Washington Township School District

***The mission of the Washington Township Public Schools** is to provide a safe educational environment for all students to attain the skills and knowledge specified in the New Jersey Core Curriculum Content Standards at all grade levels so as to ensure their full participation in our global society as responsible, self-directed, and civic-minded citizens.*

Course Title:	Science

Grade Level(s):	6th

Duration:	*Full Year:*	X	*Semester:*		*Marking Period:*	
Course Description:	The Washington Township School District seventh grade science curriculum uses an integrated approach to general science that focuses with units on physical, life, and earth science. By using this approach, teachers are able to meet the needs of all students while aligning with the New Jersey Model Science Curriculum Framework, New Jersey Student Learning Standards for Science (NJSLS-S), and the Next Generation Science Standards. Each course will engage students with multiple opportunities to engage with disciplinary core ideas, science and engineering practices, and crosscutting concepts targeted in the performance expectations, with scaffolding faded over the course of the year in each dimension. Hands-on activities are stressed and include student discovery, laboratory experiments, problem solving, model building, cooperative learning, computer usage, classroom discussion, teacher demonstrations, and writing opportunities for research and self-expression. Interdisciplinary subject areas are incorporated whenever possible. Students are introduced to the use of scientific tools and methods used for investigations.					
Grading Procedures:	Mastery of Standards - 60% (tests, projects, and some lab activities) Development of Skills - 40% (independent practice, quizzes, and some lab activities)					
Primary Resources:	CK-12 Physical Science, Life Science, and Earth Science for Middle School OpenSciEd Kesler Science					

Washington Township Principles for Effective Teaching and Learning

- Implementing a standards-based curriculum
- Facilitating a learner-centered environment
- Using academic target language and providing comprehensible instruction
- Adapting and using age-appropriate authentic materials
- Providing performance-based assessment experiences
- Infusing 21st century skills for College and Career Readiness in a global society

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BOE Approval: ________________________________

Unit Title: Physical Science 6.1 Light & Matter
Unit Description: How does a one-way mirror work? Though most everyone knows that one-way mirrors exist, having students model how they work turns out to be a very effective way to develop their thinking about how visible light travels and how we see images. Initial student models in this 6th grade light and matter science unit reveal a wide variety of ideas and explanations that motivate the unit investigations that help students figure out what is going on and lead them to a deeper understanding of the world around them. A video of an experience with a one-way mirror, gets students to organize and write down their initial ideas and then they dig in to test those ideas and figure out what is really happening. Students build a scaled box model of what they saw in the video to test out their ideas. Using two boxes combined together with a one-way mirror in between the two, students vary the presence of light in the two boxes to figure out how a one-way mirror works and improve their initial models so they accurately explain how light is reflected and transmitted through materials and the basics of how these behaviors of light result in the images we see. As the first 6th grade science unit in the OpenSciEd program, during the course of this unit, students also develop the foundation for classroom norms for collaboration that will be important across the whole program while answering several questions.
Unit Duration: 18 days total
Desired Results
Standard(s): ● MS-PS4-2 ○ Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials. This standard focuses on understanding how waves behave when they encounter different substances or materials. ● MS-LS1-8 ○ Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories. This standard explores how sensory receptors in organisms respond to stimuli from the environment and how these responses are processed.
Indicator(s): The Disciplinary Core Ideas (DCIs), Science and Engineering Practices (SEPs), and Crosscutting Concepts (CCCs) for the specified NGSS Standards: **MS-PS4-2** ● **DCI:** PS4.B: Electromagnetic Radiation ○ Electromagnetic radiation (e.g., light) can be modeled as a wave of changing electric and magnetic fields or as particles called photons. The wave model is useful for explaining many features of electromagnetic radiation, and the particle model explains other features. ● **SEP:** Developing and Using Models ○ Develop and use a model to describe phenomena. ● **CCC:** Cause and Effect ○ Cause and effect relationships are routinely identified, tested, and used to explain change. **MS-LS1-8** ● **DCI:** LS1.B: Growth and Development of Organisms ○ Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction. ● **SEP:** Obtaining, Evaluating, and Communicating Information ○ Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication. ● **CCC:** Systems and System Models ○ Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems.

Understandings: • *Students will understand the dual reflective and transmissive properties of materials like one-way mirrors.* • *Students will analyze the relationship between light location and the reflective/transmissive behavior of one-way mirrors.* • *Students will explain the optical phenomena of one-way mirrors through scientific inquiry and modeling.*	**Essential Questions:** See Learning Plan Unit Question: Why do we sometimes see different things when looking at the same object?
Assessment Evidence	
Performance Tasks: (Expectation Activities) • Create a Model. Students create a detailed model of the one-way mirror system and explain how it functions. This includes demonstrating how varying light conditions affect whether the mirror acts like a mirror or a window. • Experiment. Students conduct an experiment to compare how light interacts with different materials, such as a one-way mirror, a regular mirror, and a pane of glass.	**Other Evidence:** • Presentation. Students prepare a presentation or a written report explaining how the one-way mirror works based on their investigations and observations.
Benchmarks: Unit 6.1 Common Assessment	

Learning Plan

Learning Activities

- **Lesson 1: How can something act like a mirror and a window at the same time? (4 class periods)**
  - CK-12 Physical Science for Middle School: 16. Waves
    - 16.1 Mechanical Wave, 16.2 Transverse Wave, and 16.3 Longitudinal Wave.
  - We watch a puzzling video of a music student who can see his reflection in what seems to be a mirror. The student doesn't see the teacher on the other side of the mirror, but the teacher can see through it like a window. We wonder how something can act like a mirror and window at the same time. We investigate the system using a box model that represents it. We develop an Initial Class Consensus Model, brainstorm related phenomena, and develop a Driving Question Board and an Ideas for Investigation chart. We figure out these things: Some materials can be reflective and see through at the same time. Whether the material is reflective or see-through may be related to where there is a light.
- **Lesson 2: What happens if we change the light? (3 class periods)**
  - CK-12 Physical Science for Middle School: 16. Waves
    - 16.4 Surface Wave
  - In this lesson, we observe the one-way mirror in and out of the box model. We move the flashlight to Room B, make both rooms light, and make both rooms dark. We figure out these things: When we change the location of light in the box system, the phenomenon reverses. Reflection happens on the side that is lit, while the side that is dark is see-through. The one-way mirror phenomenon is strongest when there is a difference in light between the rooms. Light travels in straight lines. For us to see an object, light must leave a light source, bounce off the object, and travel in a direct path to enter our eyes.
- **Lesson 3: What happens when light shines on the one-way mirror? (3 class periods)**
  - CK-12 Physical Science for Middle School: 16. Waves
    - 16.5 Wave Amplitude and 16.6 Wavelength

- We know that the one-way mirror acts like a mirror in a brightly lit room and acts like a window in a dark room. To figure out why it behaves this way, we compare what happens when light shines on the one-way mirror, a pane of glass, and a regular mirror. We record initial observations and then use a light meter to measure the amount of light transmitted through and reflected off each of those materials. We use a tool to develop an experimental question and then plan the investigation. We document our observations and analyze data to figure out what happens when light shines on the one-way mirror. We figure out these things: Light travels in straight lines. (reinforcing 4th grade) When light shines on an object, it is reflected (bounces off), transmitted (passes through), or some combination of these, depending on the object's material.

- **Lesson 4: How do similar amounts of light transmit through and reflect off the one-way mirror? (1 class period)**
  - CK-12 Physical Science for Middle School: 16. Waves
    - 16.7 Wave Frequency and 16.8 Wave Speed
  - We wonder how similar amounts of light transmit through and reflect off the one-way mirror. We think it has something to do with how the one-way mirror is made. We read more about regular mirrors and one-way mirrors and find out that regular mirrors have a thick layer of silver on the glass, and one-way mirrors have a thin layer of silver embedded in a plastic film on the glass. We modify a model to explain what happens when light shines on the different structures in each material. We figure out these things: A material can have different structures, even at a microscale, that cause different amounts of light to transmit through or reflect off of it.
- **Lesson 5: How do light and the one-way mirror interact to cause the one-way mirror phenomenon? (1 class period)**
  - CK-12 Physical Science for Middle School:
    - 16.9 Wave Interactions and 16.10 Wave Interference
  - In this lesson, we revisit the anchoring phenomenon and model interactions between light, the people, and the one-way mirror to explain why the music student and the teacher all see the music student. We realize that a little light reflects off the teacher and enters the student's eyes, which makes us wonder why the student doesn't see the teacher. We figure out these things: When light reflects off the music student and travels to the one-way mirror, about half of the light reflects off the silver structures back to the student's eyes and the other half transmits through the transparent parts to the teacher's eyes. The light that transmits through the one way mirror reflects off the teacher and travels to the one-way mirror. About half of that light reflects off the silver structures back to the teacher's eyes and the other half transmits through the transparent parts to the student's eyes.
- **Lesson 6: Why does the music student not see the teacher? (2 class periods)**
  - CK-12 Life Science for Middle School: 11. Human Biology
    - 11.47 Vision
  - In this lesson, we know that light has reflected off the teacher and enters the student's eyes. We wonder why the student can't see her. To figure this out, we obtain more information about what happens when light enters the eye. We model how light inputs transform into signals that the brain processes to tell us what we see. We think about experiences from our everyday lives to help us explain why we only see some inputs of light better than other inputs. We figure out: Light changes direction (refracts) when it travels between different transparent materials. When a light input is detected by sense receptors in our eye, it is turned into a signal that travels along the optic nerve to the brain, which processes it into what we see. When there are multiple inputs, the brain responds to the strongest signal.
- **Lesson 7: Why do the music student and the teacher see the music student but the music student can't see the teacher?(1 class period)**
  - CK-12 Life Science for Middle School: 11. Human Biology
    - 11.48 Eyes
  - We review the class models from Lessons 5 and 6, the class science ideas list, and our individual Progress Trackers. We develop a written explanation to answer the question: Why does the teacher see the music student? We individually draft an explanation to answer the question: Why does the music student see himself but not the teacher? We self-assess our

explanations and give and receive peer feedback on them. We then revise a final explanation. We figure out: The music student sees himself because light reflects off the music student to the one-way mirror and reflects back to his eyes. This light input is the strongest signal that is processed by his brain. The teacher sees the music student because light reflects off the music student to the one way mirror and transmits through the one-way mirror to her eyes. This light input is the strongest signal that is processed by her brain. The music student can't see the teacher and the teacher can't see her reflection because the light inputs from those objects are weaker and the brain doesn't respond to them.

- **Lesson 8: Why do we sometimes see different things when looking at the same object? (3 class periods)**
  - CK-12 Life Science for Middle School: 11. Human Biology
    - 11.49 Vision Correction
  - We investigate the best light conditions for the one way mirror phenomenon to occur and decide the effect is greatest when there is a large difference in light on both sides of the material. We use this idea to investigate related phenomena. We conclude that other materials, like glass, can act like one-way mirrors in situations in which there is a similar light differential on either side of the material. We use our model and science ideas to demonstrate what we have learned on an assessment. We revisit the DQB to document the questions we have answered in the unit and to reflect on our learning. We figure out these ideas: Differences in light on either side of an object or material can cause us to see different things when looking at the same object or material. The brighter or more prominent an object appears, the more light that reaches our eyes from the object.

Unit Learning Goal and Scale *(Level 2.0 reflects a minimal level of proficiency)*	
Standard(s): MS-PS4-2 Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.	
4.0	• Student consistently develops accurate and detailed models that clearly describe how waves (including light) interact with different materials.- Models include labels and annotations that effectively illustrate reflection, absorption, and transmission of waves.- Student demonstrates a deep understanding of how materials affect wave behavior and accurately predicts outcomes based on the model.
3.0	• Students develop models that generally describe how waves interact with materials, with some accuracy and detail. Models include labels and some annotations to illustrate reflection, absorption, and transmission of waves. Students show understanding of how materials affect wave behavior and makes reasonable predictions based on the model.
2.0	• Student develops basic models that partially describe how waves interact with materials, with limited accuracy and detail.- Models include minimal labels or annotations to illustrate reflection, absorption, and transmission of waves.- Student demonstrates some understanding of how materials affect wave behavior but struggles to make accurate predictions based on the model.
1.0	• Student attempts to develop a model but does not effectively describe how waves interact with materials.- Model lacks labels and annotations or does not illustrate reflection, absorption, and transmission of waves.- Student shows limited understanding of how materials affect wave behavior and cannot make accurate predictions based on the model.
0.0	• Student does not attempt to develop a model to describe how waves interact with materials.- No evidence of understanding or effort related to the standard.

Standard(s): MS-LS1-8 Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories.	
4.0	• Student consistently gathers and synthesizes information from multiple credible sources about sensory receptors and their responses to stimuli.- Information is thorough, accurate, and effectively communicates how sensory receptors send messages to the brain for immediate behavior or storage as memories.- Student demonstrates a deep understanding of the topic and effectively evaluates the credibility and bias of sources.
3.0	• Student gathers and synthesizes information from multiple sources about sensory receptors and their responses to stimuli, with mostly accurate information.- Information generally communicates how sensory receptors send messages to the brain for immediate behavior or storage as memories.- Student shows understanding of the topic and evaluates the credibility and bias of sources with some effectiveness.
2.0	• Student gathers limited information from sources about sensory receptors and their responses to stimuli, with some inaccuracies.- Information provides basic understanding of how sensory receptors send messages to the brain for immediate behavior or storage as memories.- Student demonstrates partial understanding of the topic and struggles to evaluate the credibility and bias of sources.
1.0	• Student attempts to gather information but does not effectively synthesize or provide accurate information about sensory receptors and their responses to stimuli.- Information is unclear or incomplete about how sensory receptors send messages to the brain for immediate behavior or storage as memories.- Student shows limited understanding of the topic and does not effectively evaluate the credibility or bias of sources.
0.0	• Student does not attempt to gather or synthesize information about sensory receptors and their responses to stimuli.- No evidence of understanding or effort related to the standard.

Unit Modifications for Special Population Students	
Advanced Learners	CK-12 Extended Reading Material - CK-12 Physical Science for Middle School and Extra Practice
Struggling Learners	Use L1 Differentiated Instruction Activities Flexi 2.0 CK-12 Assistant
Multilingual Learners	OpenSciEd Translated Activities for Multilingual Learners CK12 Translated
Special Needs Learners	Follow IEP modifications and work with special education teachers to make modifications and use L1 Differentiated Instruction Activities.
Learners with a 504	CK-12 Extended Reading Material - CK-12 Physical Science for Middle School and Extra Practice

Unit Title: Physical Science 6.2 Thermal Energy

Unit Description: What keeps different cups or containers from warming up or cooling down? Students begin this 6th grade science unit by experimenting whether a new plastic cup sold by a store keeps a drink colder for longer than the regular plastic cup that comes free with the drink. Students find that the drink in the regular cup warms up more than the drink in the special cup. This prompts students to identify features of the cups that are different, such as the lid, walls, and hole for the straw, that might explain why one drink warms up more than the other.

In this 6th grade science unit, students investigate the different cup features they conjecture to explain the phenomenon, starting with the lid. They model how matter can enter or exit the cup via evaporation. However, they find that in a completely closed system, the liquid inside the cup still changes temperature. This motivates the need to trace the transfer of energy into the drink as it warms up. Through a series of lab investigations and simulations, students find two ways to transfer energy into the drink: (1) the absorption of light and (2) thermal energy from the warmer air around the drink. They are then challenged to design their own drink container that can perform as well as the store-bought container, following a set of design criteria and constraints.

Unit Duration: 37 days total

Desired Results

Standard(s):

- MS-PS1-4
  - Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.
- MS-PS3-3
  - Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.
- MS-PS3-4
  - Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample.
- 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.
- MS-PS4-2
  - Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.
- MS-ETS1-4
  - Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

Indicator(s): The Disciplinary Core Ideas (DCIs), Science and Engineering Practices (SEPs), and Crosscutting Concepts (CCCs) for the specified NGSS Standards:

MS-PS1-4

- **DCI:** PS1.A: Structure and Properties of Matter and PS1.B: Chemical Reactions
  - Gasses and liquids are made of molecules or inert atoms that are moving about relative to each other.
  - The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter.
- **SEP:** Developing and Using Models
  - Develop a model to predict and/or describe phenomena.
- **CCC:** Cause and Effect
  - Cause and effect relationships may be used to predict phenomena in natural or designed systems.

MS-PS3-3

- **DCI:** PS3.A: Definitions of Energy and PS3.B: Conservation of Energy and Energy Transfer

- ○ Temperature is a measure of the average kinetic energy of particles of matter. The relationships between the temperature and the total energy of a system depend on the types, states, and amounts of matter present.
- ○ Energy is spontaneously transferred out of hotter regions or objects and into colder ones.

- **SEP:** Constructing Explanations and Designing Solutions
  - Apply scientific ideas or principles to design, construct, and test a design of an object, tool, process, or system.
- **CCC:** Energy and Matter
  - The transfer of energy can be tracked as energy flows through a designed or natural system.

MS-PS3-4

- **DCI:** PS3.A: Definitions of Energy and PS3.B: Conservation of Energy and Energy Transfer
  - The term "heat" as used in everyday language refers both to thermal energy (the motion of atoms or molecules within a substance) and the transfer of that thermal energy from one object to another.
  - Energy is spontaneously transferred out of hotter regions or objects and into colder ones.
- **SEP:** Planning and Carrying Out Investigations
  - Plan an investigation individually and collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered.
- **CCC:** Scale, Proportion, and Quantity
  - Proportional relationships (e.g., speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes.

MS-PS3-5

- **DCI: PS3.B:** Conservation of Energy and Energy Transfer
  - When the motion energy of an object changes, there is inevitably some other change in energy at the same time.
- **SEP: Engaging in Argument from Evidence**
  - Construct, use, and present oral and written arguments supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon.
- **CCC: Energy and Matter**
  - Energy may take different forms (e.g., energy in fields, thermal energy, energy of motion).

MS-PS4-2

- **DCI: PS4.A:** Wave Properties and **PS4.B:** Electromagnetic Radiation
  - A sound wave needs a medium through which it is transmitted.
  - When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of the light.
- **SEP: Developing and Using Models**
  - Develop and use a model to describe phenomena.
- **CCC: Structure and Function**
  - Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used.

MS-ETS1-4

- **DCI: ETS1.B:** Developing Possible Solutions
  - A solution needs to be tested, and then modified on the basis of the test results, in order to improve it.
- **SEP: Developing and Using Models**
  - Develop a model to generate data to test ideas about designed systems, including those representing inputs and outputs.
- **CCC: Systems and System Models**
  - Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems.

Understandings: ● *Students will design, construct, and test a device that maximizes or minimizes thermal energy transfer.*	**Essential Questions:** See Learning Plan Unit Question: How can containers keep stuff from warming up or cooling down?

Students will develop and use models to describe how waves are reflected, absorbed, or transmitted through various materials. *Students will develop models to generate data for iterative testing and modification of a proposed object, tool, or process.*	
Assessment Evidence	
Performance Tasks: (Expectation Activities) **Develop a Model.** Observe and compare the temperature changes of iced drinks in different types of cups (e.g., regular vs. fancy cups). Develop a system model to explain the observed differences in temperature change, considering factors such as cup design and materials. **Experiment.** Plan and conduct investigations to test different cup features (e.g., lids, double walls) for their impact on keeping a drink cold or hot. **Design.** Design, build, and test prototypes of cups with features aimed at improving temperature retention.	**Other Evidence:** **Create a Report.** Students can create a detailed report or presentation summarizing their findings from the investigations and experiments. **Develop a Diagram.** Students can develop a visual model or diagram that illustrates how various cup features (e.g., lids, double walls) impact temperature changes. **Design an Experiment.** Students can design and carry out their own experiment to test a new variable related to cup temperature retention, such as different types of insulation or materials.
Benchmarks: Unit 6.2 Common Assessment	
Learning Plan	

Learning Activities

- **Lesson 1: Why does the temperature of the liquid in some cup systems change more than in others? (3 class periods)**
  - CK-12 Physical Science for Middle School: 2. Matter and Change
    - 2.11 States of Matter, 2.12 Solid, 2.13 Liquid, and 2.14 Gas.
  - We observe an iced drink in a regular cup warming up more quickly compared with an iced drink in a fancy cup. We develop systems models to explain what is happening in the two cups that one can better maintain the temperature of the drink. We brainstorm related phenomena and ask questions about design features that influence how well an object can keep something hot or cold. We figure out: The cup system includes the different parts of the cup and the water and air inside the cup. All of these parts work together (interact) to form the system. Some systems have structural features that help maintain the temperature of a substance inside the system, keeping the substance hot or cold longer compared with other systems. Heat can enter the cup system and/or cold can leave the cup system, and maybe gases can escape the system too.
- **Lesson 2: What cup features seem most important for keeping a drink cold? (2 class periods)**
  - CK-12 Physical Science for Middle School: 2. Matter and Change
    - 2.16 Kinetic Theory of Matter
  - We plan and carry out an investigation to figure out 2 things. First, what cup features are important for keeping a drink cold? Second, how would changing the cup features cause the drink to warm up faster? We collect, organize, and publicly analyze data from our investigation to identify patterns to determine which cup features help maintain a drink's temperature. We figure out: Some systems have structural features that are designed to help maintain the temperature of a substance inside the system. The cup features that seem to play a significant role in keeping a drink cold are a lid, double walls, and maybe the type of cup material.
- **Lesson 3: How are the cup features that keep things cold the same or different for keeping things hot? (2 class periods)**

- CK-12 Physical Science for Middle School: 2. Matter and Change
  - 2.17 Change of State
- We look at the order of cups based on their ability to keep liquids cold. We investigate whether these same features are able to keep liquids hot. Based on our findings, we revise our explanation from Lesson 1 to explain how particular cup features help to keep liquids hot and/or cold. We ask additional questions about the cup features now that we know more. We then design an experiment to investigate our questions and ideas about how the lid works. We figure out: Cups that can keep liquids cold are also able to keep liquids hot. Cups with lids are able to keep liquids hot and cold better than cups without lids. Cups with more walls or layers will be able to keep liquids hot and cold better than cups without lids.

- **Lesson 4: How does a lid affect what happens to the liquid in the cup? (3 class periods)**
  - CK-12 Physical Science for Middle School: 2. Matter and Change
    - 2.18 Freezing, 2.19 Melting, 2.20 Boiling,
  - We plan and carry out investigations to determine the effect of a lid on temperature change and mass change of a hot liquid in a cup. We calculate the mean for two cup systems to compare the temperature drop and mass change in each condition. We develop and use a particulate model of liquids and gases to explain the mass loss in an open system. We figure out: The lid helps to maintain the temperature of a hot liquid inside the cup and it slows down matter loss from the system. Liquids and gases are made of particles. Particles in gas have a lot of space between them but those in liquids do not. The smallest particle of water is a molecule. Molecules of water in liquid go into gas over time (evaporation). An open system has space for matter to enter or exit. A closed system is one in which no matter can enter or exit. The hot liquid cools down even when we prevent most matter from leaving the cup system by using a lid.
- **Lesson 5: Where does the water on the outside of the cold cup system come from? (1 class period)**
  - CK-12 Physical Science for Middle School: 2. Matter and Change
    - 2.22 Condensation
  - We construct an investigation to support or refute the claim that the formation of water droplets (condensation) on the outside of a cup of cold water comes from water leaking through the cup walls. We measure the mass of a cup of cold water before and after condensation forms on the outside. We also observe condensation on the outside of a cup of cold water that has been dyed using food coloring. We use our observations and data to construct an argument to refute the claim that water droplets on the outside of the cup come from inside the cup system. The water droplets that form on the outside of a cup of cold water come from the air outside the cup, not from the inside of the cup. Water droplets often condense on a cold surface when humid air comes in contact with the surface. Liquids do not move through solids. Matter does not enter or leave a closed system; therefore, the mass of a closed system does not change.
- **Lesson 6: How can we explain the effect of a lid on what happens to the liquid in the cup over time? (2 class periods)**
  - CK-12 Physical Science for Middle School: 2. Matter and Change
    - 2.21 Evaporation
  - We use a model to show why water molecules cannot leave the cup at some points in the cup system but can at other points. We complete an individual assessment that includes making predictions about whether a cup with a new lid design will keep a drink cooler than a cup with an old lid design, developing a plan for collecting data to see if the amount of liquid changed in either cup over time and developing a model to explain why one cup system would lose more mass than another. We figure out these things: Liquids, gases, and solids are made of particles of matter. Particles in a gas have a lot of space between them, but particles in liquids and solids do not. Liquids and gases are made of particles that can move around freely, but solids are made of particles that cannot.
- **Lesson 7: If matter cannot enter or exit a closed system, how does a liquid in the system change temperature? (1 class period)**
  - CK-12 Physical Science for Middle School: 15. Thermal Energy and Heat
    - 15.1 Thermal Energy
  - We consider what we know about the components (or structures) of the closed cup system, how they function, and how they interact with one another and with other objects and substances outside of

the cup system to determine what else might cause a temperature change in the liquid inside. We develop models to represent our ideas about interactions between energy (light, heat, or cold) and the closed cup system. We use these models to explain the temperature change, and we determine ways to test our ideas to figure out how energy interacts with the closed cup system. We figure out: Since most of the matter does not enter or leave the cup system with a lid, light and heat or cold may interact with the system to cause a temperature change in the liquid inside. *note: students will likely use “heat waves” as an initial representation for heat, and this is OK at this point in the unit. From lessons 8-14, students develop their understanding of heat, and the way they represent it in their models.

- **Lesson 8: How does a cup’s surface affect how light warms up a liquid inside the cup? (2 class periods)**
  - We carry out an investigation to test the interaction between light and the cup surface in warming up the cold water inside the cups. We shine light on cups with walls of different materials and colors and measure the amount of incoming, reflected, and transmitted light, and we also place some cups in a completely dark condition. We figure out that the water in all the cups warms up, even the cups in the dark condition, but it warms up more in the cups in the light conditions. We wonder about additional mechanisms by which the water inside the cups warms up.. We figure out: Light can transfer energy into a system. When light that shines on a surface is not reflected or transmitted, it is absorbed, which warms the matter it shines on. Temperature changes in the water can still occur even if light does not transmit through the cup wall and even if there’s no light.
- **Lesson 9: How does the temperature of a liquid on one side of a cup wall affect the temperature of a liquid on the other side of the wall? (1 class period)**
  - CK-12 Physical Science for Middle School: 15. Thermal Energy and Heat
    - 15.5 Conduction, 15.6 Convection, 15.7 Thermal Radiation
  - We brainstorm how to test whether heat or cold is entering or leaving a cup system. We plan and carry out an investigation to place the cup in a water bath and measure the temperature inside and outside the cup to see if heat or cold is moving between the two systems. We figure out that when there is a temperature change inside the cup system, there is also a temperature change outside the system. We conclude that heat or cold moves through the cup wall and that the greater the temperature difference between the cup and water bath systems, the more energy is transferred between the two. We figure out: When the temperature of a sample of matter in one system decreases, the temperature of the matter in the neighboring system increases. When the temperature difference between two neighboring systems is great, more energy transfers between them. Heat or cold can move through the wall of the cup system.
- **Lesson 10: What is the difference between a hot and a cold liquid? (2 class periods)**
  - CK-12 Physical Science for Middle School: 15. Thermal Energy and Heat
    - 15.2 Temperature and 15.3 Heat
  - We investigate the differences between hot and cold liquids at the particle scale. A video showing candy dissolving in hot, warm, and cold water motivates us to investigate how water behaves differently at varying temperatures by adding food coloring to hot, room-temperature, and cold water. After collecting qualitative evidence that correlates movement in water to temperature, we read about a historical study supporting the idea that movement of water particles and temperature are closely connected. All three sources of information reinforce the ideas that (1) liquids are made of particles and (2) particles move more when a liquid is hotter and less when it is colder. We figure out that: The movement of particles is related to the temperature of the water, with particles in colder water moving less than particles in hotter water.
- **Lesson 11: Why do particles move more in hot liquids? (1 class period)**
  - CK-12 Physical Science for Middle School: 14. Introduction to Energy
    - 14.2 Kinetic Energy
  - We wonder what happened in the Food Coloring Lab at the particle scale and how this relates to energy. We make observations from a simulation and obtain evidence that hot liquids have particles that move faster and cold liquids have particles that move slower. We call this energy of movement kinetic energy. We spray perfume on one side of the classroom and smell it on the other side, evidence that particles in gas move freely like particles in liquids. We use new ideas about kinetic energy to explain our previous lab observations. We revisit our original iced drink warming up in the regular plastic cup and wonder where the kinetic energy came from. We figure out: A particle’s

speed is related to how much kinetic energy it has. The particles in hot liquids and gases have more kinetic energy than the particles in cold liquids and gases. Liquids and gases are made of particles that can move around freely.

- **Lesson 12: How does the motion of particles compare in a sample of matter at a given temperature? (2 class periods)**
  - CK-12 Physical Science for Middle School: 15. Thermal Energy and Heat
    - 15.8 Thermal Conductors and Insulators
  - We use a simulation to investigate how individual particles in a sample of gas do not have the same kinetic energy, and how the kinetic energy of each particle is constantly changing as they collide with one another. We argue that temperature is a measure of the average speed of the particles in a sample of matter, and that the total energy of that sample is the sum of the kinetic energy of all the particles in the sample combined. We figure out: Not all particles in a sample of matter have the same kinetic energy. Kinetic energy is transferred from one particle to another in a particle collision. Temperature is a measure of the average kinetic energy of the particles in a sample of matter. The total kinetic energy of a sample of matter is the sum of the kinetic energy of all the particles in that sample. If you add more particles, the total kinetic energy increases but the temperature (the average kinetic energy) might stay the same.
- **Lesson 13: How could the motion of particles on one side of a solid wall affect the motion of the particles on the other side of that wall? (2 class periods)**
  - CK-12 Physical Science for Middle School: 15. Thermal Energy and Heat
    - 15.9 Heating System
  - We use a simulation to analyze particle speeds before and after a collision. We use marbles to investigate the effects of collisions on particle speeds in different situations to simulate interactions between particles in a gas, a liquid, and a solid. We use a simulation to analyze particle interactions in different solids in contact with each other at different temperatures. We figure out these things: Particles in a solid vibrate back and forth in place. Collisions between particles in a solid, liquid, and/or gas can transfer kinetic energy (KE or motion energy) from one particle to another. The more particles in a sample of matter that are in contact with another sample of matter, the greater the amount of particle KE is transferred from the warmer piece of matter to the cooler pieces of matter over time. The more particles an object is made of, the more energy must leave or enter the system in order to change the temperature of that object.
- **Lesson 14: Does our evidence support that cold is leaving the system or that heat is entering the system? (3 class periods)**
  - CK-12 Physical Science for Middle School: 15. Thermal Energy and Heat
    - 15.10 Cold System
  - We sort evidence collected during previous lessons to support or refute claims that temperature changes are due to heat or cold moving into or out of the cup system. We conduct an investigation to collect additional evidence, helping us figure out that heat moves into the cup system, causing a temperature change. We revise our cup system models and apply our new understanding to answer questions from the DQB and explain related phenomena.We figure out: Temperatures change when energy moves from warmer to cooler matter. Energy is transferred when higher-energy particles come into contact with lower energy particles.
- **Lesson 15: How do certain design features slow down to the transfer of energy into a cup? (3 class periods)**
  - CK-12 Physical Science for Middle School: Introduction to Physical Science
    - 1.12 Technological Design Process
  - We learn about the Cold Cup Challenge and look at examples of effective cup designs. We still need to explain how certain features work (i.e., double walls, porous materials, color). We jigsaw the gaps in our knowledge and conduct a gallery walk to share our findings. We reach consensus about mechanisms for energy transfer, which will help us in the design challenge. We figure out: Shiny/ light-colored materials (feature) prevent light from being absorbed. Absorption of light by particles (mechanism) transfers energy to the cup. Porous materials with air pockets (feature) slow down the conduction of energy because there are fewer particles to collide across the air pockets. Conduction of energy from particle collisions (mechanism) transfers energy. A double-walled cup with a vacuum or air between the walls (feature) slows down the conduction of energy because there are fewer or no particles to collide between the walls. This is a similar mechanism as in porous materials.

- **Lesson 16: How can we design a cup system to slow energy transfer into the liquid inside it? (2 class periods)**
    - CK-12 Physical Science for Middle School: 1. Introduction to Physical Science
        - 1.13 Technological Design Constraints
    - We review the Cold Cup Challenge and design our cups, pointing out features we have evidence will slow energy transfer. We build our first cup designs, test them, and evaluate our results compared to the criteria and constraints. We provide feedback to each other to improve our cup designs. We figure out: The more clearly a design task is defined, the more likely the solution (cup system) will meet the criteria and constraints. A designed cup needs to be tested and then modified on the basis of the test results that will help evaluate the solution to how well it meets the criteria and constraints of a problem.
- **Lesson 17: How can we improve our first design to slow energy transfer into the cup system even more? (2 class periods)**
    - We review our test results and feedback from our first design. We clarify the criteria and constraints and then redesign, build, test, and evaluate a new cup. We make observations from the new data to identify the features of the best performing cups. We figure out: Surface materials that reflect more light help cups perform better on the bright light and temperature test. Materials used on the cup walls that reduce the amount of contact between layers help cups perform better on the regular light and temperature test. The use of fewer materials can still be effective on the two temperature tests, while also reducing costs, diameter, and environmental impact.
- **Lesson 18: How can containers keep stuff from warming up or cooling down? (3 class periods)**
    - We review and interpret test results across our best cup designs. We use evidence to offer suggestions as our class works together to design the Ultimate Cold Cup. We generalize our model to explain patterns to minimize or maximize energy transfer, and use our model to predict how energy transfer could be maximized or minimized in everyday examples. Finally, we revisit the Driving Question Board and discuss all of the questions we can now answer. We figure out: The rate of energy transfer between systems speeds up or slows down depending on the number of particle collisions. The rate of energy transfer between matter and light speeds up or slows down depending on how much light is absorbed. The amount of matter in a substance affects the rate of energy transfer and how much energy is needed to increase the substance's temperature.

Unit Learning Goal and Scale *(Level 2.0 reflects a minimal level of proficiency)*	
Standard(s): MS-PS1-4: Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.	
4.0	• Develops a comprehensive and accurate model that clearly predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed. Demonstrates a deep understanding of the relationship between thermal energy and particle behavior.
3.0	• Develops an accurate model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed. Shows a good understanding of the concepts, with minor errors or omissions.
2.0	• Develops a basic model that somewhat predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed. Demonstrates partial understanding of the concepts, with several errors or omissions.

1.0	● Attempts to develop a model but fails to accurately predict or describe changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed. Shows limited understanding of the concepts.
0.0	● Does not attempt to develop a model or the model is completely inaccurate and shows no understanding of the concepts.

Standard(s): MS-PS3-3: Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.	
4.0	● Successfully designs, constructs, and tests a device that effectively minimizes or maximizes thermal energy transfer. Demonstrates a thorough understanding of scientific principles and provides detailed explanations and analyses.
3.0	● Designs, constructs, and tests a device that minimizes or maximizes thermal energy transfer with minor flaws. Shows a good understanding of scientific principles and provides adequate explanations and analyses.
2.0	● Designs and constructs a basic device that somewhat minimizes or maximizes thermal energy transfer. Demonstrates partial understanding of scientific principles, with several errors or incomplete explanations.
1.0	● Attempts to design and construct a device but it does not effectively minimize or maximize thermal energy transfer. Shows limited understanding of scientific principles.
0.0	● Does not attempt to design, construct, or test a device or the attempt is completely ineffective and shows no understanding of the scientific principles.

Standard(s): MS-PS3-4: Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample.	
4.0	● Plans a thorough and detailed investigation that accurately determines the relationships among energy transferred, type of matter, mass, and change in average kinetic energy of particles. Demonstrates a deep understanding of the scientific method and principles.
3.0	● Plans a detailed investigation that determines the relationships among energy transferred, type of matter, mass, and change in average kinetic energy of particles with minor errors. Shows a good understanding of the scientific method and principles.
2.0	● Plans a basic investigation that somewhat determines the relationships among energy transferred, type of matter, mass, and change in average kinetic energy of particles. Demonstrates partial understanding of the scientific method and principles.
1.0	● Attempts to plan an investigation but fails to accurately determine the relationships among energy transferred, type of matter, mass, and change in average kinetic energy of particles. Shows limited understanding of the scientific method and principles.
0.0	● Does not attempt to plan an investigation or the attempt is completely inaccurate and shows no understanding of the scientific method and principles.

Standard(s): 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.

4.0	• Constructs, uses, and presents well-reasoned arguments with strong evidence to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object. Demonstrates a deep understanding of the concepts.
3.0	• Constructs, uses, and presents arguments with sufficient evidence to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object. Shows a good understanding of the concepts.
2.0	• Constructs, uses, and presents basic arguments with limited evidence to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object. Demonstrates partial understanding of the concepts.
1.0	• Attempts to construct and present arguments but fails to provide sufficient evidence or accurately support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object. Shows limited understanding of the concepts.
0.0	• Does not attempt to construct or present arguments or the arguments are completely inaccurate and show no understanding of the concepts.

Standard(s): MS-PS4-2: Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.	
4.0	• Develops and uses a comprehensive and accurate model to describe that waves are reflected, absorbed, or transmitted through various materials. Demonstrates a deep understanding of wave interactions with materials.
3.0	• Develops and uses an accurate model to describe that waves are reflected, absorbed, or transmitted through various materials with minor errors. Shows a good understanding of wave interactions with materials.
2.0	• Develops and uses a basic model to somewhat describe that waves are reflected, absorbed, or transmitted through various materials. Demonstrates partial understanding of wave interactions with materials.
1.0	• Attempts to develop and use a model but fails to accurately describe that waves are reflected, absorbed, or transmitted through various materials. Shows limited understanding of wave interactions with materials.
0.0	• Does not attempt to develop or use a model or the model is completely inaccurate and shows no understanding of wave interactions with materials.

Standard(s): MS-ETS1-4: Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.	
4.0	• Develops a comprehensive and accurate model to generate data for iterative testing and modification of a proposed object, tool, or process, resulting in an optimal design. Demonstrates a deep understanding of the iterative design process.
3.0	• Develops an accurate model to generate data for iterative testing and modification of a proposed object, tool, or process with minor errors, resulting in a good design. Shows a good understanding of the iterative design process.
2.0	• Develops a basic model to generate data for iterative testing and modification of a proposed object, tool, or process, resulting in a satisfactory design. Demonstrates partial understanding of the iterative design process.

1.0	• Attempts to develop a model but fails to generate useful data for iterative testing and modification of a proposed object, tool, or process, resulting in a poor design. Shows limited understanding of the iterative design process.
0.0	• Does not attempt to develop a model or the model is completely inaccurate and shows no understanding of the iterative design process.

Unit Title: Earth and Space Science 6.3 Weather, Climate, & Water Cycling

Unit Description: This 6th grade science unit on weather, climate, and water cycling is organized into four lesson sets. The first two sets examine small-scale storms, while the third and fourth sets explore mesoscale weather systems and large-scale precipitation patterns. Each segment of the unit is centered around different anchoring phenomena.

The unit starts by engaging students with videos of hailstorms from various locations and times of the year. These videos show ice of different sizes falling from the sky, sometimes accompanied by rain and wind, even when the temperature stays above freezing. This phenomenon prompts students to investigate questions such as how ice can fall on warm days, how clouds form, why some clouds produce heavy storms while others do not, and how water enters the atmosphere.

In the second half of the unit, students analyze a weather report about a winter storm that affected the midwestern United States. Through maps, transcripts, and videos, students learn that the storm was expected to bring significant snow and ice to the northeastern part of the country within a day. This leads students to explore questions about the causes of large-scale storms and their movement across different regions.

Unit Duration: 42 days total

Desired Results

Standard(s):

- MS-ESS2-4
  - Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity.
- MS-ESS2-5
  - Collect data to provide evidence for how the motions and complex interactions of air masses result in changes in weather conditions.
- MS-ESS2-6
  - Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates.
- MS-PS1-4
  - Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.

Indicator(s): The Disciplinary Core Ideas (DCIs), Science and Engineering Practices (SEPs), and Crosscutting Concepts (CCCs) for the specified NGSS Standards:

MS-ESS2-4

- **DCI:** ESS2.C: The Roles of Water in Earth's Surface Processes
  -
- **SEP:** Developing and Using Models
  - Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity.
- **CCC:** Systems and System Models:
  - Systems can be used to model the interactions and dynamics of Earth's water cycle.

MS-ESS2-5

- **DCI:** ESS2.D: Weather and Climate
  -
- **SEP:** Analyzing and Interpreting Data:
  - Collect and analyze data to provide evidence for how the motions and complex interactions of air masses result in changes in weather conditions.
- **CCC:** Patterns
  - Weather patterns and their changes can be observed and analyzed through data.

MS-ESS2-6

- **DCI:** ESS2.D: Weather and Climate

- SEP: Developing and Using Models
    - Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates.
- **CCC:** Systems and System Models
    - Models help explain the global patterns of atmospheric and oceanic circulation.

MS-PS1-4

- **DCI:** PS1.A: Structure and Properties of Matter
- **SEP:** Developing and Using Models:
    - Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.
- **CCC:** Systems and System Models
    - Models can represent the interactions of particles and the effects of thermal energy on their motion and states.

Understandings:

- *Students will investigate different types of precipitation and the conditions leading to their formation, including the roles of temperature, humidity, and cloud movement.*
- *Students will analyze how temperature and humidity variations affect air density and movement, and understand their impact on atmospheric conditions and weather phenomena.*
- *Students will explore the interactions of air masses at frontal boundaries and their influence on weather and precipitation, while examining global patterns in air movement and ocean currents to predict weather events.*

Essential Questions: See Learning Plan

Unit Question: Why does a lot of hail, rain, or snow fall at some times and not others?

Assessment Evidence

Performance Tasks: (Expectation Activities)

- **Create a Model**: Create a simple model to show how different weather conditions, like temperature and wind, might be related to hail.
- **Experiment**: Look at pictures of hailstones and read about hailstorms. Find out what factors, like temperature and humidity, might make hail more likely, and how these conditions vary in different places and seasons.
- **Essay**: Examine temperature readings from different heights in the atmosphere. Understand how air temperature changes with altitude and how this affects the movement of air particles.

Other Evidence:

- **Interactive Digital Presentations**: Students can create digital presentations or slideshows using tools like PowerPoint or Google Slides to showcase their understanding.
- **Classroom Exhibits**: Students can design and set up a small exhibit or poster board in the classroom that displays their research and findings. This can include models, diagrams, and key information about their topic.
- **Concept Maps**: Students can develop concept maps that visually organize and represent the relationships between different weather phenomena, temperature changes, and air mass interactions..

Benchmarks: Unit 6.3 Common Assessment

Learning Plan

Learning Activities

- **Lesson 1: What causes this kind of precipitation event to occur? (3 class periods)**
  - CK-12 Earth Science for Middle School: 11. Weather
    - 11.1 Introduction to Weather and 11.5 Precipitation
  - We observe three video clips of hail falling in different areas of the United States on different days. We develop a model to try to explain what causes this to occur. We develop questions for our Driving Question Board (DQB) about the mechanisms that cause different kinds of precipitation events. We brainstorm investigations we could do and sources of data that could help us figure out answers to our questions. We figure out these things: Rain and wind accompany some hail events. Some of the water that reaches the ground reached a low enough temperature to freeze, at some point, before it fell. Clouds can be seen moving into and out of the area where it hailed. Cloud movement in the sky, moving air (wind) at Earth's surface, and temperature may be related to why, where, and when different forms of precipitation fall.
- **Lesson 2: What are the conditions like on days when it hails? (1.5 class periods)**
  - CK-12 Earth Science for Middle School: 11. Weather
    - 11.2 Humidity
  - We examine photos of hailstones and analyze and interpret data from cases of hail events at different locations and times of year to notice patterns and identify relevant factors that might explain the formation of hail. We figure out these things: Hailstones are made of ice, often in layers. Hailstorms are more common in the central United States, with fewer events in the west. The days that have hail also have relatively warm air temperatures (mostly in the 50–90℉ range, which is above the melting/freezing point of water) and relative humidity in the range of 37–96 percent. Hailstorms happens later in the day in the spring, summer, and fall. They impact a small area (20-60 square miles).
- **Lesson 3: How does the air higher up compare to the air near the ground? (1.5 class periods)**
  - CK-12 Earth Science for Middle School: 10. Atmospheric Processes
    - 10.1 Importance of the Atmosphere, 10.2 Composition of the Atmosphere, and 10.4 Temperature of the Atmosphere
  - We analyze and interpret temperature profiles of the atmosphere collected from weather balloons at various altitudes at different locations during different times of the year. We develop a consensus model for representing the motion of the molecules that make up air at different temperatures. We figure out these things: Regardless of the season, the temperature of the air always decreases as you move away from Earth's surface and higher into the atmosphere. The air temperature at very high altitudes (approx. 40,000 ft) is coldest in winter. When the temperature of the air increases, the speed of the molecules that make up air increases, and when the temperature of the air decreases, the speed of the molecules that make up air decreases.
- **Lesson 4: Why is the air near the ground warmer than the air higher up? (2.5 class periods)**
  - CK-12 Earth Science for Middle School: 10. Atmospheric Processes
    - 10.10 Solar Energy on Earth and 10.13 Solar Energy and Latitude.
  - We plan and carry out an investigation to figure out what causes the air above different ground surfaces to be warmer than the air higher in the atmosphere. We measure the temperature of the air at different ground surfaces, the air temperature above those surfaces, and the amount of sunlight reaching and reflecting off those surfaces. We figure out these things: Energy from the Sun is absorbed by the ground, which then increases the kinetic energy (and therefore temperature) of the particles in the ground. Different surfaces heat up differently depending on how much energy from the Sun is absorbed. As particles in the air come into contact with the ground, energy is transferred to those particles through conduction. On a sunny day, air temperatures above the ground are cooler than the ground itself.
- **Lesson 5: What happens to the air near the ground when it is warmed up? (2.5 class periods)**
  - CK-12 Earth Science for Middle School: 10. Atmospheric Processes
    - 10.3 Pressure and Density of the Atmosphere
  - We conduct an investigation to figure out how transferring thermal energy into and out of a parcel of air in a closed system (a bottle of air with a soap bubble film over the top) affects that air's volume and behavior. We conduct a second investigation to observe how density changes in a parcel of air (in a balloon) cause it to float or sink in the surrounding air. For each investigation, we develop a model to represent how the speed, spacing, and density of the molecules that make up air are affected by temperature changes. We figure out these things: Changing the temperature of a parcel

of air causes changes in the air's density due to changes in the kinetic energy (speed) and spacing of the molecules that make up the air. Parcels of air that are less dense than the surrounding air rise. Parcels of air that are more dense than the surrounding air sink. As they rise, parcels of warm, less dense air eventually cool off, transferring thermal energy to the surrounding air.

- **Lesson 6: How can we explain the movement of air in a hail cloud? (2 class periods)**
  - CK-12 Earth Science for Middle School: 11. Weather
    - 11.3 Clouds
  - We examine photos and a video of clouds that produce hail to look for patterns in the motion of air. We construct an explanation using evidence for the path of air movement below, within, and at the top of a cloud that tends to form hail. We figure out: Air near the surface of the ground is warmed from thermal energy transfer from the ground through conduction. The warm air near the ground becomes less dense than the surrounding air and rises. Eventually, the warm air transfers its energy to the surrounding air, becoming just as cold and dense as the air around it, and it stops rising. If that air becomes even cooler than the surrounding air, it sinks. This type of air movement happens more on sunny days because the air right above the ground gets warmed up more by light from the Sun on those days. Air is a mixture of different types of substances) in the gas state including water vapor which is measured as humidity.
- **Lesson 7: Where did all that water in the air come from, and how did it get into the air? (2 class periods)**
  - CK-12 Earth Science for Middle School: 11. Weather
    - 11.2 Humidity and 8.3 The Water Cycle
  - We plan and carry out an investigation to determine where the water in the air comes from by measuring the humidity in the air over samples of different Earth surfaces. We figure out these things: Water can go into the air (increasing its humidity) from many different types of surfaces with water in or on them. When individual water molecules on the surface of a liquid gain enough motion energy (kinetic energy), they leave the liquid to become a gas; this process is called evaporation.
- **Lesson 8: What happens to water vapor in the air if we cool the air down, and why? (2 class periods)**
  - CK-12 Earth Science for Middle School: 11. Weather
    - 11.3 Clouds
  - We carry out investigations to explore what happens when air containing water vapor is cooled and what happens when water droplets make contact with each other. We use magnetic marbles to develop a model for how mutual attraction between water molecules and changes in their speed cause water to change from gas to liquid when it cools below a certain temperature. Water molecules are attracted to each other. When they are moving fast enough, they can break away from each other and bounce off each other. When they are moving slow enough, they clump and stick together. Water droplets can grow over time as they run into other water droplets or as more molecules of water vapor condense and stick to them. When water is below a certain temperature (its condensation/boiling point), the molecules are moving slow enough to remain in liquid form; when water is above that temperature, the molecules are moving fast enough to remain in gas form; they change state when cooled below or heated above that temperature.
- **Lesson 9: Why don't we see clouds everywhere in the air, and what is a cloud made of? (1 class period)**
  - CK-12 Earth Science for Middle School: 11. Weather
    - 11.3 Clouds
  - We read about what clouds are made of, why we can see them, the role of cloud condensation nuclei, and methods of cloud seeding. We argue that what happens in clouds is similar to what we see happen on the surface of a cold gel pack over humid air in our 2-L bottles. We figure out these things: Clouds are made of water droplets and/or ice crystals and molecules of gas (including water vapor). We see clouds because the water droplets or crystals in them reflect and scatter or absorb a noticeable amount of light. For molecules of water vapor in the air to start the condensation or deposition process, the air has to reach 100% humidity and then be cooled. The water vapor also needs a solid surface to stick to. In the air, these surfaces are cloud condensation nuclei (small, solid particles).
- **Lesson 10: Why do clouds or storms form at some times but not others? (2 class periods)**
  - CK-12 Earth Science for Middle School: 11. Weather

        - 11.7 Fronts and 11.8 Thunderstorms
    - We use our Gotta-Have-It Checklist to test and revise a thunderstorm simulation to produce larger and smaller storms. We focus on temperature and humidity conditions that are likely to produce storms. We think about what additional features we would like to include in the simulation and we design interfaces for those features. We figure out these things: A greater difference between near-ground and atmospheric temperatures is correlated with larger storm development. Higher humidity is correlated with stronger storms. Simulations are models that can represent only parts of a system, which limits their use.
- **Lesson 11: Why don't water droplets or ice crystals fall from the clouds all the time? (2 class periods)**
    - CK-12 Earth Science for Middle School: 11. Weather
        - 11.6 Air Masses
    - We try to lift or suspend different objects with air blown upward, and we record the weight of different objects and the amount of force registered when air is blown toward or away from a digital scale. We develop a model to show how objects might be lifted, fall, or remain suspended in the air depending on the relative strength of two different forces acting on them. We record the air pressure using a homemade barometer and record the cloud cover and precipitation outside. We figure out these things: The more mass something has, the greater the force of gravity pulling down on it (which can be measured as its weight on a scale). Moving air (wind) pushes (exerts a force on) matter in its path. Air moving upward (updrafts) can keep an object suspended or floating in the air when the force from the molecules in that air colliding with that object counterbalances the downward force from gravity. When those forces are no longer balanced, the object that was suspended will start moving upward or downward. A barometer can detect changes in the density of the air outside of it.
- **Lesson 12: What causes more lift in one cloud versus another? (2 class periods)**
    - CK-12 Physical Science for Middle School: 2. Matter and Change
        - 2.1 Mass, Volume, Density
    - We plan and carry out an investigation to determine what variables affect the amount of lift produced in a fluid. We explain how the results of our investigation help us understand how differences between air and ground temperatures can cause different amounts of lift and movement of air. We figure out these things: When one spot in a fluid heats up, it becomes less dense, which causes it to rise. When it cools down, it becomes more dense and sinks. This leads to circular motion in fluids, called convection. The greater the thermal energy input into the fluid, the stronger the lift or convection currents. The more of Earth's surface that is in contact with the air above it, the more thermal energy it can transfer to that air. Some winds are the result of this convection. Air at the surface moves toward an area where warmed air rose, filling in the space left behind.
- **Lesson 13: Why do some storms produce (really big) hail and others don't? (3 class periods)**
    - CK-12 Earth Science for Middle School: 11. Weather
        - 11.12 Blizzards
    - We add to our Gotta-Have-It checklist and develop a final model to explain why some storms produce hail. We revisit the DQB and discuss the questions that we have now answered. We apply our understanding to a new phenomenon (hurricanes) and individually take an assessment.
- **Lesson 14: What causes a large-scale precipitation event like this to occur? (2 class periods)**
    - CK-12 Earth Science for Middle School: 11. Weather
        - 11.14 and 11.15 Predicting Weather
    - We explore video and maps from three parts of a weather report and forecast from Jan. 19, 2019. We develop a model to explain how what was happening in one part of the country at one point in time can be connected to what is predicted to happen in another part of the country over a day later. We develop questions for our Driving Question Board (DQB). We brainstorm ways we could investigate these questions. We will figure out these ideas: Some storms are very large (hundreds of miles across) and can last for many days. These large-scale storms can produce different types and amounts of precipitation over different areas. Many of the mechanisms we used to explain small-scale precipitation events seem like they could be relevant to explaining large-scale storms too. Large-scale storms also may have something to do with large areas of cold air and warm air moving over great distances.
- **Lesson 15: What happens with temperature and humidity of air in large storms? (2 class periods)**
    - CK-12 Earth Science for Middle School: 11. Weather

        - 11.6 Air Masses and 11.7 Fronts
    - In this lesson we use temperature, humidity, and radar data across eight-hour increments during the timeline of the storm to track the movement of air and precipitation. We consider how air moves horizontally in large parcels, called air masses, and we also notice that precipitation and storms develop where air masses of different characteristics meet. As a class, we develop different ways of representing what is happening with warm air and cold air across the land. We figure out these ideas: Air masses are large parcels of air (hundreds of miles wide) with similar characteristics (e.g., temperature, humidity). Air masses move horizontally, such as from west to east across the United States. Storms and precipitation can develop where two air masses with different characteristics meet; this boundary is called a front.
- **Lesson 16: How do warm air masses and cold air masses interact along the boundaries between them? (2 class periods)**
    - We carry out an investigation to explore what happens along a frontal boundary where warm air and cold air meet. We develop models to describe interactions between warm and cold air masses and use patterns in data to explain changes in precipitation that can occur when air masses collide. We figure out: When a warm air mass moves toward a cold air mass, the warm air slides over the cold air. When a cold air mass moves toward a warm air mass, the cold air pushes into and below the warm air, pushing it up and over. Both interactions cause predictable changes in weather. The maximum amount of water vapor that air at a given temperature can hold is referred to as 100% relative humidity. The maximum amount of water vapor that can be in the air changes based on the temperature of the air; warmer air can hold more water vapor than colder air. Cooling air at 100% relative humidity will cause water vapor to condense out of the air; the greater the decrease in air temperature, the greater the amount of water vapor that will condense out of it.
- **Lesson 17: Is there a relationship between where the air is rising and where precipitation falls? (1 class period)**
    - CK-12 Earth Science for Middle School:
        - 11.16 Weather Maps 11. Weather
    - We analyze national pressure maps from around the time of the original forecast. We construct an explanation of the patterns we notice among (1) the area of lowest air pressure, (2) the locations of the fronts, and (3) where precipitation would fall. We apply scientific ideas to explain what is causing these three things to be connected to one another. We will figure out these ideas: When the air pressure outside decreases, it tends to correspond with the appearance of cloudier skies and in some cases precipitation. Large-scale, low-pressure air masses can move and their movement can be predicted. The movement and location of warm and cold fronts appear to be connected to this low pressure center. Precipitation tends to fall along the line of the cold front and warm front and behind the low pressure center.
- **Lesson 18: How can we explain what is happening across this storm (and other large-scale storms)? (2 class periods)**
    - We explore video and maps from three parts of a weather report and forecast from Jan. 19, 2019. We develop a model to explain how what was happening in one part of the country at one point in time can be connected to what is predicted to happen in another part of the country over a day later. We develop new questions for our Driving Question Board (DQB) and brainstorm ways we could investigate these questions. We will figure out these things: Many storms are due to the path that air masses follow as they are moving, other air masses they interact with along their boundaries (fronts), and how much lift occurs in the air mass or along those fronts. We have new questions about whether certain weather patterns are typical for different places in our country and what causes any differences in those from one place to another over longer periods of time.
- **Lesson 19: Are there patterns to how air masses move that can help predict where large storms will form? (1 class period)**
    - CK-12 Earth Science for Middle School: 11. Weather
        - 12.1 Weather vs. Climate
    - In this lesson, we observe a visualization showing precipitation movement across the United States in a predictable pattern from west to east in most locations. These predictable air movements seem to bring colder air from the north and warmer air from the south. We zoom out to a global view and notice the U.S. pattern is the same as other places in the northern hemisphere and a mirror image of the southern hemisphere. We figure out these things: There are patterns in the direction that air and

precipitation move over a region. Patterns in air movement are caused by prevailing winds and the prevailing winds in the northern hemisphere mirror the southern hemisphere. These patterns help us predict where air and precipitation come from (colder from the north and warmer from the south). Climate is the long-term average of weather in an area, typically averaged over 30 years.

- **Lesson 20: How do oceans affect whether a place gets a lot or a little precipitation? (2 class periods)**
  - CK-12 Earth Science for Middle School: 12. Climate
    - 12.2 Effect of Atmospheric Circulation on Climate, 12.3 Effect of Continental Position on Climate, and
  - In this lesson, we come to agreement about the temperature of air masses and the direction of their movement. We gather additional information about the role of the ocean by observing a visualization of ocean temperatures, reading about ocean currents, and interpreting precipitation data for coastal cities. We revise a model for air mass interactions that explain (1) the places where certain kinds of air masses form, and (2) their predictable movements over time. We figure out: The ocean is warmer near the equator and cooler near the poles. Ocean currents can bring warmers waters toward the poles and cooler waters toward the equator. More evaporation occurs over warmer ocean waters. The temperature of the ocean affects the humidity of the air moving over it.
- **Lesson 21: Why is there less precipitation further inland in the Pacific Northwest than further inland from the Gulf Coast? (2 class periods)**
  - CK-12 Earth Science for Middle School: 12. Climate
    - 12.4 Effect of Continental Position on Climate and 15. Effect of Altitude and Mountains on Climate.
  - We analyze precipitation, temperature, and elevation data at five locations along two different prevailing wind pathways to explore why there is less precipitation further inland in the Pacific Northwest than there is further inland from the Gulf Coast. We model what happens as an air mass moves from above the ocean to locations over mountains and relatively flat landforms. We develop a list of key ideas and data we need to explain climate patterns in places outside of the United States. We figure out: Changes in elevation affect the flow of air over the land. As elevation increases, the air flowing over the land is forced upward; as elevation decreases the air flowing over the land can fall back downward. Air that is forced upward cools as it rises and tends to lose much of the water vapor in it through condensation and precipitation.
- **Lesson 22: How can we explain differences in climate in different parts of the world? (1 class period)**
  - CK-12 Earth Science for Middle School: 12. Climate
    - 12.6 Climate Zones and Biomes
  - We use our key ideas list from Lesson 21 to explain why the rainforests are located where they are and why they have different climates. We revisit the Driving Question Board and discuss all of our questions that we have now answered.

Unit Learning Goal and Scale *(Level 2.0 reflects a minimal level of proficiency)*	
MS-ESS2-4: Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity.	
4.0	• Accurately develops a comprehensive model that fully describes the water cycle, including detailed processes and interactions. Clearly shows how energy from the sun and gravity drive the water cycle with all stages represented.
3.0	• Develops a model describing the water cycle with most relevant processes; minor inaccuracies may be present. Demonstrates understanding of key processes with minor omissions or inaccuracies.

2.0	• Model describes some aspects of the water cycle but may be incomplete or contain inaccuracies.
1.0	• Provides a limited or incomplete model with significant inaccuracies.
0.0	• Model is missing or fails to address the water cycle.

MS-ESS2-5: Collect data to provide evidence for how the motions and complex interactions of air masses result in changes in weather conditions.	
4.0	• Collects and analyzes comprehensive data to accurately demonstrate how air masses interact and affect weather changes, with detailed and relevant evidence.
3.0	• Collects and analyzes data to show interactions of air masses and weather changes with some minor inaccuracies or gaps in evidence.
2.0	• Collects basic data but with limited analysis or incomplete evidence for interactions of air masses and weather changes.
1.0	• Data collection and analysis are insufficient, with significant gaps or inaccuracies affecting the demonstration of air mass interactions and weather changes.
0.0	• Data is missing or irrelevant, failing to show air mass interactions or weather changes effectively.

MS-ESS2-6: Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates.	
4.0	• Develops a detailed and accurate model showing how unequal heating and Earth's rotation cause atmospheric and oceanic circulation patterns, explaining their effect on regional climates.
3.0	• Creates a clear model of circulation patterns with minor inaccuracies or incomplete explanations of the effects on regional climates.
2.0	• Develops a basic model with some inaccuracies or missing details in the explanation of circulation patterns and their effects on climates.
1.0	• Model is incomplete or contains significant inaccuracies in showing circulation patterns and their effects on regional climates.
0.0	• Model is missing or fails to accurately describe atmospheric and oceanic circulation patterns and their effects on climate.

MS-PS1-4: Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.	
4.0	• Develops a thorough model predicting and describing changes in particle motion, temperature, and state with thermal energy, supported by clear and accurate explanations.

3.0	• Provides a clear model with some minor inaccuracies in predicting and describing changes in particle motion, temperature, and state with thermal energy.
2.0	• Develops a basic model with limited accuracy in describing changes in particle motion, temperature, and state with thermal energy.
1.0	• Model is incomplete or inaccurate in predicting and describing changes in particle motion, temperature, and state with thermal energy.
0.0	• Model is missing or fails to address changes in particle motion, temperature, and state with thermal energy.

Unit Title: Earth and Space Science 6.4 Plate Tectonics & Rock Cycling

Unit Description: Mountains move! And there are ocean fossils on top of Mt. Everest! In this plate tectonics and rock cycling unit, students come to see that the Earth is much more active and alive than they have thought before. The unit launches with documentation of a 2015 Himalayan earthquake that shifted Mt. Everest suddenly to the southwest direction. Students also discover that Mt. Everest is steadily moving to the northeast every year and getting taller as well. Students wonder what could cause an entire mountain to move during an earthquake.

Students investigate other locations that are known to have earthquakes and they notice landforms, such as mountains and ridges that correspond to earthquake patterns. They read texts, explore earthquake and landform patterns using a data visualization tool, and study GPS data at these locations. Students develop an Earth model and study mantle convection motion to explain how Earth's surface could move from processes below the surface. From this, students develop models to explain different ways plates collide and spread apart, ultimately explaining how Mt. Everest could move all the time in one direction, and also suddenly, in a backward motion, during an earthquake. The unit ends with students using what they have figured out about uplift and erosion to explain how a fossil was found at Mt. Everest without having to dig for it.

Unit Duration: 25 days total

Desired Results

Standard(s):

- MS-ESS1-4
  - Construct a scientific explanation based on evidence from geological records and astronomical observations to support the claim that Earth's geosphere, biosphere, hydrosphere, and atmosphere interact as a system.
- MS-ESS2-1
  - Construct a scientific explanation based on evidence from geological records and astronomical observations to support the claim that Earth's geosphere, biosphere, hydrosphere, and atmosphere interact as a system.
- MS-ESS2-2
  - "Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.
- MS-ESS2-3
  - "Analyze and interpret data on the properties of water and its effects on Earth materials and surface processes.

Indicator(s): The Disciplinary Core Ideas (DCIs), Science and Engineering Practices (SEPs), and Crosscutting Concepts (CCCs) for the specified NGSS Standards:

MS-ESS1-4

- **DCI:** ESS2.A: Earth's Materials and Systems and ESS2.B: Plate Tectonics and Large-Scale System Interactions
  - How Earth's systems interact (geosphere, biosphere, hydrosphere, atmosphere)
  - Earth's systems are interconnected and can affect each other.
- **SEP:** Constructing Explanations and Designing Solutions:
  - Use evidence from geological records and astronomical observations to construct a scientific explanation of the interactions among Earth's systems.
- **CCC:** Systems and System Models
  - Earth's systems (geosphere, biosphere, hydrosphere, and atmosphere) interact as a system and can be modeled to understand these interactions.

MS-ESS2-1

- **DCI:** ESS2.A: Earth's Materials and Systems and ESS2.B: Plate Tectonics and Large-Scale System Interactions
  - How Earth's systems interact (geosphere, biosphere, hydrosphere, atmosphere).

  - Earth’s systems are interconnected and can affect each other.
- **SEP:** Constructing Explanations and Designing Solutions
  - Use evidence from geological records and astronomical observations to construct a scientific explanation of the interactions among Earth’s systems.
- **CCC:** Systems and System Models
  - Earth’s systems (geosphere, biosphere, hydrosphere, and atmosphere) interact as a system and can be modeled to understand these interactions.

MS-ESS2-2

- **DCI:** ESS2.A: Earth’s Materials and Systems and ESS2.C: The Roles of Water in Earth’s Surface Processes
  - How geoscience processes have shaped Earth's surface over time.
  - Water’s role in shaping Earth's surface.
- **SEP:** Constructing Explanations and Designing Solutions
  - Use evidence to construct explanations of how geoscience processes have changed Earth’s surface over different time and spatial scales.
- **CCC:** Patterns
  - Identify patterns in geoscience processes and their impacts on Earth's surface over various time and spatial scales.

MS-ESS2-3

- **DCI:** **ESS2.C:** The Roles of Water in Earth’s Surface Processes
  - Water's effects on Earth materials and surface processes.
- **SEP:** Analyzing and Interpreting Data
  - Analyze and interpret data regarding the properties of water and its impacts on Earth materials and surface processes.
- **CCC:** Cause and Effect
  - Analyze how water properties affect Earth materials and surface processes.

Understandings:

- *Students will develop an understanding of the processes that cause mountains to grow, shrink, and move.*
- *Students will analyze and interpret data related to the changes in mountain heights and movements.*
- *Students will create and refine models to explain the phenomena of mountain growth, shrinkage, and movement.*

Essential Questions: See Learning Plan

Unit Question: What causes Earth’s surface to change?

Assessment Evidence

Performance Tasks: (Expectation Activities)

- Develop a Model. Students will develop an initial model explaining how mountains grow, move, and shrink.
- Brainstorming. Students will brainstorm related phenomena, ask questions, and generate a list of data and information needed to understand mountain growth, movement, and shrinkage.
- Analyze Data. Students will analyze global data on mountain peaks to understand the patterns of mountain growth, shrinkage, and movement.

Other Evidence:

- Compare and Contrast. Students will compare and contrast data from different mountain ranges to understand the factors influencing their changes.
- Model Revision and Peer Review. Students will revise their initial models based on new information and feedback from peers.
- Presentation. Students will demonstrate their understanding of the concepts by presenting their findings to the class.

Benchmarks: Unit 6.4 Common Assessment

Learning Plan

[Learning Activities]

- **Lesson 1: What is causing Mt. Everest and other mountains to move, grow, or shrink? (4 class periods)**
  - CK-12 Earth Science for Middle School: 6. Geological Activity and Earthquakes
    - 6.1 Geological Stresses and 6.5 Mountain Building
  - We read about how Mt. Everest is getting taller and moving yearly to the northeast. We analyze other mountain peaks around the world and find that other mountains are also getting taller, but others are shrinking. We develop an initial model explaining how mountains grow, move, and shrink. We brainstorm related phenomena, ask questions, and generate a list of data and information we need to better understand how mountain peaks can grow, shrink, and move. We figure out: Some mountains move. Mountains can get taller. Mt. Everest is growing over time - new data shows. Mountains can also shrink.
- **Lesson 2: How are earthquakes related to where mountains are located? (2 class periods)**
  - CK-12 Earth Science for Middle School: 6. Geological Activity and Earthquakes
    - 6.6 Earthquakes, 6.7 Earthquake Zones, and 6.9 Earthquakes at Convergent Plate Boundaries
  - We look at data sources from Ridgecrest, CA before and after an earthquake. We use Seismic Explorer to determine that there seems to be a pattern with greater earthquake activity at mountains that are increasing in elevation. We figure out: The ground moves back and forth in an earthquake. Some parts of the surface crack open with a noticeable difference in between the ground on either side of the crack after an earthquake. Earthquakes exist on or near almost all mountain ranges. There seems to be a correlation between when mountains were highest or growing and where the eqs are the largest or most frequent. While earthquakes seem to be correlated to changes in elevation, we are uncertain what is occurring under the surface, and what the land is like under the surface.
- **Lesson 3: How does what we find on and below Earth's surface compare in different places? (2 class periods)**
  - CK-12 Earth Science for Middle School: 3. Planet Earth
    - 3.12 Earth's Interior, 3.13 Earth's Outer Layers, 3.14 Earth's Inner Layers.
  - After we figure out that earthquakes are correlated to mountain changes, we wonder what is happening underground where earthquakes occur and what we will find at and below the surface in different places around Earth. We develop models and gather data from various media and investigations about the structure and composition of materials at and below the surface. We share observations and data and update our Progress Trackers. We figure out: Sediment and solid rock make up Earth's surface. Solid rock, known as bedrock, is found on, near, or below the surface of Earth. As we move deeper underground, rocks become increasingly hotter and compressed. This can cause rocks to change state, and tend to more readily move and shift. The rock deep below the ocean bottom is denser than the rock deep below the continents.
- **Lesson 4: What is happening to Earths' surface and the material below it during an earthquake? (2 class periods)**
  - CK-12 Earth Science for Middle School: 6. Geological Activity and Earthquakes
    - 6.4 Faults and 6.18 Earthquake Damage
  - We develop a profile view model of Ridgecrest. We use a foam board to model the bedrock and determine the break in the land must go all the way through the bedrock. We analyze the area of the earthquake by making a cross section in Seismic Explorer. We develop a profile model of North America. We determine that the big sections of Earth between long fault lines are plates. We look at a world map for where there could be other plates on the map. We figure out: Sections of bedrock in between the fault lines of cracks from earthquakes are called plates. These cracks go down through the bedrock to where the rock begins to creep and move. There are other plates in the world that can be found in between the lines of other long sections of fault lines. Models of the crust and mantle have scale limitations due to the size of the Earth and its layers.

- **Lesson 5: How does plate movement affect the land around mountains such as Mt. Everest? (1 class period)**
    - CK-12 Earth Science for Middle School: 5. Plate Tectonics
        - 5.15 Continent-Continent Convergent Plate Boundaries
    - We look for patterns in GPS data to examine land movement around Mt. Mitchell, and use a physical model to demonstrate that the entire North American plate moves at a constant speed and in a specific direction. We further revise a cross section model of the North American plate from the previous lesson to connect its movement to the behavior of the deeper, hotter bedrock. We use Seismic Explorer to investigate the movement of all plates on Earth's surface. We figure out: All plates are constantly moving in different directions and at different speeds. Plates move because they sit on top of deeper, warmer rock layers which move, or creep. When creep occurs, mountains and all other features on the plate above also move.
- **Lesson 6: How could plate movement help us explain how Mt. Everest and other locations are changing in elevation? (3 class periods)**
    - CK-12 Earth Science for Middle School: 5. Plate Tectonics
        - 5.7 Earth's Tectonic Plates, 5.8 Tectonic Plate Motions, 5.9 Theory of Plate Tectonics.
    - We use models of plates and plate movement to identify and describe in detail the results of plate interactions between plates of similar or differing densities, and develop drawn models to communicate our findings. We use the models we develop to help explain what might cause the elevation changes and other changes we know about at Mt. Everest. We consider how earthquakes could be a result of uneven plate movement. We celebrate how many questions we can now answer from the DQB. We figure out: When plates move towards each other, they collide and mountains can get taller. Plates can move next to each other in opposite directions. Plate boundaries or edges are rough and so when they interact they can get stuck against each other or slip against each other which we can feel as earthquakes. Plate movements cause earthquakes. Plate movements can cause mountains to get taller**.**
- **Lesson 7: What happens at mountains where we see volcanic activity? (1 class period)**
    - CK-12 Earth Science for Middle School: 7. Geological Activity and Volcanoes
        - 7.1 Volcanoes and 7.2 Volcanoes at Plate Boundaries.
    - In this lesson, we use map images to determine that most volcanoes occur along the boundary between oceanic and continental plates. We observe and describe what happens when a denser oceanic plate collides with a less dense continental plate. We revisit our mountain cards from Lesson 1, and read to figure out that volcanic eruptions can either add new earth material to existing landforms or destroy them. We update our Potential Causes for Mountain Movement Chart. We figure out: Volcanoes occur in lines where an oceanic plate collides with a continental plate. When an oceanic plate collides with a continental plate, the oceanic plate moves under the continental plate. The oceanic plate heats up, causing the bedrock and sediments to melt and the water in the sediments to boil. The melted earth materials and steam move upward through openings called volcanoes in the continental plate. Volcanic eruptions can cause mountains to grow or shrink in height.
- **Lesson 8: What is occurring at locations where two plates are moving away from each other? (2 class periods)**
    - CK-12 Earth Science for Middle School: 5. Plate Tectonics
        - 5.10 Divergent Plate Boundaries in the Oceans and 5.11 Divergent Plate Boundaries.
    - We make claims about what could be occurring at the Mid-Atlantic Ridge. We collect evidence to determine if the claims are supported or refuted by evidence. We use our knowledge of the ridge, volcanoes, and the presence of magma to update our Potential Causes for Mountain Movement chart. We figure out: Plates are moving apart along the Mid-Atlantic Ridge. Scientists call the place where two plates are moving apart a ridge. Magma from the mantle is pushing up from under the plate, which can be seen in places like volcanoes and fissures in Iceland and along ridges. New oceanic plate material is formed at ridges. Magma pushes on plates causing plates to move, which changes mountain elevation and location over time.
- **Lesson 9: What causes mountains to change? (1 class period)**
    - CK-12 Earth Science for Middle School: 13. Weathering and Soils
        - 13.1 Weathering and Erosion

- We revisit our Potential Causes for Mountain Movement chart to take stock of what we have figured out. We revise this chart to capture the causal chain of events that need to occur for a mountain to move or grow. We revisit the DQB to see what questions we can answer and we make predictions about what we think the Andes mountains and the Mid-Atlantic Ridge will look like in the future and what it looked like in the past. We figure out: Plates move because the magma underneath them is moving. Plate movement causes changes to mountains.

- **Lesson 10: Where were Africa and South America in the past? (1 class period)**
  - CK-12 Earth Science for Middle School: 5. Plate Tectonics
    - 5.1 Continental Drift and 5.2 Wegener and the Continental Drift Hypothesis.
  - We use math to determine that Africa and South America could have been together 146 million years ago and reason out data from this time period will be found underground. We look for patterns in mapped data across the continents from this period. We then complete an exit ticket to make a claim about the two plates touching. We figure out: Oceanic plates that were created over time were not always in existence. Average rates of plate movement and plate direction can be used to determine where plates were once located. Small changes to the distance between continents can add up to larger visible changes seen from a larger scale. Older rock and associated fossils can be found under younger rock and fossils. To support that two land masses were once together, patterns in data across the two land masses need to be similar or the same. Data from rock strata, fossils, and other changes in land supports that the African and South American continents were once together at the Mid-Atlantic Ridge.
- **Lesson 11: Where were the other plates located in the distant past? (2 class periods)**
  - CK-12 Earth Science for Middle School: 5. Plate Tectonics
    - 5.3 Magnetic Polarity Evidence for Continental Drift, 5.4 Bathymetric Evidence of Seafloor Spreading, and 5.5 Magnetic Evidence for Seafloor Spreading.
  - We use multiple types of data from models of all the land masses as evidence to develop a flat map model that predicts where the land masses used to be located relative to each other millions of years ago. We identify and discuss the strengths and weaknesses of the evidence supporting our model. We diagram our model and the data that supports it, and articulate our reasoning to explain the positions of the land masses millions of years ago that are predicted by the model. We figure out: All major land masses were once touching, forming a part of a large single landmass that existed hundreds of millions of years ago. Multiple sources of data are necessary to determine where plates were located in the past.
- **Lesson 12: Where did mountains that aren't at plate boundaries today, like the Appalachians and Urals, come from? (1 class period)**
  - CK-12 Earth Science for Middle School: 14. Erosion and Deposition
    - 14.1 Erosion by Streams, 14.2 Deposition, 14.3 Erosion by Groundwater, 14.4 Deposition by Groundwater, 14.5 Erosion by Waves, and 14.6 Deposition by Waves
  - We use map images and data to compare the mountain sites we are studying. We remember that the Appalachians are decreasing in elevation, while the Urals are neither increasing nor decreasing. We know that colliding plates cause mountains to form and increase in elevation, but the Appalachians and the Urals are not located near plate boundaries. We use evidence from an online simulation to construct an explanation for how and when the Applachians and the Urals were formed. We figure out: The Appalachian Mountains, first formed 470 million years ago, and the Ural Mountains, formed more than 300 million years ago, were both created in the same way that other mountains were formed-- through plate collisions. Plate interactions cannot explain why the Appalachians are decreasing in elevation or why the Ural Mountains are neither increasing or decreasing in elevation.
- **Lesson 13: What causes mountains to shrink in elevation? (1 class period)**
  - CK-12 Earth Science for Middle School: 14. Erosion and Deposition
    - 14.8 Erosion by Wind, 14.9 Deposition by Wind, 14.10 Erosion by Glaciers, and 14.11 Deposition by Glaciers.
  - After recalling what we already know about erosion and weathering, we read about erosion rates and how scientists use these rates to determine how erosion is changing the surface. Then, using both the erosion rates and uplift rates for Mt. Everest and Mt. Mitchell, we develop a representation of each model and how these two processes are affecting them. We determine that when erosion rates are higher than uplift rates, like at Mt. Mitchell, a mountain

will shrink in elevation. We figure out: The relationship between the erosion rates above the surface and the uplift rates below the surface determine the elevation above sea level. Erosion rates greater than uplift rates result in decreases in elevation, erosion rates less than uplift rates result in increases in elevation, and erosion rates equal to uplift rates results in no elevation change.

- **Lesson 14: How is there an exposed marine fossil on Mt. Everest? And, what other remaining questions from our Driving Question Board can we now answer? (2 class periods)**
    - CK-12 Earth Science for Middle School: 15. Understanding Earth's History
        - 15.3 Earth History and Clues from Fossils
    - We revisit our Driving Question Board and determine what questions we have made progress on. We explain our related phenomena. We revisit our mountain cards to determine that we still need to explain the presence of marine fossils on mountains. We gather evidence to help support what is occuring for marine fossils to end up on mountains and take an assessment. We then revisit our Driving Question Board and answer our unit question. We figure out that: Plate movement has caused uplift to occur at mountains, pushing up rocks that used to exist on ancient seafloors. Over time, marine fossils from the ancient seafloor are exposed due to erosional processes. Erosional processes will always be occurring and will continue into the distant future.

Unit Learning Goal and Scale *(Level 2.0 reflects a minimal level of proficiency)*	
Standard(s): MS-ESS1-4: Construct a scientific explanation based on evidence from geological records and astronomical observations to support the claim that Earth's geosphere, biosphere, hydrosphere, and atmosphere interact as a system.	
4.0	• Constructs a thorough and accurate scientific explanation using comprehensive evidence from both geological and astronomical sources. Clearly connects interactions among Earth's systems.
3.0	• Constructs a clear scientific explanation with relevant evidence from geological and astronomical sources. Identifies interactions among Earth's systems.
2.0	• Constructs a partial scientific explanation with some relevant evidence but lacks depth in connecting Earth's systems.
1.0	• Constructs a limited scientific explanation with minimal evidence. Little to no connection among Earth's systems.
0.0	• No scientific explanation provided or evidence is irrelevant.

Standard(s): MS-ESS2-1:Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process.	
4.0	• Develops a detailed and accurate model showing how Earth's materials cycle and how energy drives these processes. Model includes multiple components and their interactions.
3.0	• Develops a clear model showing the cycling of Earth's materials and energy flow. Model includes major components and interactions.

2.0	• Develops a basic model with some elements of Earth's material cycling and energy flow. Model is incomplete or unclear in parts.
1.0	• Develops a limited model with minimal detail on material cycling and energy flow. Model is inaccurate or incomplete.
0.0	• No model developed or model does not address material cycling or energy flow.

Standard(s): MS-ESS2-2: Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.	
4.0	• Constructs a well-supported explanation with detailed evidence on how geoscience processes have changed Earth's surface at various time and spatial scales.
3.0	• Constructs a clear explanation with evidence on how geoscience processes have changed Earth's surface. Addresses different time and spatial scales.
2.0	• Constructs a partial explanation with limited evidence on geoscience processes affecting Earth's surface. Coverage of time and spatial scales is uneven.
1.0	• Constructs a limited explanation with minimal evidence. Time and spatial scales are not well addressed.
0.0	• No explanation provided or explanation is not relevant to geoscience processes or Earth's surface changes.

Standard(s): MS-ESS2-3: Analyze and interpret data on the properties of water and its effects on Earth materials and surface processes.	
4.0	• Analyzes and interprets data with great accuracy, demonstrating a deep understanding of water properties and their effects on Earth materials and surface processes.
3.0	• Analyzes and interprets data accurately, showing a good understanding of water properties and their effects on Earth materials.
2.0	• Analyzes and interprets data with some accuracy. Understanding of water properties and their effects on Earth materials is basic.
1.0	• Analyzes and interprets data with minimal accuracy. Understanding of water properties and effects is limited.
0.0	• No analysis or interpretation of data, or the data is irrelevant.

Unit Title: Earth and Space Science 6.5 Natural Hazards

Unit Description: This unit begins with students experiencing, through text and video, a devastating natural event that caused major flooding in coastal towns of Japan. This event was the 2011 Great Sendai or Tōhoku earthquake and subsequent tsunami that caused major loss of life and property in Japan. Through this anchoring phenomenon, students think about ways to detect tsunamis, warn people, and reduce damage from the wave. As students design solutions to solve this problem, they begin to wonder about the natural hazard itself: what causes it, where it happens, and how it causes damage.

The first part of the unit focuses on identifying where tsunamis occur, how they form, how they move across the ocean, and what happens as they approach shore. The second part of the unit transitions students to consider combinations of engineering design solutions and technologies to mitigate the effects of tsunamis. Finally, students apply their understanding to consider how to communicate about another natural hazard to stakeholders in a community.

Unit Duration: 21 days total

Desired Results

Standard(s):

- MS-ESS3-2
  - Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.
- MS-PS4-3
  - Apply scientific ideas about waves to design, test, and refine a device that converts energy from one form to another.
- MS-ETS1-1
  - Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution.
- MS-ETS1-2
  - Develop a model to generate and test design solutions that meet the criteria and constraints of a design problem.

Indicator(s): The Disciplinary Core Ideas (DCIs), Science and Engineering Practices (SEPs), and Crosscutting Concepts (CCCs) for the specified NGSS Standards:

MS-ESS3-2

- **DCI:** ESS3.B: Natural Hazards
  - Understanding natural hazards is crucial for predicting and mitigating their impacts.
- **SEP:** Analyzing and Interpreting Data
  - Engage with real-world data to draw conclusions about hazard risks and develop informed strategies for mitigation.
- **CCC:** Cause and Effect
  - Understanding cause and effect relationships helps students grasp how natural hazards are triggered and the subsequent impacts

MS-PS4-3

- **DCI:** PS4.B: Electromagnetic Radiation
  - This core idea explores how waves, including electromagnetic waves, interact with matter and transfer energy
- **SEP:** Engaging in Argument from Evidence
  - Engaging in argumentation based on scientific evidence helps them refine their devices and ensure they function as intended
- **CCC:** Energy and Matter
  - Understand how energy is converted and conserved in their designs, which aligns with the objective of creating energy conversion devices

MS-ETS1-1

- **DCI:** ETS1.A: Defining and Delimiting Engineering Problems
  - Precise problem definition is crucial for developing effective solutions.
- **SEP:** Defining and Delimiting Engineering Problems
  - practice identifying the key aspects of an engineering problem, which helps them understand the scope and limitations of potential solutions.
- **CCC:** Defining and Delimiting Engineering Problems
  - Recognizing the importance of clearly defined problems ensures that students can develop targeted and effective solutions

MS-ETS1-2

- **DCI:** ETS1.B: Developing Possible Solutions
  - This core idea involves generating and testing multiple solutions to an engineering problem.
- **SEP:** Developing and Using Models
  - Using models allows students to visualize and test their design solutions in a controlled environment.
- **CCC:** Models
  - Models are a fundamental tool in both science and engineering for representing and testing ideas.

Understandings:	Essential Questions: See Learning Plan
• *Students will analyze the causes and effects of tsunamis, particularly focusing on how they form, move, and impact communities.* • *Students will brainstorm, design, and refine engineering solutions to detect, warn, and mitigate the impact of tsunamis.* • *Students will develop and evaluate communication strategies to warn and prepare communities for tsunamis and other natural hazards*	Unit Question: Where do natural hazards happen and how do we prepare for them?

Assessment Evidence

Performance Tasks: (Expectation Activities)	Other Evidence:
• Presentation. Students will create and present their own engineering solutions to detect, warn, and reduce damage from tsunamis, justifying their choices based on criteria and constraints. • Engineering Design. Students will develop a detailed plan for a tsunami detection and warning system, considering the scientific principles and design limitations, and present their findings. • Safety Poster. Students will create a comprehensive communication strategy that ensures all at-risk populations receive timely and accurate tsunami warnings. They will present their strategy, highlighting how it addresses the needs of diverse community members.	• Report. Students will produce a written report that outlines their findings, identifies patterns in the data, and predicts future tsunami locations based on historical trends. • Diagrams/Models. Students will create diagrams or models demonstrating their understanding of tsunami wave formation and movement. They will compare and contrast the different models and explain which aspects of tsunami behavior each model best represents.

Benchmarks: Unit 6.5 Common Assessment

Learning Plan

Learning Activities

- **Lesson 1: What happens to a community when a tsunami occurs? (3 class periods)**
  - CK-12 Earth Science for Middle School: 6. Geological Activity and Earthquakes
    - 6.12 Tsunami

- We read about and watch the 2011 tsunami triggered by an earthquake off the eastern coast of Japan, causing devastating loss of life and structural damage. We develop initial engineering ideas intended to detect tsunamis, provide warning of their approach, and reduce their impact. We think about what makes some engineering ideas more promising or challenging than others. We brainstorm related natural hazards and ask questions to generate a list of data and information we need to better understand where these hazards occur and how we can prepare for them. We figure out: A tsunami is a large wave that results from movement of the ocean floor. Tsunamis cause major flooding that damages homes and property and harms people in the community. Proposed solutions include a system of detection sensors, warning plans, and design solutions to reduce damage.

- **Lesson 2: Where do tsunamis happen and what causes them? (2 class periods)**
  - CK-12 Earth Science for Middle School: 6. Geological Activity and Earthquakes
    - 6.6 Earthquakes and 6.10 Intraplate Earthquakes
  - We investigate historical tsunami data and figure out spatial patterns for where tsunamis occur and that most are caused by earthquakes. We use digital tools, analyze maps and graphs, and notice that only certain types of earthquakes cause tsunamis. We establish a cause-and-effect relationship between types of earthquakes and tsunami formation. We use this relationship to forecast the locations that may be at risk for future tsunamis. We figure out these things: Tsunamis form as a result of earthquakes, volcanic eruptions, and landslides. Stronger, shallow earthquakes tend to be most related to tsunami formation. Almost all tsunamis occur along plate boundaries where the plates are colliding. Data about where tsunamis have occurred in the past help to forecast where they might happen in the future.
- **Lesson 3: What causes a tsunami to form and move? (3 class periods)**
  - CK-12 Earth Science for Middle School: 6. Geological Activity and Earthquakes
    - 6.13 21st Century Tsunami and 6.7 Earthquake Zones
  - We analyze three wave models to make sense of how an earthquake-driven tsunami forms and moves to shore. We use different perspectives to understand various aspects of the phenomena, and then we identify benefits and limitations of each model. We figure out these things: Physical waves form from a single point of movement, and then move outward in a circular pattern. The bigger the movement of the ocean floor, the greater the movement of the water above it. When a wave approaches shore, it gets taller until it reaches the shore, where it collapses and flows, or runs up onto the shore. The bigger the wave is when it reaches shore, the farther onto the land the water will flow. As waves move and interact with surrounding land at the shore and in the ocean, they transfer energy to the land and reflect off its surface. As this continues, the waves get smaller and smaller due to losing energy that has been transferred to their surroundings.
- **Lesson 4: How can we forecast where and when tsunamis will happen and which communities are at risk? (1 class period)**
  - CK-12 Earth Science for Middle School: 6. Geological Activity and Earthquakes
    - 6.8 Earthquakes at Transform Plate Boundaries
  - Using the Tsunami Chain of Events poster as evidence from previous lessons, we construct an explanation that describes the geologic changes that cause a tsunami. Then we use what we know about tsunamis--where they happen and what causes them--to consider how to protect people and property from their effects. We revisit the DQB to determine which questions we are now able to answer and document responses for each question. We figure out these things: Places with more people, closer to water, or at low elevations have greater risk for a tsunami to cause damage. We can use science ideas to forecast tsunamis and predict which areas will experience damage to people and property.
- **Lesson 5: How can we reduce damage from a tsunami wave? (3 class periods)**
  - CK-12 Earth Science for Middle School: 6. Geological Activity and Earthquakes
    - 6.18 Earthquake Damage and 6.19 Earthquake Safe Structures
  - We revisit the coastal communities of Japan that were affected by the 2011 tsunami to evaluate existing solutions. We define our problem, identify criteria and constraints, and evaluate each solution using a systematic process. We consider what it means for a solution to be promising for one community versus another. We figure out: Engineers account for relevant scientific principles and potential impacts on people and the natural environment when designing and evaluating solutions. Clearly identifying the design problem, criteria, and constraints allows for the evaluation

of solutions and increases the likelihood that a solution will meet the needs of communities at risk. Effective solutions to reduce damage from tsunamis need to not only dissipate the energy of the wave and deflect the water, but also meet the needs of communities at risk.

- **Lesson 6: How are tsunamis detected and warning signals sent? (1 class period)**
  - CK-12 Earth Science for Middle School: 6. Geological Activity and Earthquakes
    - 6.11 Seismic Waves and 6.17 Predicting Earthquakes
  - We read about how tsunamis are detected using a complex system of instruments set up on land (seismometers), on the ocean surface (surface buoys), on the ocean floor (tsunameters), and in space (satellites). We read that tsunami warnings are sent only when specific sets of criteria are met, first regarding the location, strength, and depth of the earthquake that is detected, and then regarding whether the tsunami is expected to reach land. We figure out these things: Tsunamis happen suddenly and can travel at high speeds over great distances. Depending on where the tsunami forms, communities have more or less time to respond. To help prevent or reduce loss of life, we need to detect a tsunami quickly and accurately in order to provide timely information to an at-risk community. Criteria and constraints for a tsunami detection system must consider the available scientific information (earthquake data) and design limitations (signal transmission through air and water).
- **Lesson 7: What are ways we can communicate with people before and during a tsunami? (2 class periods)**
  - We listen to a tsunami warning signal and read accounts of tsunami survivors from Japan. We identify stakeholders who the warning signal must work for, and then develop criteria and constraints for tsunami communication. We evaluate different communication options based on stakeholder needs. From this we learn that there are many ways to communicate with different stakeholders before and during a tsunami event. We figure out the following: Groups of people can be affected by hazards in different ways. People particularly at-risk during a hazard are older people, children, people who speak a different language, and those who are sick or need assistance. Effective plans account for the people living in a place and the resources communities have to respond. A variety of communication strategies and modalities are necessary to ensure that all people at risk receive the warning. Communication strategies include educating the community before a natural hazard happens.
- **Lesson 8: Which emergency communication systems are the most reliable in a hazard? (1 class period)**
  - CK-12 Earth Science for Middle School: 6. Geological Activity and Earthquakes
    - 6.20 Staying Safe in an Earthquake
  - We consider the ways in which people are alerted during a hazard and what would make a warning system reliable. We read about analog and digital signals and discuss what forms of communication best meet the needs and are most reliable for multiple stakeholder groups. We figure out: Communication technologies use different equipment and signals to transmit and receive information during a hazard. Digital signals use technology that makes them more reliable means of communication than analog signals. A combination of communication technologies are important to use during a hazard to ensure as many people receive the warning messages as possible.
- **Lesson 9: How can we model the systems put into place to protect communities? (1 class period)**
  - We develop a tsunami system model. We analyze the model to determine the importance and interactions of the various subsystems. We develop a process engineers use to solve problems and determine we can use our ideas to prepare for a hazard that is important to us. We figure out the following: Engineers can design a system for responding to hazards that includes design solutions to forecast, detect, warn and communicate with people, and reduce damage. Each part of the system is dependent on another part of the system; subsystems work together to meet the criteria for the overall system. Engineers engage in a generalized process to define problems, develop solutions, and optimize those solutions.
- **Lesson 10: How can we effectively prepare our communities for a natural hazard? (4 class periods)**
  - We investigate the general patterns of risk of other natural hazards in the United States and determine our local level of risk for each hazard. We choose a natural hazard, gather information,

	and plan for communication to an identified stakeholder community at risk for the hazard. We evaluate our final plans and products using constraints and criteria for effective communication with our stakeholder groups. We figure out: All communities are impacted by natural hazards with different levels of risk, and these hazards often require different ways to detect risk, warn people, and reduce damage. Knowledge about hazards (the causes of the hazard, locations at greater or lesser risk, how to design solutions, and how to respond when it happens) can empower us and others to design solutions to save lives. Effective communication and response plans account for the needs of people living in a place and the available resources to respond. Communication strategies include educating the community before a natural hazard happens and alerting people when the hazard is happening.

Unit Learning Goal and Scale *(Level 2.0 reflects a minimal level of proficiency)*	
Standard(s): MS-ESS3-2: Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.	
4.0	• Thoroughly analyzes and interprets data from multiple sources on natural hazards. Accurately forecasts future events and proposes innovative technologies for mitigation. Provides clear, evidence-based explanations and uses advanced data analysis techniques.
3.0	• Analyzes and interprets data on natural hazards effectively. Accurately forecasts future events and suggests practical technologies for mitigation. Provides evidence-based explanations and uses standard data analysis techniques.
2.0	• Analyzes and interprets data on natural hazards with some accuracy. Makes reasonable forecasts and suggests technologies for mitigation, but may lack depth or clarity. Provides explanations with partial evidence.
1.0	• Attempts to analyze and interpret data on natural hazards, but with limited accuracy. Forecasts future events with minimal success and suggests basic technologies for mitigation. Provides explanations with little evidence.
0.0	• Does not analyze or interpret data on natural hazards accurately. Fails to forecast future events or suggest technologies for mitigation. Provides explanations with no evidence.

Standard(s): MS-PS4-3: Apply scientific ideas about waves to design, test, and refine a device that converts energy from one form to another.	
4.0	• Applies scientific ideas about waves with exceptional understanding. Designs, tests, and refines a highly effective device that efficiently converts energy. Provides detailed and innovative refinements based on thorough testing.
3.0	• Applies scientific ideas about waves effectively. Designs, tests, and refines a functional device that converts energy. Provides practical refinements based on testing results.
2.0	• Applies scientific ideas about waves with some understanding. Designs and tests a device that converts energy with partial success. Provides some refinements based on limited testing.
1.0	• Attempts to apply scientific ideas about waves, but with limited understanding. Designs and tests a basic device with minimal success. Provides few or no refinements.

0.0	● Does not apply scientific ideas about waves accurately. Fails to design, test, or refine a device that converts energy.

Standard(s): MS-ETS1-1: Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution.	
4.0	● Defines criteria and constraints with exceptional precision and detail. Ensures that the design problem is thoroughly understood and all aspects are considered for a successful solution. Provides comprehensive and clear documentation.
3.0	● Defines criteria and constraints effectively. Ensures that the design problem is well understood and most aspects are considered for a successful solution. Provides clear documentation.
2.0	● Defines criteria and constraints with some precision. Ensures that the design problem is partially understood and some aspects are considered for a successful solution. Provides basic documentation.
1.0	● Attempts to define criteria and constraints, but with limited precision. Ensures that the design problem is minimally understood and few aspects are considered for a successful solution. Provides minimal documentation.
0.0	● Does not define criteria and constraints accurately. Fails to understand the design problem or consider necessary aspects for a successful solution. Provides no documentation.

Standard(s): MS-ETS1-2: Develop a model to generate and test design solutions that meet the criteria and constraints of a design problem.	
4.0	● Develops a highly detailed and accurate model to generate and test multiple design solutions. Ensures all criteria and constraints are met with innovative approaches. Provides comprehensive analysis and iteration.
3.0	● Develops a detailed and accurate model to generate and test design solutions. Ensures that most criteria and constraints are met. Provides effective analysis and iteration.
2.0	● Develops a basic model to generate and test design solutions. Ensures that some criteria and constraints are met. Provides limited analysis and iteration.
1.0	● Attempts to develop a model to generate and test design solutions, but with limited detail and accuracy. Ensures that few criteria and constraints are met. Provides minimal analysis and iteration.
0.0	● Does not develop a model to generate or test design solutions accurately. Fails to meet criteria and constraints. Provides no analysis or iteration.

Unit Title: Life Science 6.6 Cells & Systems
Unit Description: This unit launches with students hearing about an injury that happened to a middle school student that caused him to need stitches, pins, and a cast. They analyze doctor reports and develop an initial model for what is going on in our body when it heals. Students investigate what the different parts of our body are made of, from the macro scale to the micro scale. They figure out parts of our body are made of cells and that these cells work together for our body to function. Once students have figured out what their bodies are made of and how the parts of their body work together to be able to move, they wonder how the parts of our body heal. They start by watching a timelapse of a knee scrape and notice that over time the part that was scraped is filled in with new skin cells. Students investigate what happens when cells make more cells, what cells need to make more cells, and how cells get what they need to make more cells. Students return to the healing timeline they made at the start of the unit and apply what they have figured out about the interactions between the different systems in the body to explain the various events of healing that took place for the injury at the start of the unit. Finally, they apply their model for healing to explain growth at growth plates in children's bodies as they become adults.
Unit Duration: 25 days total
Desired Results
Standard(s): ● MS-LS1-1 ○ Conduct an investigation to provide evidence that living things are made of cells, which is the smallest unit of life that can be considered alive. ● MS-LS1-2 ○ Develop and use a model to describe how cells function to support the health of organisms. ● MS-LS1-3 ○ Use argument supported by evidence for how the body is organized into systems of cells, tissues, organs, and systems of organs that work together to carry out the functions of life. ● MS-LS1-8 ○ Gather and synthesize information to describe how the structure and function of the body systems work together to maintain health and function.
Indicator(s): The Disciplinary Core Ideas (DCIs), Science and Engineering Practices (SEPs), and Crosscutting Concepts (CCCs) for the specified NGSS Standards: **MS-LS1-1** ● **DCI:** LS1.A: Structure and Function ○ The cell is the basic unit of structure and function in organisms. ● **SEP:** Planning and Carrying Out Investigations ○ Conducting investigations to gather evidence that living things are made of cells. ● **CCC:** Structure and Function ○ The structure of an organism's cells determines their function and how they contribute to the organism's overall function. **MS-LS1-2** ● **DCI:** LS1.A: Structure and Function ○ Cells function to support the health and survival of organisms. ● **SEP:** Developing and Using Models ○ Creating models to describe how cells function and support the health of organisms. ● **CCC:** Systems and System Models ○ Understanding how different systems (cells, tissues, organs) work together as part of a larger system to maintain the health and function of the organism. **MS-LS1-3** ● **DCI:** LS1.A: Structure and Function ○ The organization of body systems into cells, tissues, organs, and organ systems. ● **SEP:** Engaging in Argument from Evidence

- Using evidence to support claims about how body systems work together to carry out life functions.
- **CCC:** Cause and Effect
  - Understanding how the organization of body systems affects their function and contributes to the overall health of the organism.

MS-LS1-8

- **DCI:** LS1.A: Structure and Function
  - How the structure and function of body systems are interconnected.
- **SEP:** Gathering, Analyzing, and Interpreting Data
  - Collecting and analyzing information to describe how body systems work together.
- **CCC:** Systems and System Models
  - How different body systems work together as part of a larger system to maintain health and function.

Understandings: • *Students will develop a timeline and model to represent the healing process of the foot after an injury.* • *Students will investigate how different parts of the foot (skin, muscle, bone) work together to restore function and enable walking.* • *Students will compare healing processes observed in humans and other living organisms.*	**Essential Questions:** See Learning Plan Unit Question: How do living things heal?

Assessment Evidence

Performance Tasks: (Expectation Activities) • Create a Timeline. Students will construct a detailed timeline that illustrates the sequence of events in the healing process of the foot. • Develop a Model. Students will design and build a model to demonstrate how the different parts of the foot (bones, muscles, skin) work together to restore the ability to walk. • Presentation. Students will engage in brainstorming sessions to identify and discuss other instances of healing observed in humans and other organisms.	**Other Evidence:** • Diagram. Students can draw and label a comprehensive diagram of the foot, including bones, muscles, and skin, to show how each part contributes to the healing process. • Reflection Essay. Students can write a reflective analysis that explains the healing process in the context of the injury described.

Benchmarks: Unit 6.6 Common Assessment

Learning Plan

Learning Activities

- **Lesson 1: What happened in the student's foot so they could walk again? (4 class periods)**
  - CK-12 Life Science for Middle School: 11. Human Biology
    - 11.1 Human Body and 11.2 Homeostasis
  - We share our experiences moving our bodies and times when we were unable to. We read doctor's notes and see images of an injury. We create a timeline of important events that show evidence of healing. We develop models to show how the parts of the foot work together so the patient can walk again. We brainstorm related phenomena of other times we have seen healing in humans and other living things. We figure out these things: A student who was previously able to walk was injured in an accident and could no longer walk. Some of the injured parts of the foot needed outside supports during the healing process. Over time, the injured parts of the foot were able to heal; some took longer than others. The injury caused gaps between the damaged structures in the foot.

- **Lesson 2: What do our bones, skin, and muscles do for us? (2 class periods)**
  - CK-12 Life Science for Middle School: 11. Human Biology
    - 11.3 Skin, 11.7 Bone Health, and 11.9 Muscles
  - We investigate the parts that make up a chicken wing and how they work together when moving by watching a video of the dissection of its skin, muscle, and bone. We map the parts of the chicken wing to the parts of the human foot to make sense of how these parts work together in similar ways in each. Then, we revise the investigation to figure out how function can be affected because of an injury. We figure out these things: Skin is attached to the muscle underneath it, and the muscle is attached to bones. Bones move when the muscles attached to them move. The muscles and bones are both parts of the wing system (or foot system) and interact for the wing (or foot) to move. When one part of the system is broken or injured, the whole system is affected and can't function the way it used to.
- **Lesson 3: How can medical images and diagrams help us figure out more about the structures in our body? (3 class periods)**
  - CK-12 Life Science for Middle School: 11. Human Biology
    - 11.10 Skeletal Muscles
  - We decide we need to see the different structures inside a body. We observe different types of medical images of a body. We analyze various scientific diagrams to help us interpret the different structures within the images we observed. We figure out that There are blood vessels in the different parts of the bone, muscle, and skin. There are nerves that run through the layers of the skin, the muscle, and the bone.
- **Lesson 4: Why is there blood in all of these places in the body? (3 class periods)**
  - CK-12 Life Science for Middle School: 11. Human Biology
    - 11.26 Blood
  - We view an image of blood vessels to determine that blood circulates everywhere in the body, and we notice that blood in a test tube settles into layers. We use microscopes to investigate human and mammal blood on pre-prepared slides, observing that blood is composed of several different smaller structures. We read an article to make sense of the patterns we saw, considering how the structures of the blood and its components support their functions in the body. We figure out: As a whole, the blood's function is to travel around the body carrying the things the body needs. The blood's flowy liquid nature (structure) allows it to perform its function. Blood vessels in a body help blood get to where it needs to go throughout the body. Blood is composed of a mixture of components that we cannot see without a microscope. Blood is made of red blood cells, white blood cells, platelets, and blood plasma. The structure of blood cells relates to their function: their round shape helps them travel easily through the tubular blood vessels. Platelets' structure relates to their function: their branching arms and stickiness help them plug damaged parts of the blood vessels to stop leaks.
- **Lesson 5: What do nerves do, and why are they in different parts of the body? (2 class periods)**
  - CK-12 Life Science for Middle School: 11. Human Biology
    - 11.40 Nervous System
  - Nerves, like blood vessels, are found throughout the body. We investigate nerves under a microscope and we notice that nerves have a unique and intricate structure. We read about nerves and learn that the nerve cell's structure suits its function. We engage in a few quick experiences that help us understand the role that nerves play in our bodies. Then we revisit the foot injury and think about how we can leverage what we now know about the function of nerves to better understand how the foot works and the healing process of the skin, muscles, and bones affected by the injury to the foot. We figure out: Nerve cells have a very unique structure--they have long, thin "branches" or "tentacles" extending from a central portion. Nerve cells branch out and connect to other nerve cells, forming a network of nerves that carry signals between all parts of the body and the brain. The structure of nerve cells is perfectly suited for their function--they branch out and connect with all parts of the body so that they can carry signals back and forth between the body and the brain.
- **Lesson 6: What will we see if we look at skin, bone, and muscle with the microscope, too? (1 class period)**
  - CK-12 Life Science for Middle School: Introduction to Life Science

        - 1.6 Microscope
    - We investigate pre-prepared slides of bone, skin, and muscle and then use our observational data to come to consensus around how cells' unique structures support their functions in the body. We figure out: Bone, muscle, and skin are made up of repeating patterns of microscopic structures called cells, and groups of these cells form tissues. Cells that make up different tissues are structured differently, depending on their function in the body. Structure is the characteristic of something (the shape or way it's made or arranged) that supports its function.
- **Lesson 7: Are all things made of cells? (1 class period1)**
    - CK-12 Life Science for Middle School: 2. Cell Biology
        - 2.3 Cell theory and 2.4 Prokaryotic and Eukaryotic Cells
    - This lesson marks the end of the first lesson set. Students take an individual assessment where they plan an investigation to collect data to determine if other things are made of cells. They analyze microscopic images of living and non-living things as data to look for evidence of cells. They use these data to argue from evidence that parts of living (or formerly living) things are made of cells--not things that were never living are not made of cells. We figure out: Microscopic samples from living things that we analyze are made of cells. Microscopic samples from things that were never living are not made of cells.
- **Lesson 8: What happened as the skin on top of the foot healed? (1 class period)**
    - CK-12 Life Science for Middle School: 2. Cell Biology
        - 2.19 Cell Division
    - We revisit the healing timeline and Driving Question Board to connect what questions we have answered, like what the foot is made of and how these parts work together to help us function. We revise our definition of healing to include that healing must involve filling in the gaps in the injury with cells, but we do not know how. We observe a time-lapse video of a skin wound healing to gather more information about what must be happening in the healing process. We revise our model to specifically focus on and predict what happens with cells for skin to heal. We figure this out: New skin (which is made of cells) forms as the site of the injury gets smaller and smaller.
- **Lesson 9: What is happening at the site of an injury to fill the gap? (1 class period)**
    - CK-12 Life Science for Middle School: 2. Cell Biology
        - 2.20 Cell Cycle
    - We analyze a video and microscopic images of cells splitting and growing in different organisms. By observing this process at different spatial (zoomedin/out video and images) and time scales (full/halfspeed video), we make sense of how our body fills a gap at the site of an injury, such as broken skin or bone. We figure out these things: New cells come from old cells, which grow and split through a repeated and nonrandom process. When cells grow and split, they make new cells of the same type (e.g., skin cells make new skin cells and bone cells make new bone cells). A gap in the skin, muscle, or bone is filled by new cells as a result of cells growing and splitting.
- **Lesson 10: What do cells need to grow and make more of themselves? (2 class periods)**
    - CK-12 Life Science for Middle School: 2. Cell Biology
        - 2.21 Mitosis
    - We recall what we (humans) need to grow and wonder if cells also need the same things to grow, since they are living, too. Since we can't easily study cells from our bodies, we investigate single-celled organisms. We look at data from a scientist, who grew bacteria on agar plates with different nutrient levels. We analyze the data and notice that the quantities of bacteria made increased with increasing nutrient levels. We read about other unicellular organisms and figure out that they are living things that need food to make more of themselves. We figure out: Cells need food to make more cells. More cells grow when they have more food around them. There are single-celled (unicellular) and many-celled (multicellular) living things. Cells are living things. All living things are made of cells
- **Lesson 11: How do cells get what they need to grow? (1 class period)**
    - CK-12 Life Science for Middle School: 2. Cell Biology
        - 2.5 Cell Membrane and 2.10 Diffusion
    - We observe onion cells using microscopes. We add saltwater, then plain water, to the onion skin and observe changes in the cells. We use our observations to explain how plant cells let

water out of and into the cell. We figure out: Plant cells have a cell wall and a cell membrane. The cell wall is a structure that is unique to plants and helps the cell maintain its shape. The cell membrane and cell wall act as a barrier and allow things the cell needs (food, nutrients, etc.) into and out of the cell.

- **Lesson 12: How do the structures and systems in the body work together to heal the injury? (2 class periods)**
  - CK-12 Life Science for Middle School: 11. Human Biology
    - 11.4 Skin Health and 11.7 Bone Health
  - We revisit the timeline of healing from Lesson 1 and develop explanations for how healing happens based on each event we had listed. We come to consensus about how the healing in the foot happened, developing a list of key science ideas. We use what we have figured out about healing so far to see if we can explain how the systems in our body interact to support the healing process. We figure out: The body reacts to an injury by swelling, which increases blood flow and brings extra fluid to injured tissue to help it heal. The healing process for the foot is similar to how other body parts and other living things heal as well.
- **Lesson 13: How is the process of growing similar to healing? (1 class period)**
  - We apply what we have figured out about healing to explain a related phenomenon, growth. We revisit the Driving Question Board and discuss all of our questions that we have now answered, which leads us to revise our main question to include growth. We reflect on and celebrate our experiences in this unit and this year of OpenSciEd science. We figure out: Children have growth plates in their skeletons which are gaps between their bones. Growth in humans is similar to healing. Cells fill a gap in each tissue/body part. The same structures and systems that are needed to heal are needed to grow.
- **Lesson 14: How can shifting our perceptions of ability and disability allow us to be more thoughtful about how we make our environments more accessible? (3 class periods)**
  - We revise our definition of healing to include thinking about the impacts on the way our body functions. Then we consider how we are still able to achieve our goals even when the way our body functions changes. We read and hear about five stories from people with disabilities, the challenges they face, as well as their perception of their disability. We brainstorm ways to adapt and redesign our environment in order to make it more accessible to people with disabilities. We figure out: A person could be healed, but that part of the body may have a different function than before. Some disabilities are temporary and some are permanent. Some disabilities are visible and some are invisible. Many disabled people count disability as an important part of their identity. It is something to celebrate and take pride in. It's important for environments to be designed to be more accessible for all people.

Unit Learning Goal and Scale *(Level 2.0 reflects a minimal level of proficiency)*	
Standard(s): MS-LS1-1: Conduct an investigation to provide evidence that living things are made of cells, which is the smallest unit of life that can be considered alive.	
4.0	• Conducts a thorough investigation providing detailed evidence that demonstrates a deep understanding that living things are made of cells. Uses advanced tools or techniques for data collection and analysis.
3.0	• Conducts an investigation and provides evidence that living things are made of cells, showing a good understanding of cells as the smallest unit of life.
2.0	• Conducts an investigation with some evidence that living things are made of cells, but the evidence may be incomplete or partially incorrect.
1.0	• Conducts an investigation with limited or unclear evidence about the role of cells in living organisms. The evidence may be insufficient or irrelevant.

0.0	● No investigation or evidence provided.

Standard(s): MS-LS1-2: Develop and use a model to describe how cells function to support the health of organisms.	
4.0	● Develops a highly accurate and detailed model that clearly describes how cells function to support the health of organisms, including accurate representations and explanations of cellular interactions.
3.0	● Develops and uses a model to describe how cells function to support the health of organisms. The model is accurate and provides a clear explanation, but may lack some detail.
2.0	● Develops a model that partially describes how cells function to support the health of organisms. The model may have inaccuracies or lack detail.
1.0	● Develops a model that inadequately describes how cells function to support the health of organisms. The model may be inaccurate or missing key elements.
0.0	● No model developed or model is completely inaccurate.

Standard(s): MS-LS1-3: Use argument supported by evidence for how the body is organized into systems of cells, tissues, organs, and systems of organs that work together to carry out the functions of life.	
4.0	● Constructs a well-supported argument using comprehensive and relevant evidence to explain how the body is organized into systems of cells, tissues, organs, and organ systems that work together. The argument is coherent, logical, and includes multiple lines of evidence.
3.0	● Uses evidence to support a coherent argument about how the body is organized into systems of cells, tissues, organs, and organ systems that work together. The argument is logical and includes relevant evidence.
2.0	● Uses evidence to provide an argument about how the body is organized into systems of cells, tissues, organs, and organ systems, but the argument may be incomplete or lack clarity.
1.0	● Provides an argument with minimal evidence about the organization of body systems. The argument may be poorly structured or unsupported by relevant evidence.
0.0	● No argument or evidence provided.

Standard(s): MS-LS1-8: Gather and synthesize information to describe how the structure and function of the body systems work together to maintain health and function.	
4.0	● Gathers and synthesizes information from various sources to create an insightful description of how the structure and function of body systems work together to maintain health and function. The description integrates concepts and provides in-depth analysis.
3.0	● Gathers and synthesizes information to describe how body systems work together to maintain health and function. The description is clear and accurate but may not include extensive detail.
2.0	● Gathers information and provides a basic description of how body systems work together to maintain health and function. The description may be general or lack depth.
1.0	● Gathers limited information and provides a vague description of how body systems work together. The description may lack coherence or fail to address key concepts.
0.0	● No information gathered or description provided.

Interdisciplinary Connections

ELA Indicators:

- Analyze scientific texts to determine the central ideas or conclusions.
- Cite specific textual evidence to support analysis of science and technical texts.
- Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) to address a question or solve a problem.
- Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.
- Use precise language and domain-specific vocabulary to inform about or explain the topic.
- Conduct short research projects to answer a question, drawing on several sources and refocusing the inquiry when appropriate.
- Gather relevant information from multiple print and digital sources; assess the credibility and accuracy of each source; and integrate the information while avoiding plagiarism.
- Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) on grade 7 topics, texts, and issues, building on others' ideas and expressing their own clearly.
- Present claims and findings, emphasizing salient points in a focused, coherent manner with pertinent descriptions, facts, details, and examples; use appropriate eye contact, adequate volume, and clear pronunciation.
- Include multimedia components and visual displays in presentations to clarify claims and findings and emphasize salient points.

Mathematics Indicators:

- Analyze proportional relationships and use them to solve real-world and mathematical problems.
- Recognize and represent proportional relationships between quantities.
- Apply and extend previous understandings of operations with fractions to add, subtract, multiply, and divide rational numbers.
- Use properties of operations to generate equivalent expressions.
- Solve real-life and mathematical problems using numerical and algebraic expressions and equations.
- Solve real-life and mathematical problems involving angle measure, area, surface area, and volume.
- Draw, construct, and describe geometrical figures and describe the relationships between them.
- Use random sampling to draw inferences about a population.
- Draw informal comparative inferences about two populations.
- Investigate chance processes and develop, use, and evaluate probability models.

Integration of 21st Century Skills

Indicators:

To function in the 21st Century workplace, a variety of skills need to be developed and strengthened. Some of these skills include:

1. **Developing and Using Models**
2. **Planning and Carrying Out Investigations**
    - Supported in the science lab setting but useful in many aspects of life.
3. **Constructing Explanations and Designing Solutions**
    - Supporting explanations with research and experimentation.
4. **Engaging in Argument from Evidence**

5. **Analyzing and Interpreting Data**
    - Collected during labs or proposed scenarios.
6. **Creativity and Innovation**
    - Brainstorm, collaborate, and incorporate group ideas.
7. **Critical Thinking and Problem Solving**
    - Follow the steps of the scientific method.
8. **Communication and Collaboration**
    - All types of communication are needed: oral, written, and nonverbal communication in a variety of forms and contexts. It is also important to listen effectively to decipher meaning, including knowledge, values, attitudes, and intentions.
9. **Information Literacy**
    - Use information accurately and creatively for the issue or problem at hand.
10. **Media Literacy**
    - Apply a fundamental understanding of the ethical and legal issues surrounding the access and use of media.
11. **ICT (Information, Communications, and Technology) Literacy**
    - Use technology as a tool to research, organize, evaluate, and communicate information.
12. **Flexibility and Adaptability**
    - Adapt to varied roles, jobs, responsibilities, schedules, and contexts.
13. **Initiative and Self-Direction**
    - Set goals, balance short-term and long-term goals. Utilize time and manage workload efficiently. Monitor, define, prioritize, and complete tasks without direct oversight. Demonstrate commitment to learning as a lifelong process. Reflect critically on past experiences to continue to improve.
14. **Social and Cross-Cultural Skills**
    - Know when it is appropriate to listen and when to speak. Conduct themselves in a respectable manner. Learn and respect cultural differences and work effectively with people from a range of social and cultural backgrounds. Respond open-mindedly to different ideas and values.
15. **Productivity and Accountability**
    - Set and meet goals, even in the face of obstacles.
16. **Leadership and Responsibility**
    - Use interpersonal and problem-solving skills to influence and guide others toward a goal. Inspire others to reach their very best via example and selflessness. Demonstrate integrity and ethical behavior in using influence and power. Act responsibly with the interests of the larger community in mind.