat and pressure impact geologic features?

Students **model** the rock cycle and investigate the role of heat and pressure in cycling matter and energy. They also examine rock samples and **use observational data** to engage in an **argument from evidence**.

Lesson 6 *Volcanoes: Building Up*

Focus Question: How are volcanoes formed?

Students gain an understanding of how volcanoes are formed by **modeling** the movement of magma through the earth's surface. They then examine information pertaining to different types of volcanoes and gain an understanding of the relationship between earthquakes and volcanoes.

Lesson 7 *Volcanoes: Eruption*

Focus Question: How do volcanoes change Earth's surface?

Students **conduct investigations** to gain an understanding of how volcanoes contribute to the modification and creation of landforms. Students then revisit the Krakatau event and **construct an explanation for the phenomenon**, which involves changes at Earth's surface. Students make **predictions** for how surface features will continue to change in the future as geoscience processes continue to occur.

Lesson 8 *Changing Earth's Surface*

Focus Question: How have geoscience processes changed Earth's surface?

Students **model** several different geoscience processes to gain an understanding of their effect on Earth's surface. They research a real-world example of a process they **modeled** and **present their findings**. Students then revisit the Burgess Shale event and **construct an explanation** for rock deformation.

Lesson 9 *Emergence and Extinction*

Focus Question: What do fossils and layers of sediment tell us about Earth's past?

Students **investigate** how fossils are formed and what they can tell us about the planet's history and the organisms that they represent. Through **modeling** and simulations, students examine the role of fossils in explaining the geologic events of the past. Students also use fossils to **analyze and interpret** patterns related to existence, diversity, anatomical structures, and extinction of organisms.

Lesson 10 *Distribution of Resources on Earth*

Focus Question: How do geoscience processes impact the distribution of resources on Earth?

Students map the location of a specific mineral resource to reveal its uneven distribution and **construct a scientific explanation**. They use a **model** to simulate drilling for a natural resource and calculate the cost of the simulated exploration. Students also **conduct research** related to the mineral, energy, and groundwater resources of Earth and **present their findings** to the class.

Lesson 11 *Evidence of a Dynamic Earth*

Focus Question: What evidence suggests that Earth is a dynamic geologic system?

Students again revisit Burgess Shale fossils and **construct an explanation** for an aquatic fossil being found well above sea level. Students will describe an appropriate timescale for the time since the fossil was underwater and the rate of elevation increase. Students will also **analyze and interpret data** related to the distribution of fossils and rocks, continental landforms, and features on the seafloor as evidence for plate motion in Earth's past.

Lesson 12 *Assessment*

Focus Question: What have you learned about Earth's dynamic systems?

Students, acting as scientists, **prepare and present proposals** for mitigating the effects of future geodynamic events. Students will also **evaluate** proposals from other groups and **make recommendations** for which proposals should receive funds.

Space Systems Exploration

Unit Driving Question:

What can we observe and learn about the universe from our earthly perspective?

Performance Expectations: MS-PS2-4, MS-ESS1-1, MS-ESS1-2, MS-ESS1-3, MS-ETS1-1, MS-ETS1-2, MS-ETS1-3, MS-ETS1-4

Unit Highlight: Using physical and mathematical models plus data analysis, students get a thorough understanding of the Earth-Sun-Moon system. They then apply what they've learned to investigate environmental conditions on Mars and engineer scientifically sound human habitations. As part of the unit assessment students develop a scale model of Uranus and its five largest moons and use it to make predictions about the moons' gravities, orbital speeds, and eclipses.

Pre-Assessment *Our Amazing Universe*

Focus Question: What do you know about how planets and moons move in our solar system?

Students **conduct a series of investigations** to reveal what they know about the scale properties, lunar phases, and seasons within the Sun-Earth-Moon system; the role of gravity and analyzing scale properties of objects in the solar system; and the **engineering design process.**

Lesson 1 *Calendar in the Sky: Introducing the Sun-Earth-Moon System*

Focus Question: How can a model help you understand how the interactions of the Sun, Earth, and Moon explain cycles experienced on Earth?

Students use a **model** to study the periodicity of the orbits of Earth and the Moon and how their orbits relate to the Gregorian calendar.

Lesson 2 *Howling at the Moon: Investigating Lunar Phases*

Focus Question: Why do the patterns you can see in the Moon's appearance occur?

Students use a **model** to **investigate** changes in the appearance of the Moon as it orbits Earth and how these changes relate to the positions of the Sun, Earth, and Moon.

Lesson 3 *Pulling Water: Gravity and Tides*

Focus Question: What causes tides?

Students **analyze** tide chart and moon phase data to infer how the lunar cycle affects tides.

Lesson 4 *Blackout: Solar and Lunar Eclipses*

Focus Question: What causes solar and lunar eclipses?

Students use **models** to **investigate** how the arrangement of orbital planes, within the Sun-Earth-Moon system, creates the special circumstances needed for eclipses to occur.

Lesson 5 *Reasons for Seasons: Why Earth's Tilt Matters*

Focus Question: Why does Earth have seasons?

Students use a **model** to **investigate** how the tilted axis of Earth causes changes in the distribution of solar energy on Earth's surface as Earth orbits the Sun.

Lesson 6 *Stellar Proportions: Modeling the Solar System*

Focus Question: How can we use models to understand the relative sizes of bodies in the solar system and the distances between them?

Students **develop scaled plan-view and side-view models** of the solar system and use them to **make predictions** about the seasonality of climates on other planets.

Exploration Activity *Jupiter and Its Moons*

Focus Question: How can we find and evaluate data to explore questions about Jupiter and its moons?

Students **develop and use models** of Jupiter and its four largest moons to explore **research** questions.

Lesson 7 *Gravity: Bending Space-Time*

Focus Question: How does gravity influence our solar system?

Students compare the weight of an object on different planets with respect to planet mass. They use a simple physical **model** to **investigate** how gravity affects objects of different mass.

Lesson 8 *Keeping It Together: Gravity's Role in the Universe*

Focus Question: How do planets and moons stay in their specific orbits to maintain the structure of our solar system?

Students use a hand-held Moon orbiter **model** to explore the relationships between planetary mass and the distance and speed of an orbiting body. Finally, students read about the function of gravity in the universe. They use what they have learned to **construct an explanation** for how gravity affects orbital properties of planets and their moons.

Lesson 9 *Geologists in Space: Searching for Water on Mars*

Focus Question: How can you use satellite images to look for evidence of geologic features similar to those on Earth on other planets?

Students **analyze** pairs of images from Mars and Earth **to interpret** various geologic features potentially related to surface water. Students **use textual evidence** about how water shapes Earth and photographic comparisons of Earth and Mars features **to develop scientific arguments** for why Mars does or does not have water.

Lesson 10 *The Challenges of Space Exploration*

Focus Question: What are the criteria and constraints for humans to explore and live in space?

Students **design** human habitations for Mars by **analyzing** planetary conditions, **developing design criteria, planning and modeling design solutions, and evaluating competing designs.**

Assessment *How Does the Universe Work?*

Focus Question: What have you learned about the Sun-Earth-Moon system, the solar system, and gravity?

The unit concludes with a two-part assessment. In a performance assessment, students **develop a scale model** of Uranus and its five largest moons and use it **to make predictions** about the moons' gravities, orbital speeds, and eclipses. Students also **analyze** the model's ability to demonstrate other aspects of the Uranus-moons system, including scale properties, axial tilts, orbital properties, lunar phases, and seasons on the moons. In the second part, students complete a written assessment that covers the performance expectations, disciplinary core ideas, crosscutting concepts, and science and engineering practices incorporated in the unit.

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Physical Science	Life Science	Earth/Space Science
Energy, Forces, and Motion MS-PS2-1, MS-PS2-2, MS-PS2-3, MS-PS2-5, MS-PS3-1, MS-PS3-2, MS-PS3-5, MS-ETS1-1, MS-ETS1-2, MS-ETS1-3, MS-ETS1-4	**Ecosystems and Their Interactions** MS-LS1-5, MS-LS1-6, MS-LS1-7, MS-LS2-1, MS-LS2-2, MS-LS2-3, MS-LS2-4, MS-LS2-5, MS-LS4-4, MS-LS4-6, MS-ESS3-3, MS-ETS1-1, MS-ETS1-2	**Weather and Climate Systems** MS-ESS2-4, MS-ESS2-5, MS-ESS2-6, MS-ESS3-2, MS-ESS3-4, MS-ESS3-5, MS-PS3-4, MS-ETS1-1, MS-ETS1-2
Matter and Its Interactions MS-PS1-1, MS-PS1-2, MS-PS1-3, MS-PS1-4, MS-PS1-5, MS-PS1-6, MS-PS3-4, MS-ETS1-1, MS-ETS1-2, MS-ETS1-3, MS-ETS1-4	**Structure and Function** MS-LS1-1, MS-LS1-2, MS-LS1-3, MS-LS1-6, MS-LS1-7, MS-LS1-8, MS-LS4-2, MS-LS4-3	**Earth's Dynamic Systems** MS-LS4-1, MS-ESS1-4, MS-ESS2-1, MS-ESS2-2, MS-ESS2-3, MS-ESS3-1, MS-ESS3-2, MS-ETS1-1, MS-ETS1-2, MS-ETS1-3, MS-ETS1-4
Electricity, Waves, and Information Transfer MS-LS1-8, MS-PS2-3, MS-PS3-3, MS-PS3-5, MS-PS4-1, MS-PS4-2, MS-PS4-3, MS-ETS1-1, MS-ETS1-2, MS-ETS1-3, MS-ETS1-4	**Genes and Molecular Machines** MS-LS1-1, MS-LS1-4, MS-LS3-1, MS-LS3-2, MS-LS4-4, MS-LS4-5	**Space Systems Exploration** MS-PS2-4, MS-ESS1-1, MS-ESS1-2, MS-ESS1-3, MS-ETS1-1, MS-ETS1-2, MS-ETS1-3, MS-ETS1-4

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