NEPTUNE CITY SCHOOL DISTRICT

Science
Curriculum
Grade 6

NEPTUNE CITY SCHOOL DISTRICT
Office of the Chief School Administrator, Principal
210 West Sylvania Avenue
Neptune City, NJ 07753

The Neptune City School District is appreciative and proud to accept and align the curriculum of the NEPTUNE CITY School District to properly prepare the Neptune City students for successful integration into the NEPTUNE CITY High School Educational Program.

April 1, 2025 Document C1#1

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SCHOOL DISTRICT MISSION STATEMENT

The Neptune City School District, in partnership with the parents and the community, will support and sustain an excellent system of learning, promote pride in diversity, and expect all students to achieve the New Jersey Student Learning Standards at all grade levels to become responsible and productive citizens.

NEPTUNE CITY SCHOOL DISTRICT

SCIENCE
GRADE 6
CURRICULUM

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NEPTUNE CITY SCHOOL DISTRICT

Science
Grade 6

Acknowledgements

The Science Grade 6 curriculum was developed through the dedicated efforts of Amy Corbet-Elsbree, middle school science teacher, with guidance of the district's curriculum steering committee members including Dolores Dalelio, Department Chairperson , Stacie Ferrara, Ed.D., STEM Supervisor, and Sally A. Millaway, Ed.D., Director for Curriculum, Instruction and Assessment.

Mrs. Corbet-Elsbree is commended for her dedication in developing this curriculum utilizing the UbD format and Open SciEd framework. The curriculum guide was written in alignment with the 2020 New Jersey Student Learning Standards for Science and highlights the 3-dimensional nature that these standards bring to the teaching and learning of science. The guide also includes alignment to the 2016 New Jersey Student Learning Standards for Mathematics and English Language Arts and the 2020 New Jersey Student Learning Standards in Computer Science and Design Thinking and Career Readiness, Life Literacies, and Key Skills.

This curriculum guide includes instructional strategies and resources that focus on developing scientifically literate students and provides opportunities for students to make sense of science. It is our hope that this guide will serve as a valuable resource for the staff members who teach this course and that they will feel free to make recommendations for its continued improvement.

NEPTUNE CITY SCHOOL DISTRICT

DISTRICT MISSION STATEMENT

The primary mission of the NEPTUNE CITY School District is to prepare all of our students for a life-long learning process and to become confident, competent, socially- and culturally-conscious citizens in a complex and diverse world. It is with high expectations that our schools foster:

- A strong foundation in academic and modern technologies
- A positive, equitable, and varied approach to teaching and learning
- An emphasis on critical thinking skills and problem-solving techniques
- A respect for and an appreciation for our world, its resources, and its diverse people
- A sense of responsibility, good citizenship, and accountability
- An involvement by the parents and the community in the learning process

NEPTUNE CITY School District

Educational Outcome Goals

The students in the NEPTUNE CITY schools will become life-long learners and will:

- Become fluent readers, writers, speakers, listeners, and viewers with comprehension and critical thinking skills.
- Acquire the mathematical skills, understandings, and attitudes that are needed to be successful in their careers and everyday life.
- Understand fundamental scientific principles, develop critical thinking skills, and demonstrate safe practices, skepticism, and open-mindedness when collecting, analyzing, and interpreting information.
- Become technologically literate.
- Demonstrate proficiency in all New Jersey Student Learning Standards (NJSLS).
- Develop the ability to understand their world and to have an appreciation for the heritage of America with a high degree of literacy in civics, history, economics and geography.
- Develop a respect for different cultures and demonstrate trustworthiness, responsibility, fairness, caring, and citizenship.
- Become culturally literate by being aware of the historical, societal, and multicultural aspects and implications of the arts.
- Demonstrate skills in decision-making, goal setting, and effective communication, with a focus on character development.
- Understand and practice the skills of family living, health, wellness and safety for their physical, mental, emotional, and social development.
- Develop consumer, family, and life skills necessary to be a functioning member of society.
- Develop the ability to be creative, inventive decision-makers with skills in communicating ideas, thoughts and feelings.
- Develop career awareness and essential technical and workplace readiness skills, which are significant to many aspects of life and work.

SCIENCE
GRADE 6

COURSE DESCRIPTION

The Grade 6 Science curriculum takes an integrated approach to teaching science, and includes the following topics: light; thermal energy; weather; climate; water cycle; plate tectonics; rock cycle; natural hazards; cells and systems. In each unit, students will observe and make sense of a phenomenon or problem. Investigations are driven by students' questions that arise from their interactions with the phenomena. Students learn how to construct scientific explanations and how to design evidence-based solutions. This course will provide students with strategies and tools to think critically about personal and societal issues and needs. Students can then contribute meaningfully to decision-making processes, such as discussions about climate change and innovative solutions to local and global problems.

INTEGRATED SOCIAL AND EMOTIONAL LEARNING COMPETENCIES

The following social and emotional competencies are integrated in this curriculum document:

Self-Awareness	
x	Recognize one's own feelings and thoughts
x	Recognize the impact of one's feelings and thoughts on one's own behavior
x	Recognize one's personal traits, strengths and limitations
	Recognize the importance of self-confidence in handling daily tasks and challenges
Self-Management	
x	Understand and practice strategies for managing one's own emotions, thoughts and behaviors
x	Recognize the skills needed to establish and achieve personal and educational goals
x	Identify and apply ways to persevere or overcome barriers through alternative methods to achieve one's goals
Social Awareness	
x	Recognize and identify the thoughts, feelings, and perspectives of others
x	Demonstrate an awareness of the differences among individuals, groups, and others' cultural backgrounds
x	Demonstrate an understanding of the need for mutual respect when viewpoints differ
	Demonstrate an awareness of the expectations for social interactions in a variety of setting
Responsible Decision Making	
x	Develop, implement and model effective problem solving and critical thinking skill
x	Identify the consequences associated with one's action in order to make constructive choices
x	Evaluate personal, ethical, safety and civic impact of decisions.
Relationship Skills	
x	Establish and maintain healthy relationships
x	Utilize positive communication and social skills to interact effectively with others
	Identify ways to resist inappropriate social pressure
x	Demonstrate the ability to present and resolve interpersonal conflicts in constructive ways
x	Identify who, when, where, or how to seek help for oneself or others when needed

Unit Plan Title	Laboratory Safety
Suggested Time Frame	2-4 days

Overview / Rationale
Safety is the laboratory and classroom setting is important for students and teachers. Safety is reviewed at the beginning of each school year in science courses and should be demonstrated and adhered to by teachers and students in all laboratory activities including demonstrations and lab investigations.

<table>
<tr><th colspan="2">Stage 1 – Desired Results</th></tr>
<tr><td colspan="2">Established Goals:
Although there are no specific NJSLS in Science describing safety procedures or rules, teachers should refer to the standards in each unit that requires and utilizes laboratory activities, demonstrations and investigations to support meeting the standard(s).</td></tr>
<tr><td>Essential Questions:
● How can accidents and injuries be avoided in the classroom and laboratory settings?
● What steps should be taken to respond to emergencies and accidents in the classroom, laboratory and workplace setting?</td><td>Enduring Understandings:
● Safety precautions are important for all areas of life and should be practiced by everyone on a daily basis.
● It is important that safety practices are understood and exercised in the classroom, laboratory, and on the job.</td></tr>
<tr><td colspan="2">Knowledge:
Students will know…
● Lab safety rules and expectations
● Names and uses of lab equipment
● Location and use of safety equipment</td></tr>
<tr><td colspan="2">Skills:
Students will be able to…
● Explain appropriate health and safety practices in the classroom and laboratory.
● Identify common hazards in the classroom and laboratory.
● Identify name and use of lab equipment
● Explain how to respond to various safety situations and accidents.
● Demonstrate how to use basic lab equipment and safety equipment.</td></tr>
</table>

Interdisciplinary Connections
New Jersey Student Learning Standards for English Language Arts (2016) NJSLSA.R1. Read closely to determine what the text says explicitly and to make logical inferences and relevant connections from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text. NJSLSA.R10. Read and comprehend complex literary and informational texts independently and proficiently with scaffolding as needed. **NJSLS Career Readiness,Life Literacies, and Key Skills (2020)** 9.4.2.CI.1: Demonstrate openness to new ideas and perspectives (e.g., 1.1.2.CR1a, 2.1.2.EH.1, 6.1.2.CivicsCM.2). 9.4.2.CT.2: Identify possible approaches and resources to execute a plan (e.g., 1.2.2.CR1b, 8.2.2.ED.3). 9.4.2.CT.3: Use a variety of types of thinking to solve problems (e.g., inductive, deductive). **NJSLS Computer Science and Design Thinking (2020)** 8.2.8.NT.1: Examine a malfunctioning tool, product, or system and propose solutions to the problem.

Student Resources
HS Safety Contract (Flinn) https://www.flinnsci.com/high-school-student-safety-contract---english/dc10494/ MS Safety Contract (Flinn) https://www.flinnsci.com/middle-school-science-safety-contract/dc10642/ Spanish version Safety Contract https://www.flinnsci.com/middle-school-science-safety-contract---spanish/dc10643/
Teacher Resources
Flinn Safety Course for teachers online (free with registration) https://labsafety.flinnsci.com/ NSTA Safety Resources https://www.nsta.org/topics/safety Duty of Care https://static.nsta.org/pdfs/DutyOfCare.pdf Safety and the NGSS https://static.nsta.org/pdfs/Safety%20and%20the%20Next%20Generation%20Science%20Standards_29Oct2020_FINAL.pdf

Safety Practices with Demonstrations
https://static.nsta.org/pdfs/MinimumSafetyPracticesAndRegulations.pdf

Labeling of Chemicals
https://static.nsta.org/pdfs/GloballyHarmonizedSystemOfClassificationAndLabelingOfChemicals.pdf

Eye Protection
https://www.nsta.org/eye-protection-and-safer-practices-faq

K-12 Universal Legislation

Amistad Law N.J.S.A. 18A 52:16A-88 Every board of education shall incorporate the information regarding the contributions of African Americans to our country in an appropriate place in the curriculum of elementary and secondary school students.

Diversity and Inclusion Law (N.J.S.A. 18A:35-4.36a)

Beginning in the 2021-2022 school year, each school district shall incorporate instruction on diversity and inclusion in an appropriate place in the curriculum of students in grades kindergarten through 12 as part of the district's implementation of the New Jersey Student Learning Standards.

Holocaust Law (N.J.S.A. 18A:35-28) Every board of education shall include instruction on the Holocaust and genocides in an appropriate place in the curriculum of all elementary and secondary school pupils. The instruction shall further emphasize the personal responsibility that each citizen bears to fight racism and hatred whenever and wherever it happens.

LGBT and Disabilities Law (N.J.S.A. 18A:35-4.35) A board of education shall include instruction on the political, economic, and social contributions of persons with disabilities and lesbian, gay, bisexual, and transgender people, in an appropriate place in the curriculum of middle school and high school students as part of the district's implementation of the New Jersey Student Learning Standards. N.J.S.A.18A:35-4.36 A board of education shall have policies and procedures in place pertaining to the selection of instructional materials to implement the requirements of N.J.S.A. 18A:35-4.35

Stage 2 – Assessment Evidence
Pre-Assessments: What do you know about lab safety? ***Formative Assessments:***

Lab equipment- names and uses
Room layout and safety equipment location
Use of Safety equipment- eye wash, hood, fire blanket, fire extinguisher

Summative Assessments:
Safety Test

Performance Task(s):
Safety Practical

Stage 3 – Learning Plan

- Explain and demonstrate lab expectation
- Safety tour of classroom- hood, eyewash, safety gas valve, eye goggle cabinet
- Practice fire drill
- Review Safety equipment - name, location, use
- Review scenarios and how to call for help
- Model how to handle lab equipment
- Name lab equipment and use
- Review safety procedures
- Explain how to dispose of chemicals and broken glass

Unit Plan Title	6.1 Light and Matter
Suggested Time Frame	18 days

Overview / Rationale
This unit on light and matter begins with a perplexing phenomenon of one-way mirrors and how this material can act as both a mirror and a window at the same time. Students directly observe and investigate the one-way mirror phenomenon using a scaled box model built from two combined boxes with a flashlight in one box, darkness in the other box, and a one-way mirror in between the two. Through this initial investigation, students figure out that the one-way mirror acts like a mirror on the light side of the system and a window on the dark side of the system. This experience prompts students to wonder: Why do we sometimes see different things when looking at the same object?

<table>
<tr><th colspan="2">Stage 1 – Desired Results</th></tr>
<tr><td colspan="2">Established Goals:
MS-PS4-2: Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials. [Clarification Statement:Emphasis is on both light and mechanical waves. Examples of models could include drawings, simulations, and written descriptions.] [Assessment Boundary: Assessment is limited to qualitative applications pertaining to light and mechanical waves.]
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. [Assessment Boundary: Assessment does not include mechanisms for the transmission of this information.]</td></tr>
<tr><td>Essential Questions:
Why do we sometimes see different things when looking at the same object?
What is light?
How can different materials affect what we see?</td><td>Enduring Understandings:
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.
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.
A material can have different structures, even at a microscale, that cause different amounts of light to transmit through or reflect off of it.</td></tr>
</table>

	● 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. ● 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.
Knowledge: *Students will know…* ● An object can be seen when light reflected from its surface enters the eyes. ● When light shines on an object, it is reflected or transmitted through the object, depending on the object's material. ● The path that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and water, air and glass) where the light path bends. ● Each sense receptor responds to different inputs (electromagnetic), transmitting them as signals that travel along nerve cells to the brain. The signals are then processed in the brain.	
Skills: *Students will be able to…* ● Develop a model to identify the important parts of the system and how those parts interact that could cause an object to look different in different light conditions. ● Ask questions that arise from observations of a phenomenon in which an object appears different depending on the light conditions within the defined system. ● Ask questions that can be investigated in the classroom and frame a hypothesis about what we will see from both sides of the box model if we change the amount of light on either side (structure). ● Modify a model based on evidence to match changes in what we see when we change the light in the box model (structure). ● Ask a testable question to determine how an object's material (structure; independent variable) influences the amount of light transmitted and reflected (function; dependent variable). ● Use evidence to modify a model to explain how an object's material (structure) influences the path of light as it transmits through or reflects off the material (function). ● Develop a model to describe the unobservable mechanisms that affect how a material's microscale structures change how light reflects off and transmits through the material (function). ● Revise a model to explain the observable one-way mirror phenomenon caused by unobservable interactions between light, the people, and the one-way mirror, which reflects and transmits about the same amount of light.	

- Ask questions to model the path of light as it travels through the lens of the eye, and to explain how the shape and composition of the lens causes the path of light to change directions (refract) before reaching the retina at the back of the eye.
- Develop a model that describes how the eye responds to (interacts with) different inputs of light and transforms those inputs to signals that travel along the optic nerve to the brain, which processes the signals into what we "see."
- Construct and revise an explanation using a model to explain why an object appears different (effect) depending on the interaction between light and an object's material and how the brain processes signals (causes).
- Use a model to describe how differences in light on both sides of a one-way mirror strengthens or weakens the one-way mirror phenomenon due to changing the components and interactions within and between systems.
- Apply science ideas and evidence from classroom investigations to explain a common, real-world phenomena in which a material designed for light transmission and to look transparent to the eye and brain functions as a one-way mirror due to the relationship the material has to other parts in the system.

Interdisciplinary Connections
New Jersey Student Learning Standards-ELA (2016) SL.8.5. Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest. *(MS-PS4-2)* WHST.6-8.8. Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation. (MS-LS1-8) **New Jersey Student Learning Standards- Computer Science & Design Thinking (2020)** 8.2.8.ED.2: Identify the steps in the design process that could be used to solve a problem. 8.2.8.ED.3: Develop a proposal for a solution to a real-world problem that includes a model (e.g., physical prototype, graphical/technical sketch). 8.2.8.ED.7: Design a product to address a real-world problem and document the iterative design process, including decisions made as a result of specific constraints and trade-offs (e.g., annotated sketches). 8.2.8.NT.3: Examine a system, consider how each part relates to other parts, and redesign it for another purpose.

Student Resources
Readings/References ● Lesson 4 - How is a one-way mirror made? ● Lesson 6 - How do eyeglasses help people see better? ● Lesson 8 - Walt Disney Concert Hall Case Study **Supporting Text pages** ● Handouts - All Student Handouts for Lesson 1 to 8 (Spanish Version) ● Achieve 3000 Articles - Light and Matter **Videos** ● Lesson 1 - Music Lesson Video (https://www.youtube.com/watch?v=ocs6BXQPOgg&list=PLSLDxqPb5NQlC1r3Y8UT-C0oGrb04fuFe&t=7s) ● Lesson 1 - Box Model Investigation (https://www.youtube.com/watch?v=KaJ_Q1OJ2mQ&list=PLSLDxqPb5NQlC1r3Y8UT-C0oGrb04fuFe&index=3) ● Lesson 6 - How the Eyes Work (https://www.youtube.com/watch?v=0NR6ArO8iFI&list=PLSLDxqPb5NQlC1r3Y8UT-C0oGrb04fuFe&index=4)
Teacher Resources
Teachers can access OpenSciEd resources with an account at https://www.openscied.org/: **Texts:** ● Lesson Slides for Lessons 1 to 8 ● Lesson-Specific Teacher Resources (Rubrics, References, Answer Keys) ● OpenEdSci Teacher Handbook ● Teacher Edition: Lessons 1-8 **Key Vocabulary:** ■ Reflect, Refract, Mirror, Lens, Transparent, Transmit, Absorb, Model, System, Light, Solid, Liquid, Gas, Matter, Pupil, Cornea, Retina, Optic Nerve **Websites:** ● Scholastic Study Jams - Light ● Scholastic Study Jams - Light Absorption, Reflection, & Refraction ● Scholastic Study Jams - The Senses: Seeing **Materials:** ● Material List from OpenSciEd

Stage 2 – Assessment Evidence
Pre-Assessments: Initial diagram to explain phenomena - Students share initial models to explain the phenomenon in Lesson 1 on day 1, and the class engages in a Consensus Discussion on day 3. In Lesson 2, pay attention on day 2 when students develop their group models and share their thinking in the Building Understandings Discussion. As a pre-assessment, pay particular attention to students' inclusion of important parts of the system and arrows or lines showing interaction between the parts. Look for the following: (1) agreement on key components or parts to include, such as two rooms or sides, a mirror-window between the sides, one side being lit, one side being dark; (2) uncertainty or disagreement on whether the people or eyes are an important part; and (3) use of a "path of light" model, "line of sight" model, or combination, which can be indicated by the way students use or do not use arrows in their diagrams: arrows pointing away from the eyes or arrows pointing away from the source of the light and bouncing away from objects, and arrows pointing into the eyes or a combination of the above. Driving Question Board - The Driving Question Board is another opportunity for pre-assessment. You can see the types of questions your students ask and what they are asking about. It is also important that the class comes up with a set of questions to support investigations as you begin the unit. This means your class will need more open-ended, testable questions that are asking how or why something is happening. You may need to spend time helping students turn close-ended questions into open-ended ones that will lead the class toward more-productive investigations. **Formative Assessments:** Lesson 5 - Classroom Consensus Model Each Lesson - Progress Tracker and Student Self-Assessments **Summative Assessments:** LinkIt 6.1 Light and Matter Unit Test (TBD) Lesson 7 - Handout 1: Explaining the one-way mirror phenomenon Lesson 7 - Handout 2: Self Assessment and Peer Feedback Lesson 7 - Handout 3: Final explanation: One-way Lesson 8 - Portraits Through Glass: Individual Assessment

Stage 3 – Learning Plan
Lesson 1 (4 days): How can something act like a mirror and a window at the same time? We watch a puzzling video of a person who can see their reflection in what seems to be a mirror. The person doesn't see the people on the other side of the mirror, but those people 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. **Lesson 2 (3 days): What happens if we change the light?** 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. **Lesson 3 (3 days): What happens when light shines on the one-way mirror?** 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. **Lesson 4 (1 day): How do similar amounts of light transmit through and reflect off the one-way mirror?** 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. **Lesson 5 (1 day): How do light and the one-way mirror interact to cause the one-way mirror phenomenon?** 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 adults all see the music student. We realize that a little light reflects off the adults and enters the student's eyes, which makes us wonder why the student doesn't see the adults. **Lesson 6 (2 days): Why does the music student not see the adults?** In this lesson, we know that light has reflected off the adults and enters the student's eyes. We wonder why the student can't see them. 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.

Lesson 7 (1 day): Why do the music student and the adults see the music student but the music student can't see the adults?
In this lesson, we review the class models from Lessons 5 and 6, the class science ideas list, and our individual Progress Trackers. As a class, we develop a written explanation to answer the question: Why do the adults see the music student? We individually draft an explanation to answer the question: Why does the music student see themself but not the adults? We self-assess our explanations and give and receive peer feedback on them. We then revise a final explanation.

Lesson 8 (3 days): Why do we sometimes see different things when looking at the same object?
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.

Unit Plan Title	6.2 Thermal Energy
Suggested Time Frame	37 Days

Overview / Rationale
This unit on thermal energy transfer begins with students testing whether a new plastic cup sold by a store keeps a drink colder for longer compared to the regular plastic cup that comes free with the drink. Students investigate the different cup features to explain the phenomenon, starting with the lid. Through a series of lab investigations and simulations, students find that there are two ways to transfer energy. They are then challenged to design their own drink container that can perform as well as the store-bought container.

Stage 1 – Desired Results

Established Goals:
New Jersey Student Learning Standards in Science (2020)

- **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. *[Clarification Statement: Emphasis is on qualitative molecular-level models of solids, liquids, and gases to show that adding or removing thermal energy increases or decreases kinetic energy of the particles until a change of state occurs. Examples of models could include drawing and diagrams. Examples of particles could include molecules or inert atoms. Examples of pure substances could include water, carbon dioxide, and helium.]*
- **MS-PS3-3:** Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer. *[Clarification Statement: Examples of devices could include an insulated box, a solar cooker, and a Styrofoam cup.]*
- **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. *[Clarification Statement: Examples of experiments could include comparing final water temperatures after different masses of ice melted in the same volume of water with the same initial temperature, the temperature change of samples of different materials with the same mass as they cool or heat in the environment, or the same material with different masses when a specific amount of energy is added.]*
- **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. *[Clarification Statement: Examples of empirical evidence used in arguments could include an inventory or other representation of the energy before and after the transfer in the form of temperature changes or motion of object.]*
- **MS-PS4-2*:** Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials. *[Clarification Statement: Emphasis is on both*

light and mechanical waves. Examples of models could include drawings, simulations, and written descriptions.] ● **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. *These performance expectations are developed across multiple units. This unit reinforces or works toward these Next Generation Science Standards Performance Expectations that students should have previously developed or will develop more fully in future units.	
Essential Questions: ● How can containers keep stuff from warming up or cooling down? ● What is energy? ● What is the difference between an open and a closed system? ● How can a closed system still gain or lose heat? ● What are two ways energy might be transferred into a closed system?	**Enduring Understandings:** ● Temperature is a measure of the average kinetic energy (KE) of the particles in a sample of matter. ● Kinetic energy is transferred from one particle to another in a particle collision. ● Collisions between particles can transfer kinetic energy (KE or motion energy) from one particle to another. ● Energy transfer speeds up with more contact and slows down with less contact; thus, energy transfer happens faster within and between solids and slower within and between gasses. ● The amount of matter and type of matter that is warming up or cooling down affects how fast energy transfer happens and how much energy is needed.
Knowledge: *Students will know that…* ● Gasses and liquids are made of molecules or inert atoms that are moving about relative to each other. In a liquid, the molecules are constantly in contact with others; in a gas, they are widely spaced except when they happen to collide. In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations. ● The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter. ● 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. In science, heat is used only for this second meaning; it refers to the energy transferred due to the temperature difference between two objects. (secondary to MS-PS1-4) ● Temperature is not a measure of energy; the relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present.	

- Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present. (MS-PS3-3), (MS-PS3-4)
- When the kinetic energy of an object changes, there is inevitably some other change in energy at the same time. (MS-PS3-5)
- The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment. (MS-PS3-4)
- Energy is spontaneously transferred out of hotter regions or objects and into colder ones. (MS-PS3-3)
- 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. (MS-PS4-2)
- The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that is likely to limit possible solutions. (secondary to MS-PS3-3)
- A solution needs to be tested and then modified on the basis of the test results in order to improve it. There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (secondary to MS-PS3-3)

Skills:
Students will be able to...

- Develop an initial model to describe a phenomenon in which a substance changes temperature and identify structural parts of the system that slow down or speed up the temperature change (function).
- Ask questions that arise from careful observation and can be investigated in the classroom to test how parts of the cup systems contribute to warming up or maintaining the temperature of the substance inside.
- Plan and carry out an investigation to gather evidence to answer scientific questions about how parts of the cup system relate to the temperature change of the liquid inside.
- Analyze and interpret data to find patterns indicating which parts of the cup system (features) influence the temperature change of the substance inside the system.
- Develop and use a model to explain how the best-performing and worst-performing cup systems affect the temperature change of a substance inside a system.
- Plan an investigation to investigate how the lid (a structural feature of the cup system) works to slow the temperature change (function) of a substance inside the system.
- Plan and carry out investigations to determine the effect of a lid on temperature change and mass change in systems that are more open and less open.
- Analyze and interpret data by applying concepts of probability to calculate the mathematical mean to compare the temperature change and mass change across conditions (patterns) and use these measures to make claims about the effect of the lid.
- Develop a model to describe why mass is lost in some conditions but not others (open systems versus less-open systems), using a particle model of matter for liquids and gases.

- Collect and analyze different forms of data to identify patterns across our data sources that serve as evidence that condensation that forms on the outside surface of a cold cup system comes from the air outside the system.
- Construct an argument to support the claim that water forming on the outside surface of a cold cup system comes from the air outside the system and is not leaving the system through the walls.
- Develop and use a particle model of matter for solids, liquids, and gases to show how structural differences in a cup system allow water molecules to leave the system at some points in the system but not at others.
- Plan an investigation and in the design, identify the controls, the tools needed to gather the data, and how much data is needed to support a claim about how much liquid (matter) leaves two different cup systems over 30 days.
- Develop two models to show relationships among the parts of the mostly closed cup system and how light and heat or cold (i.e., mechanisms) cause the liquid inside to warm up or cool down (effect).
- Develop and use models to describe how light transmission through, reflection off, and absorption by cup walls causes changes in the temperature (effect) of water inside the cup.
- Carry out an investigation to measure temperature inside and outside a cup system to test whether heat or cold moves through the wall of the system.
- Develop models based on evidence to explain that matter is made of particles that are in motion, and though the individual particles are not visible to the eye, their collective behavior can be observed as more or less movement depending on the matter's temperature.
- Construct an explanation about why food coloring moves more in hot water than in cold water using the idea that at the particle scale, particles in liquids at warmer temperatures have more kinetic energy than particles in liquids at cooler temperatures.
- Carry out an investigation to look for patterns in data generated by using an interactive simulation of the particles in a gas (which are too small to be observed) to observe the kinetic energy of individual particles and the transfer of energy when they collide.
- Analyze and interpret data to mathematically represent the cause-and-effect relationships between the average kinetic energy of the particles of a gas, the temperature of the gas, and the total kinetic energy of all the particles in the gas.
- Carry out investigations using a particle model of matter (with marble manipulatives and computer simulations) to generate evidence that one way the temperature of matter changes over time is that kinetic energy is transferred in collisions between the particles (matter) within and between solids, liquids, and gasses.
- Develop and use models to track how energy spontaneously transfers out of hotter regions and into colder ones and causes changes in the water's temperature within the cup system.
- Construct written arguments supported by empirical evidence and scientific reasoning to support claims describing how energy spontaneously transfers out of hotter regions or objects and into colder ones.
- Obtain and use information from scientific texts to evaluate the function of certain design features in minimizing energy transfer into a system.

- Develop a consensus model for explaining two mechanisms for energy transfer into a system, and design features that minimize energy transfer into a system.
- Design a solution for a cup system with features (structures) to slow energy transfer into the liquid inside the cup (function).
- Carry out investigations to collect data to evaluate the performance of cup systems that slow energy transfer given the criteria and constraints of the problem, and to modify design features (structures) based on test results (functions).
- Design a solution that is modified based on test results to improve the features (structures) to better slow energy transfer (effect) by reducing the absorption of light or opportunity for particle collisions (function/cause).
- Carry out investigations to collect data to evaluate the performance of cup systems that slow energy transfer given the criteria and constraints of the problem, and to propose ways to optimize design features (structures) based on the test results (functions).
- Develop a model based on patterns in performance that can be used to predict ways to minimize or maximize energy transfer into or out of a variety of systems.
- Evaluate a design solution for a disaster blanket that includes several design features (structure) to minimize energy transfer (function) that could result in body heat loss.

Interdisciplinary Connections
New Jersey Student Learning Standards in English Language Arts (2016) RST.6-8.1. Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions. *(MS-PS3-5)* RST.6-8.3. Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks. *(MS-PS3-3)(MS-PS3-4)* RST.6-8.7. Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). *(MS-PS1-4)* SL.8.5. Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest. *(MS-PS4-2) (MS-ETS1-4)* WHST.6-8.1. Write arguments focused on discipline content. *(MS-PS3-5)* WHST.6-8.7. Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration. (MS-PS3-3) *(MS-PS3-4)* **New Jersey Student Learning Standards in Mathematics (2016)** MP.2. Reason abstractly and quantitatively. (MS-PS3-4) (MS-PS3-5) *(MS-ETS1-4)* 6.RP.A.1. Understand the concept of ratio and use ratio language to describe a ratio relationship between two quantities. *(MS-PS3-5)* 6.NS.C.5. Understand that positive and negative numbers are used together to describe quantities having opposite directions or values (e.g., temperature above/below zero, elevation above/below sea level, credits/debits, positive/negative electric charge); use positive and negative numbers to represent quantities in real-world contexts, explaining the meaning of 0 in each situation. (MS-PS1-4) 6.SP.B.5. Summarize numerical data sets in relation to their context. *(MS-PS3-4)*

7.SP. Develop a probability model and use it to find probabilities of events. Compare probabilities from a model to observed frequencies; if the agreement is not good, explain possible sources of the discrepancy. *(MS-ETS1-4)*
7.RP.A.2. Recognize and represent proportional relationships between quantities. *(MS-PS3-5)*
8.F.A.3. Interpret the equation y = mx + b as defining a linear function, whose graph is a straight line; give examples of functions that are not linear. *(MS-PS3-5)*

New Jersey Student Learning Standards inComputer Science & Design Thinking (2020)
8.2.8.ED.2: Identify the steps in the design process that could be used to solve a problem.
8.2.8.ED.3: Develop a proposal for a solution to a real-world problem that includes a model (e.g., physical prototype, graphical/technical sketch).
8.2.8.ED.7: Design a product to address a real-world problem and document the iterative design process, including decisions made as a result of specific constraints and trade-offs (e.g., annotated sketches).
8.2.8.NT.3: Examine a system, consider how each part relates to other parts, and redesign it for another purpose.
8.2.8.ETW.2: Analyze the impact of modifying resources in a product or system (e.g., materials, energy, information, time, tools, people, capital).
8.2.8.ETW.3: Analyze the design of a product that negatively impacts the environment or society and develop possible solutions to lessen its impact.

Student Resources

Readings/References
- Lesson 10 - Reading on James Joule's Experiment
- Lesson 16 - Bright Light and Temperature Investigation
- Lesson 16 - Cup Diameter Investigation
- Lesson 16 - Environmental Impact Test
- Lesson 16 - Price Check Test
- Lesson 16 - Regular Light and Temperature Investigation

Supporting Text pages
- Handouts - All Student Handouts for Lesson 1 to 18 (Spanish Version)
- Achieve 3000 Articles - Thermal Energy

Technology
- Particle Heating and Cooling Simulation
- Molecular View of a Liquid Simulation
- Molecular View of a Gas Simulation
- Gas Particle Simulation
- Conduction in Solids Reduces Simulation
- Conduction in Solids Full
- Collision Up Close Simulation

Teacher Resources
Teachers can access OpenSciEd resources with an account at https://www.openscied.org/: **Texts:** ● Lesson Slides for Days 1 to 18 of OpenSciEd (available online at OpenSciEd.org) ● Lesson-Specific Teacher Resources (Rubrics, References, Answer Keys) (available online at OpenSciEd.org) ● OpenEdSci Teacher Handbook ● Teacher Edition: Lessons 1-6 ● Teacher Edition: Lessons 7-14 ● Teacher Edition: Lessons 15-18 **Key Vocabulary:** ■ Temperature, Structure, Mechanism, Vacuum, Insulate, Absorb, Claim, Solid, Liquid, Gas, Matter, Condensation, Mixture, Evaporation, Particle Motion, Energy, Energy Transfer, Conduction, Kinetic Energy, Transmit, Ambient Light, Reflecting Light, Porosity **Websites:** ● PBS Energy Sources ● Bill Nye - Thermal Energy ● Scholastic Study Jams - Heat ● Forms of Energy - Energy Laws **Videos:** ● Lesson 4 - Time-lapse Water in a Glass (https://www.youtube.com/watch?v=Q4P6N0ZrF2o&list=PLSLDxqPb5NQlDIUbyvh5b8h7l3EfoY3DN&index=2) ● Lesson 4 - Slow-motion Video Steam & Evaporation (https://www.youtube.com/watch?v=npkBC4GYodg&list=PLSLDxqPb5NQlDIUbyvh5b8h7l3EfoY3DN&index=3) ● Lesson 10 - Peppermint Candy in Different Water (https://www.youtube.com/watch?v=Bjy9av_hm4Y&list=PLSLDxqPb5NQlDIUbyvh5b8h7l3EfoY3DN&index=4) ● Lesson 13 - Preparing Magnetic Marbles (https://www.youtube.com/watch?v=6AFdGd___Nk&list=PLSLDxqPb5NQlKwSsLF_1Dzl2x88AQiJQ0&index=2) **Materials:** ● Material List from OpenSciEd

Stage 2 – Assessment Evidence
Pre-Assessments: Initial Models in Science Notebooks - The initial models developed during the lesson are a good opportunity to pre-assess student understanding of systems thinking, particle models, and energy transfer. The two most important times to do this include: (1) between day 1 and day 2, after students have developed their initial cup system models and (2) during the Consensus Discussion on day 2 when they develop an initial model for a related system. For the initial cup system models, look and listen for ● agreement on the components of the system models (such as the walls, lids, straws, water inside, air inside between the water and the lid, and ice), ● agreement that the structural components (parts of the cups) have some similarities (made of plastic) and differences (thin versus thick), and ● disagreement about how the drink inside warms up (processes or mechanisms such as heat or light going into the cup and air or cold leaving the cup). These disagreements will motivate the need for further investigations. Driving Question Board Reinforce for students to generate open-ended questions, such as how and why questions, to post to the board, but celebrate any questions students share even if they are close-ended questions. Make note of any close-ended questions and use navigation time throughout the unit to have your students practice turning these kinds of questions into open-ended questions when they relate to the investigations underway. **Formative Assessments:** Lesson 5 - Cold Lemonade on a Hot Day! - Claim, Evidence, Reasoning Framework Lesson 6 - Explaining the Effect of Different Lid Designs Lesson 14 - Icing Injuries Assessment **Summative Assessments:** LinkIt 6.2 Thermal Energy Unit Test (TBD) Lesson 16 - Cold Cup Design Challenge: Iced drinks bought from coffee shops and restaurants warm up and water down too quickly, especially on warm, sunny days. Stores sell reusable cups that keep a drink colder for longer and reduce environmental impacts, but these cups can be expensive. Using everyday materials, students will design, build and evaluate a cup that uses the best design features to keep a drink as cold as store bought cups. Lesson 18 - Disaster Blanket Design Assessment: In emergencies, shelter or a place to sleep is very important. Often people spend nights outside on the ground. The government is trying to identify a solution that will keep people warm when

they need to sleep directly on the ground. They are considering three different types of blankets and evaluating how well each of them will keep people warm. Given the government's constraints and criteria, students will make a recommendation based on the provided data for which blanket the government should choose. Students will explain their reasoning for their recommendations and will use data to justify their blanket choice**.**

Stage 3 – Learning Plan
Lesson 1 (3 days): Why does the temperature of the liquid in some cup systems change more than in others? 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 so 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. **Lesson 2 (2 days): What cup features seem most important for keeping a drink cold?** 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. **Lesson 3 (2 days): How are the cup features that keep things cold the same or different for keeping things hot?** 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. **Lesson 4 (3 days): How does a lid affect what happens to the liquid in the cup?** 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. **Lesson 5 (1 day): Where does the water on the outside of the cold cup system come from?** 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.

Lesson 6 (2 days): How can we explain the effect of a lid on what happens to the liquid in the cup over time?
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.

Lesson 7 (1 day): If matter cannot enter or exit a closed system, how does a liquid in the system change temperature?
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.

Lesson 8 (2 days): How does a cup's surface affect how light warms up a liquid inside the cup?
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.

Lesson 9 (1 day): 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?
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.

Lesson 10 (2 days): What is the difference between a hot and a cold liquid?
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.

Lesson 11 (1 day): Why do particles move more in hot liquids?
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.

Lesson 12 (2 days): How does the motion of particles compare in a sample of matter at a given temperature?
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.

Lesson 13 (2 days): 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?
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.

Lesson 14 (3 days): Does our evidence support that cold is leaving the system or that heat is entering the 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.

Lesson 15 (3 days): How do certain design features slow down the transfer of energy into a cup?
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.

Lesson 16 (2 days): How can we design a cup system to slow energy transfer into the liquid inside it?

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.

Lesson 17 (2 days): How can we improve our first design to slow energy transfer into the cup system even more?
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.

Lesson 18 (3 days): How can containers keep stuff from warming up or cooling down?
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.

Unit Plan Title	6.3 Weather, Climate and Water Cycling
Suggested Time Frame	41 Days

Overview / Rationale
This unit on weather, climate, and water cycling is broken into four separate lesson sets. In the first two lesson sets, students explain small-scale storms. In the third and fourth lesson sets, students explain mesoscale weather systems and climate-level patterns of precipitation. The unit starts out with anchoring students in the exploration of a series of videos of hailstorms from different locations across the country at different times of the year. These cases spark questions and ideas for investigations, such as investigating how ice can be falling from the sky on a warm day, how clouds form, why some clouds produce storms with large amounts of precipitation and others don't, and how all that water gets into the air in the first place. The second half of the unit is anchored in the exploration of a weather report of a winter storm that affected large portions of the midwestern United States. The maps, transcripts, and video that students analyze show them that the storm was forecasted to produce large amounts of snow and ice accumulation in large portions of the northeastern part of the country within the next day. This case sparks questions and ideas for investigations around trying to figure out what could be causing such a large-scale storm and why it would end up affecting a different part of the country a day later.

Stage 1 – Desired Results

Established Goals:

New Jersey Student Learning Standards in Science (2020)

- **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. *[Clarification Statement: Emphasis is on qualitative molecular-level models of solids, liquids, and gasses to show that adding or removing thermal energy increases or decreases kinetic energy of the particles until a change of state occurs. Examples of models could include drawing and diagrams. Examples of particles could include molecules or inert atoms. Examples of pure substances could include water, carbon dioxide, and helium.]*
- **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. *[Clarification Statement: Emphasis is on the ways water changes its state as it moves through the multiple pathways of the hydrologic cycle. Examples of models can be conceptual or physical.] [Assessment Boundary: A quantitative understanding of the latent heats of vaporization and fusion is not assessed.]*
- **MS-ESS2-5:** Collect data to provide evidence for how the motions and complex interactions of air masses result in changes in weather conditions. *[Clarification*

Statement: Emphasis is on how air masses flow from regions of high pressure to low pressure, causing weather (defined by temperature, pressure, humidity, precipitation, and wind) at a fixed location to change over time, and how sudden changes in weather can result when different air masses collide. Emphasis is on how weather can be predicted within probabilistic ranges. Examples of data can be provided to students (such as weather maps, diagrams, and visualizations) or obtained through laboratory experiments (such as with condensation).] [Assessment Boundary: Assessment does not include recalling the names of cloud types or weather symbols used on weather maps or the reported diagrams from weather stations.] ● **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. *[Clarification Statement: Emphasis is on how patterns vary by latitude, altitude, and geographic land distribution. Emphasis of atmospheric circulation is on the sunlight-driven latitudinal banding, the Coriolis effect, and resulting prevailing winds; emphasis of ocean circulation is on the transfer of heat by the global ocean convection cycle, which is constrained by the Coriolis effect and the outlines of continents. Examples of models can be diagrams, maps and globes, or digital representations.] [Assessment Boundary: Assessment does not include the dynamics of the Coriolis effect.]*	
Essential Questions: ● Why does a lot of hail, rain, or snow fall at some times and not others? ● What is the weather? ● What factors influence weather? ● What is the difference between weather and climate? ● What factors influence a region's climate?	**Enduring Understandings:** ● Global movements of water and its changes in form are propelled by sunlight and gravity. ● The complex patterns of the changes and the movement of water in the atmosphere, determined by winds, landforms, and ocean temperatures and currents, are major determinants of local weather patterns. ● Variations in density due to variations in temperature drive a global pattern of interconnected ocean currents. ● Water continually cycles among land, ocean, and atmosphere via evaporation, condensation and crystallization, and precipitation. ● Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, and landforms. These interactions vary with latitude, altitude, and local and regional geography, all of which can affect oceanic and atmospheric flow patterns. ● The ocean exerts a major influence on weather and climate by absorbing

	energy from the sun, releasing it over time, and globally redistributing it through ocean currents.

Knowledge:
Students will know…

- Rain and wind accompany some hail events.
- 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.
- Hailstones are made of ice, often in layers.
- 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.
- 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 ground 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.
- 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.
- Air near the surface of the ground is warmed from thermal energy transfer from the ground through conduction.
- Air is a mixture of different types of substances) in the gas state including water vapor which is measured as humidity.
- 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.
- Water molecules are attracted to each other.
- 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.
- Clouds are made of water droplets or water crystals (ice) and molecules of gas (including water vapor).
- 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.
- 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, lifting the warm air up and over.
- Climate is the long-term average of weather in an area, typically averaged over 30 years.
- The temperature of the ocean affects the humidity of the air moving over it.
- 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.

Skills:

Students will be able to…

- Develop an initial model to describe changes and mechanisms at both the observable and the particle level that cause hail to fall during a brief time period.
- Ask questions that arise from careful observation of phenomena and gaps in our current models to clarify and seek additional information about how changes to the flow of matter and energy in the air above and around a location on Earth's surface could cause short-duration precipitation events and longer-duration precipitation events (scale).
- Analyze and interpret data using graphical displays (e.g., maps, charts, graphs, tables) of large data sets to identify temporal and spatial patterns in the range of weather conditions that lead to the formation of precipitation (hail)
- Analyze and interpret sets of data to identify patterns (similarities across data sets) that provide evidence that air temperature changes based on altitude above Earth's surface independently of geographical location or time of year.
- Develop a model to show the relationship between the motion of the molecules that make up air and the energy of those molecules to explain the patterns of change in air temperature at various altitudes.
- Plan an investigation collaboratively by identifying variables of interest, tools to gather data, methods for obtaining measurements, and how many sites are necessary to determine if a pattern exists between the temperature of the ground and the temperature of the air right above it.
- Collect, analyze, and interpret data using graphical displays (tables of data we obtain from our own investigations) to identify ground and surface air temperature patterns as they relate to incoming and reflected solar radiation.
- Develop and use a model to describe phenomena and unobservable mechanisms that track the transfer of energy from the Sun to the ground and then to the air at the surface.
- Conduct investigations to collect and use observations and data as evidence to determine the effects of thermal energy transfer to the air in contact with Earth's surface.
- Develop and use a model to track and describe how transferring thermal energy to and from a fixed amount of air (matter) in a closed system affects its volume and density due to unobservable mechanisms (causes), including changes in the speed and spacing of the molecules that make up that air.
- Analyze and interpret data including graphical displays of large data sets to identify cause-and-effect relationships to construct an explanation of how the movement of

parcels of air via conduction and convection causes the upward and downward movement of air in clouds.

- Develop and use a model to describe how thermal energy from the Sun causes movement of parcels of air via conduction to cause the formation of clouds.
- Obtain information by reading scientific texts adapted for classroom use and summarize key ideas to determine that the air is a mixture of different types of gases (matter), including water vapor, and that relative humidity is a measure of a small proportion of molecules of water vapor in the air.
- Plan and conduct an investigation using a model to gather data to serve as evidence to support a claim about where water in the air originates (inputs).
- Develop and use a model to predict and describe changes in particle motion and the movement of water molecules from a liquid into the air (via evaporation) when the thermal energy of the water increases (cause).
- Carry out an investigation to collect data about the patterns in the appearance and growth of water droplets in humid air that is cooled down and how water droplets interact to serve as evidence to explain the causes of condensation (effect).
- Develop and use a model to describe unobservable mechanisms that explain why the mutual attraction between water molecules and a decrease in their speed causes them to condense (effect) when water reaches a low enough temperature (condensation/boiling point).
- Obtain and communicate information by reading scientific texts adapted for classroom use to determine key ideas and cause-and-effect relationships related to what clouds are made of, why we can see them, the role of cloud condensation nuclei, and methods of cloud seeding.
- Apply scientific ideas and principles to construct an explanation and represent interactions between energy and matter that lead to the condensation and crystallization of water in the atmosphere and the formation of clouds.
- Modify a model—based on evidence—to build a storm system by changing the input variables, such as temperature and humidity, and measuring changes in the output, the size of storm formation.
- Evaluate the limitations of the thunderstorm simulation, identifying which aspects of the system are represented in the model and which additional aspects could be added to account for thunderstorm development.
- Construct an explanation that includes correlational relationships between temperature and humidity that can be used to predict storm development.
- Use mathematical thinking and construct an explanation to predict patterns in the relationship between the relative strength of two opposing forces on different objects and the resulting change in motion of those objects.
- Develop a model to represent balanced and unbalanced forces on an object suspended by an upward current of air, and use the model to predict and explain whether the object would remain suspended (stability) or start moving downward or upward (change) due to the relative strength of the opposing forces.
- Collaboratively plan an investigation to collect data, identifying independent and dependent variables and controls and how the data are recorded, to serve as the basis for

evidence that greater temperature differences between the ground and the air higher in the atmosphere cause greater lift (effect) of air.

- Develop a model to represent how varying inputs of thermal energy affect the resulting movement of air (output) to show the relationships among variables that can predict greater lift and movement of air.
- Construct an explanation that includes qualitative relationships between variables that predict the movement of a fluid (air), based on the transfer of energy that drives the motion.
- Develop and use a model to describe and explain unobservable mechanisms that drive the cycling of matter and the flow of energy into and through the air to cause some storms to produce large hail while others do not.
- Construct an explanation, using a model and previously developed science ideas, to explain what causes hurricanes to form, grow, and produce (effect) strong winds and large amounts of rain (cycling of matter and flow of energy).
- Analyze data using maps of national weather conditions and forecasts to identify temporal and spatial relationships (patterns) between precipitation, cloud cover, temperature, and air pressure.
- Develop an initial model to explain how precipitation that is happening in one part of the country at one point in time could be connected (cause/effect) to what is predicted to happen in another part of the country at a later time.
- Use a previous model to identify mechanisms at the observable and the particle levels to explain the causes of this large-scale weather phenomenon.
- Ask questions about possible patterns in and causes for a storm affecting large parts of the country over multiple days or causes shared between this precipitation event and a smaller-scale, shorter-duration precipitation event (a hailstorm).
- Use graphical displays of temperature, humidity, and radar data to identify temporal and spatial patterns as air masses interact in a large storm system.
- Use an argument supported by empirical evidence and scientific reasoning based on patterns from data and maps to support an explanation that precipitation forms along the boundary of two air masses with different temperature and humidity characteristics.
- Develop and use models to observe and describe the complex patterns of change that occur when warm and cold air masses interact in the atmosphere.
- Use computational thinking to describe how patterns in data support explanations of the changes in weather that occur where warm and cold air masses interact.
- Analyze data using maps of air pressure recorded over the country at different points in time and forecasts (temporal and spatial relationships) to identify patterns (the movement of low-pressure systems) and the relationship between this (patterns) and the location of fronts and precipitation.
- Construct an explanation that includes the qualitative relationships presented in a weather forecast among (1) the area of lowest air pressure and where it will move to, (2) the locations of the fronts, and (3) where precipitation will fall, using scientific ideas and principles to explain what would be causing these three things to be connected to one another.

- Compare and critique two arguments on the same topic and analyze whether they emphasize similar or different mechanisms (cause) in their explanations of the patterns in how the weather changed (effect) during the Jan. 19, 2019 storm.
- Apply scientific ideas and related evidence to evaluate whether the new mechanisms (air mass movement, interaction of fronts, and low pressure areas cause that were used in an explanation of one large-scale storm are also needed to explain the patterns in the how the weather will change [effect] in the predictions made for three other storms occurring at a different time of year.
- Ask questions about typical patterns and causes related to these in how air masses move across the country and how where a place is located (near the coast or inland, high elevation or low, in the northeast vs. southwest) affects the amount and type of precipitation that the place receives over more than a few years.
- Use visualized precipitation data from a large data set to identify spatial patterns in the direction of air masses movement that influences long term weather patterns in predictable ways.
- Integrate text and media to gather additional information to clarify how ocean currents that circulate cooler and warmer waters to different latitudes affect air mass temperature and humidity.
- Use sea surface temperature maps and tabular precipitation data to articulate a spatial pattern connecting offshore ocean temperatures to precipitation on land.
- Analyze and interpret data to identify patterns in the data to provide evidence of the relationship between elevation (cause), air temperature, and precipitation (effect).
- Use graphical displays of global climate datasets (e.g., sunlight, ocean temperature, water and wind movement) to identify relationships between the transfer of energy and the cycling of matter that explain the location and climate of rainforests around the globe.

Interdisciplinary Connections
New Jersey Student Learning Standards in English Language Arts (2016) RST.6-8.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). *(MS-PS1-4)* RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts. (MS-ESS2-5) RST.6-8.9 Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic. (MS-ESS2-5) WHST.6-8.8 Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation. *(MS-ESS2-5)* SL.8.5 Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest. *(MS-ESS2-6)* **New Jersey Student Learning Standards in Mathematics (2016)** 6.NS.C.5 Understand that positive and negative numbers are used together to describe quantities having opposite directions or values (e.g., temperature above/below zero, elevation above/below

sea level, credits/debits, positive/negative electric charge); use positive and negative numbers to represent quantities in real-world contexts, explaining the meaning of 0 in each situation. (MS-PS1-4) (MS-ESS2-5)
MP.2 Reason abstractly and quantitatively. (MS-ESS2-5)

New Jersey Student Learning Standards in Computer Science & Design Thinking (2020)
8.2.8.ED.2: Identify the steps in the design process that could be used to solve a problem.
8.2.8.ED.3: Develop a proposal for a solution to a real-world problem that includes a model (e.g., physical prototype, graphical/technical sketch).
8.2.8.ITH.2: Compare how technologies have influenced society over time.
8.2.8.ETW.4: Compare the environmental effects of two alternative technologies devised to address climate change issues and use data to justify which choice is best.

Student Resources

Readings/References

- Lesson 4 - Cloudy Day: Sample Data for Colorado Springs
- Lesson 8 - Procedure for Investigation C
- Lesson 9 - Can Other Gases In The Air Turn Into Liquids or Solids?
- Lesson 13 - Tracing Paths of Hailstones
- Lesson 14 - Cloud Cover and Precipitation Map
- Lesson 18 - Weather Forecast Maps
- Lesson 19 - Why Do Air And Water Spin In Different Directions On Earth?
- Lesson 20 - How The Ocean Changes Our Weather

Supporting Text pages

- Handouts - All Student Handouts for Lesson 1 to 22 (Spanish Version)
- Achieve 3000 Articles - Weather, Climate and Water Cycling

Videos

- Tennis Ball Size Hail in Fort Scott, KS (https://www.youtube.com/watch?v=9PeACgaLC4A&list=PLSLDxqPb5NQkeQ6keX5p55s7glZVvLg-b&index=2)
- Hail Storm in Phoenix, AZ (https://www.youtube.com/watch?v=Lx4TUg3TD-s&list=PLSLDxqPb5NQkeQ6keX5p55s7glZVvLg-b&index=3)
- Lesson 6 - Cloud Growth Time-lapse (https://www.youtube.com/watch?v=Lf64E66odvc&list=PLSLDxqPb5NQkeQ6keX5p55s7glZVvLg-b&index=5)
- Lesson 8 - Slow-motion Water Droplet Collision (https://www.youtube.com/watch?v=zme6jTvoRB8&list=PLSLDxqPb5NQkeQ6keX5p55s7glZVvLg-b&index=4)
- Lesson 14 - Weather Report & Forecasting (https://www.youtube.com/watch?v=NlriliiyWmI&list=PLSLDxqPb5NQkeQ6keX5p55s7glZVvLg-b&index=6)

- Lesson 18 - Weather Report & Forecasting (https://www.youtube.com/watch?v=XiUATBKzNSY&list=PLSLDxqPb5NQkeQ6keX5p55s7glZVvLg-b&index=7)

Teacher Resources
Teachers can access OpenSciEd resources with an account at https://www.openscied.org/: **Texts:** ● Lesson Slides for Days 1 to 22 of OpenSciEd (available online at OpenSciEd.org) ● Lesson-Specific Teacher Resources (Rubrics, References, Answer Keys) (available online at OpenSciEd.org) ● OpenEdSci Teacher Handbook ● Teacher Edition: Lessons 1-6 ● Teacher Edition: Lessons 7-13 ● Teacher Edition: Lessons 14-18 ● Teacher Edition: Lessons 19-22 **Key Vocabulary:** ■ Temperature, Humidity, Climate, Water Cycle, Water Vapor, Condensation, Evaporation, Convection, Conduction, Precipitation, Wind, Hail, Ice, Snow, Sleet, Clouds, Thunderstorms, Hurricanes, Blizzards, Air Pressure, Weather Fronts, Elevation, Air Masses, Prevailing Winds **Videos:** ● Lesson 4 - Investigation Setup https://www.youtube.com/watch?v=KJ6LJOOHBVo&list=PLSLDxqPb5NQks_9E11uq8vvJW6OXkRYvt) ● Lesson 5 - Part 1 Investigation Setup (https://www.youtube.com/watch?v=v66IGyjxPHQ&list=PLSLDxqPb5NQks_9E11uq8vvJW6OXkRYvt&index=3) ● Lesson 5 - Part 2 Investigation Setup (https://www.youtube.com/watch?v=Fj0hj_28Iqs&list=PLSLDxqPb5NQks_9E11uq8vvJW6OXkRYvt&index=4) ● Lesson 7 - Investigation Setup (https://www.youtube.com/watch?v=D0ne3Khi1D4&list=PLSLDxqPb5NQks_9E11uq8vvJW6OXkRYvt&index=5) ● Lesson 8 - Part 1 Investigation Setup (https://www.youtube.com/watch?v=d1-MLTgiqPI&list=PLSLDxqPb5NQks_9E11uq8vvJW6OXkRYvt&index=6) ● Lesson 8 - Part 2 Investigation Setup (https://www.youtube.com/watch?v=72MhytbmsZ0&list=PLSLDxqPb5NQks_9E11uq8vvJW6OXkRYvt&index=7) ● Lesson 9 - Investigation Setup (https://www.youtube.com/watch?v=quzVJlQ0qUo&list=PLSLDxqPb5NQks_9E11uq8vvJW6OXkRYvt&index=8)

- Lesson 11 - Part 1 Investigation Setup (https://www.youtube.com/watch?v=sFdZVVPpBUQ&list=PLSLDxqPb5NQks_9E11uq8vvJW6OXkRYvt&index=10)
- Lesson 11 - Part 2 Investigation Setup (https://www.youtube.com/watch?v=ZxXPCxHE9a0&list=PLSLDxqPb5NQks_9E11uq8vvJW6OXkRYvt&index=9)
- Lesson 12 - Investigation Setup (https://www.youtube.com/watch?v=iTPnuchO4WI&list=PLSLDxqPb5NQks_9E11uq8vvJW6OXkRYvt&index=11)

Materials:

- Material List from OpenSciEd

Stage 2 – Assessment Evidence
Pre-Assessments: Initial diagram to explain phenomena Driving Question Board You may need to spend time helping students turn close-ended questions into open-ended ones that will lead the class toward more-productive investigations. **Formative Assessments:** Lesson 6 - Explaining the Movement of Air in a Hailstorm Cloud Each Lesson - Progress Tracker and Student Self-Assessments **Summative Assessments:** LinkIt 6.3 Weather, Climate & Water Cycling Unit Test (TBD) Lesson 13 - Student Transfer Task: Hurricane Assessment Tasks Lesson 17 - Air Pressure Prediction and Map Analysis Lesson 18 - Putting the Pieces Together Lesson 22 - Rainforest Climate Assessment Tasks

Stage 3 – Learning Plan
Lesson 1 (3 days): What causes this kind of precipitation event to occur? 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. **Lesson 2 (1. 5 days): What are the conditions like on days when it hails?** 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. **Lesson 3 (1. 5 days): How does the air higher up compare to the air near the ground?** 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. **Lesson 4 (2. 5 days): Why is the air near the ground warmer than the air higher up?** 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. **Lesson 5 (2. 5 days): What happens to the air near the ground when it is warmed up?** 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. **Lesson 6 (2 days): How can we explain the movement of air in a hail cloud?** 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. **Lesson 7 (2 days): Where did all that water in the air come from, and how did it get into the air?** 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. **Lesson 8 (2 days): What happens to water vapor in the air if we cool the air down, and why?**

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.

Lesson 9 (1 day): Why don't we see clouds everywhere in the air, and what is a cloud made of?
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.

Lesson 10 (2 days): Why do clouds or storms form at some times but not others?
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.

Lesson 11 (2 days): Why don't water droplets or ice crystals fall from the clouds all the time?
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.

Lesson 12 (2 days): What causes more lift in one cloud versus another?
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.

Lesson 13 (3 days): Why do some storms produce (really big) hail and others don't?
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 (2 days): What causes a large-scale precipitation event like this to occur?
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.

Lesson 15 (2 days): What happens with temperature and humidity of air in large storms?

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.

Lesson 16 (2 days): How do warm air masses and cold air masses interact along the boundaries between them?
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.

Lesson 17 (1 day): Is there a relationship between where the air is rising and where precipitation falls?
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.

Lesson 18 (2 days): How can we explain what is happening across this storm (and other large-scale storms)?
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.

Lesson 19 (1 day): Are there patterns to how air masses move that can help predict where large storms will form?
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.

Lesson 20 (2 days): How do oceans affect whether a place gets a lot or a little precipitation?
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.

Lesson 21 (2 days): Why is there less precipitation further inland in the Pacific Northwest than further inland from the Gulf Coast?
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.

Lesson 22 (1 day): How can we explain differences in climate in different parts of the world?
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 Plan Title	6.4 Rock Cycling and Plate Tectonics (Phase II)
Suggested Time Frame	26 days

Overview / Rationale
Students are presented with the earthquake data to determine what, if any, changes had occurred to Mt. Everest. Students find that Mt. Everest has grown in elevation over the years. Students also discover that Mt. Everest is steadily moving to the NE every year. This leads to questions about whether changes are happening to other mountains in the world. Students analyze data from five other mountain peaks and their surroundings and find that some mountains are also growing in elevation, like Mt. Everest, while other mountains are decreasing or not changing in elevation. Students brainstorm ideas for what could be causing these changes to mountains and create an initial consensus model to explain how mountains can move, grow, and shrink. Students analyze plate movement data and carry out investigations to model what could happen as these plates move and interact. Students conclude that plate movement is the cause of earthquakes, while earthquakes are correlated to mountains moving.

Stage 1 – Desired Results

Established Goals:
New Jersey Student Learning Standards in Science (2020)

- **MS-ESS1-4:** Construct a scientific explanation based on evidence from rock strata for how the geologic time scale is used to organize Earth's 4.6-billion-year-old history. *[Clarification Statement: Emphasis is on how analyses of rock formations and the fossils they contain are used to establish relative ages of major events in Earth's history. Examples of Earth's major events could range from being very recent (such as the last Ice Age or the earliest fossils of homo sapiens) to very old (such as the formation of Earth or the earliest evidence of life). Examples can include the formation of mountain chains and ocean basins, the evolution or extinction of particular living organisms, or significant volcanic eruptions.] [Assessment Boundary: Assessment does not include recalling the names of specific periods or epochs and events within them.]*
- **MS-ESS2-1:** Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process. *[Clarification Statement: Emphasis is on the processes of melting, crystallization, weathering, deformation, and sedimentation, which act together to form minerals and rocks through the cycling of Earth's materials.] [Assessment Boundary: Assessment does not include the identification and naming of minerals.]*
- **MS-ESS2-2:** Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales. *[Clarification Statement: Emphasis is on how processes change Earth's surface at time and spatial scales that can be large (such as slow plate motions or the uplift of large mountain ranges) or small (such as rapid landslides or microscopic geochemical reactions), and how many geoscience processes (such as earthquakes, volcanoes, and meteor impacts) usually behave gradually but are punctuated by catastrophic events. Examples of geoscience*

processes include surface weathering and deposition by the movements of water, ice, and wind. Emphasis is on geoscience processes that shape local geographic features, where appropriate.] ● **MS-ESS2-3:** Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of the past plate motions. *[Clarification Statement: Examples of data include similarities of rock and fossil types on different continents, the shapes of the continents (including continental shelves), and the locations of ocean structures (such as ridges, fracture zones, and trenches).] [Assessment Boundary: Paleomagnetic anomalies in oceanic and continental crust are not assessed.]*

Essential Questions:	**Enduring Understandings:**
● What is causing Mt. Everest and other mountains to move, grow, or shrink? ● How are earthquakes related to where mountains are located? ● How does what we find on and below Earth's surface compare in different places? ● What is happening to Earths' surface and the material below it during an earthquake? ● How does plate movement affect the land around mountains such as Mt. Everest? ● How could plate movement help us explain how Mt. Everest and other locations are changing in elevation? ● What happens at mountains where we see volcanic activity? ● What is occurring at locations where two plates are moving away from each other? ● What causes mountains to change? ● Where were Africa and South America in the past? ● Where were the other plates located in the distant past? ● Where did mountains that aren't at plate boundaries today, like the Appalachians and Urals, come from? ● What causes mountains to shrink in elevation? ● How is there an exposed marine fossil on Mt. Everest? And, what other remaining questions from our Driving Question Board can we now answer?	● Mount Everest and other mountains change in height and location. ● After an earthquake occurred in Ridgecrest, California, a shift in the location and the elevation of the surface was observed. ● The properties of solid rock, bedrock, change as we move deeper underground due to increasing pressure and heat. ● Plates on Earth's surface are surrounded by long lines of fault lines. There are many plates that make up the surface of Earth. ● Plates on Earth move at constant speeds and in specific directions. ● When plates on Earth move, they can move together, move apart or slide past each other. Sometimes one plate goes under another and/or pushes another plate up. ● Volcanoes occur where oceanic plates collide with continental plates. Volcanoes can either build up or destroy landforms when they erupt. ● Steaming cracks in the ground can be found along the Mid-Atlantic Ridge in Iceland. ● Mountains change due to plates moving caused by magma moving. ● The distance between continents has been increasing over time. ● Continental plates have moved over the surface of the spherical Earth over many

	millions of years, resulting in their current locations on the globe. ● The Appalachian Mountains are decreasing in elevation, and the Ural Mountains are neither increasing nor decreasing in elevation. ● Scientists can measure both the rate of uplift and the rate of erosion at different mountain sites. ● Ancient marine fossils can be found at the top of many mountains.

Knowledge:
Students will know…

- Some mountains move.
- Mountains can get taller.
- Mt. Everest is growing over time.
- Mountains can also shrink.
- 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 earthquakes 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.
- The surface is often covered with sediment (broken rock, dirt, gravel, sand).
- Sediment and solid rock make up Earth's surface.
- Rocks have different properties, including density and melting point.
- Everywhere we look, solid rock, known as bedrock, is found on, near, or below the surface of Earth.
- The characteristics of rocks change the deeper underground they are.
- As we move deeper underground, temperature increases and rocks are more compressed.
- As rocks become hotter and more compressed, their behavior changes - they change state, and tend to begin to move and shift.
- The rock deep below the ocean bottom is more dense than the rock deep below the continents.
- Sections of bedrock in between these fault lines of cracks from earthquakes are called plates.
- These cracks must go really far down into and through the bedrock to where the rock begins to creep, shift, and move.
- There is evidence of at least two really large and long crack lines on either side of most of the United States.
- There are other plates in the world that can be found in between long lines of fault lines.
- Models of our crust and mantle have scale limitations due to the size of the Earth and its layers.

- 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.
- 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; when plates interact, they can get stuck against or slip against each other, which we can feel as earthquakes.
- Plate movement causes earthquakes.
- Plate movement can cause mountains to get taller.
- Volcanoes occur in some of the same places where earthquakes occur.
- Volcanoes occur in lines where an oceanic plate collides with a continental plate.
- When a more dense oceanic plate collides with a less dense continental plate, the oceanic plate moves under the continental plate.
- The portion of the oceanic plate that moves below the continental plate begins to heat 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 in height when new earth material is added, or shrink when existing earth material is scattered.
- 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 being formed at ridges.
- The pushing of magma on the plates causes the plates to move, which causes changes to mountain elevation and location over time.
- Plate movement causes changes to mountains.
- There are a sequence of events that occur to cause changes to a mountain.
- This sequence involves magma moving and pressing on the crust, which makes the plates move. This plate movement results in changes to the surface of Earth, including changes to mountain height and location.
- 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.
- All major continents were once touching and formed a large single landmass that existed hundreds of millions of years ago.
- Multiple sources of data are needed to determine where plates were located in the past.

- The Appalachian Mountains, 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.
- Erosion rates are a representation of how much an area of land is worn down by all the erosive processes together.
- Uplift rates are a representation of how much the land is being pushed up from below by plate movements.
- The relationship between the erosion rates above the surface and the uplift rates below the surface determine the elevation above sea level.
    - Erosion rates that are higher than uplift rates result in land decreasing in elevation.
    - Erosion rates that are less than uplift rates result in land increasing in elevation.
    - Erosion rates that are equal to uplift rates results in no change in elevation.
- Tectonic 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 to erode the landscape into the distant future.
- We can now better explain our related phenomena using our science ideas.
- We can now explain more questions from our Driving Question Board using our science ideas.

Skills:
Students will be able to…
- Develop a model showing what is happening at a scale larger than we can see (patterns) to help explain what happened to the different mountains to (cause) them to change (in elevation and/or location).
- Ask questions that arise from our analysis of information showing that Mt. Everest and four other mountain peaks are changing to seek additional information about what caused the changes (effects) we read about.
- Present an oral and written argument that earthquakes either caused or are correlated to the elevation and location changes of the mountain cases and Ridgecrest, California.
- Use digital tools to examine a large data set at different spatial and temporal scales to compare global earthquake activity to local activity.
- Develop and use models to describe the structure, composition, and temperature of materials below the surface of Earth, and some of the processes (pressure and heat) that cause changes to those earth materials.
- Construct a scientific explanation based on evidence from text, media, and investigations to explain changes that occur to materials below the surface of Earth that are not directly observable.
- Develop a profile model across the North American plate to explain the changes seen in bedrock after an earthquake by showing what is found at and below the observable surface.
- Construct an explanation using qualitative evidence from class investigations to explain what is happening to the bedrock below the observable surface when an earthquake causes a shift or break in the land.

- Analyze a graphical display of a large data set of plate movement in order to determine whether a causal or correlational relationship exists between plate movement and mountain movement.
- Develop and use models showing what is happening at varying spatial and time scales to describe how plates interact at plate boundaries.
- Construct an argument supporting a model of how plate interactions could cause mountains and earthquakes.
- Apply scientific ideas and evidence to construct an explanation for the processes that cause some of the large scale interactions of Earth's plates that result in the effects (volcanoes) of those interactions.
- Support or refute a claim orally and in writing, based on evidence from multiple locations over a large distance along the ridge to explain what is happening where two plates are moving apart.
- Compare data and evidence from the case cards and the Mid-Atlantic Ridge to determine that volcanoes are correlated with some cases of mountain change, but not the cause of all mountains changing.
- Construct an explanation using representations on the Causal Chain of Events poster to explain how the causal (not correlational) events lead to a mountain changing in elevation or location.
- Analyze maps displaying patterns of large sets of data to determine that Africa and South America could have been touching at the Mid-Atlantic Ridge (spatial relationship) between roughly 125 and 146 million years ago.
- Construct an explanation of changes in the global position of land masses over time including reasoning that shows how rock strata and fossil evidence adequately supports a map of where Earth's land masses (parts of plates that were not created or destroyed as plates were moving) were located millions of years ago.
- Construct a scientific explanation based on evidence from a model that colliding tectonic plates caused the formation of the Appalachian Mountains and the Ural Mountains at time and spatial scales that are not observable.
- Apply mathematical concepts (proportional relationships and unit rates) from the unobservable processes of erosion and plate movement over time to figure out how much Mt. Everest and Mt. Mitchell is changing now and uses these to predict how much they would change in the future.
- Develop and use a model to show the tectonic process of uplift can create mountains at a time scale too large to see.
- Construct an explanation based upon prior investigations and evidence that gradual changes have caused marine fossils to become exposed on mountains due to erosion (accumulating) over time, and those gradual changes will lead to the destruction of the marine fossils due to erosional processes over time.

Interdisciplinary Connections
New Jersey Student Learning Standards in English Language Arts (2016) RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts. (MS-ESS1-4)(MS-ESS2-2)(MS-ESS2-3) RST.6-8.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (MS-ESS2-3) RST.6-8.9 Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic. (MS-ESS2-3) WHST.6-8.2 Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content. (MS-ESS1-4)(MS-ESS2-2) SL.8.5 Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest. (MS-ESS2-1)(MS-ESS2-2) **New Jersey Student Learning Standards in Mathematics (2016)** 6.EE.B.6 Use variables to represent numbers and write expressions when solving a real-world or mathematical problem; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set. *(MS-ESS1-4)*(MS-ESS2-3) 7.EE.B.4 Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities. *(MS-ESS2-3)* 7.EE.B.6 Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities. *(MS-ESS1-4)* MP.2 Reason abstractly and quantitatively. (MS-ESS2-3)

Student Resources
Primary Source Readings ● 6.4 Plate Tectonics & Rock Cycling Student Edition Secondary Source Readings ● Achieve3000 Articles ○ Volcano Rumbles ○ Why is Denver a Mile High? ○ Hiker Blazes the Trail ○ What Oil Brings ○ Earthquake! ○ Volcano Puts on a Show Supporting Text pages ● Handouts - All student handouts are within the lesson folders Technology: ● Chromebook with internet access Websites:

• 6.4 L5 Plate Movement Simulation • 6.4 L4 Where are there Earthquakes in North America? • 6.4 L2 Earthquake Data • 6.4 L12 Ancient Earth Simulation Videos: • Unit 6.4 Student Video Playlist
Teacher Resources
Teachers can access OpenSciEd resources with an account at https://www.openscied.org/: **Texts:** • OpenSciEd Teacher Handbook • 6.4 Elements of NGSS Dimensions • 6.4 Plate Tectonics & Rock Cycling Unit Overview Materials • Unit 6.4 Kit Material List **Technology** • Chromebook with internet access • Desktop with internet access • SmartBoard/Promethean board **Websites:** • 6.4 L5 Plate Movement Simulation • 6.4 L4 Where are there Earthquakes in North America? • 6.4 L2 Earthquake Data • 6.4 L12 Ancient Earth Simulation **Videos:** • **Unit 6.4 Teacher Video Playlist** • **Unit 6.4 Plate Tectonics & Rock Cycling Video Links**

Stage 2 – Assessment Evidence
Pre-Assessments: The student work in Lesson 1 available for assessment should be considered a pre-assessment. It is an opportunity to learn more about the ideas your students bring to this unit. Revealing these ideas early on can help you be more strategic in how to build from and leverage student ideas across the unit. The initial models developed on the first and third days of Lesson 1 are a good opportunity to pre-assess student understanding of Earth's systems, including how land can move and change. At the end of day 1, after students compare their initial models, and during day 2, the class develops an initial consensus model for a mountain growing. On day 3, after students compare

their second initial model for a mountain shrinking, the class develops an initial consensus model.

The Driving Question Board is another opportunity for pre-assessment. Reinforce for students to generate open-ended questions, such as how and why questions and to post to the board. However, any questions students share, even if they are close-ended questions, can be valuable. Make note of any close-ended questions and use navigation time throughout the unit to have your students practice turning these questions into open-ended questions when they relate to the investigations underway.

Formative Assessments:
Students use erosion rate data and uplift rate data to predict how Mt. Everest and Mt. Mitchell will potentially be changed over time into the future.
The Progress Tracker is a thinking tool that was designed to help students keep track of important discoveries that the class makes while investigating phenomena and figures out how to prioritize and use those discoveries to develop a model to explain phenomena. It is important that what the students write in the Progress Tracker reflects their own thinking at that particular moment in time. In this way, the Progress Tracker can be used to formatively assess individual student progress or for students to assess their own understanding throughout the unit. Because the Progress Tracker is meant to be a thinking tool for kids, we strongly suggest it is not collected for a summative “grade” other than for completion.

Summative Assessments:
This is a summative assessment at a point in the unit where students can synthesize what they have figured out. Using models they have co-developed of where the continents might have been in the past based on multiple data sets, students explain why the evidence they have from the data sets supports the model they created and where the continents will be in the future. This is an opportunity for midpoint grading, if needed.This lesson includes a transfer task to give students an opportunity to use the 3 dimensions to make sense of a different phenomenon. In this task it is presented to students that fossil fragments of crinoid organisms ended up towards the top of mountains like Mt. Everest. Scientists were able to see and identify these exposed fossils on mountains without having to dig them up. Using what students know about plate tectonics and the processes of weathering and erosion, they develop a model and explain how this fossil can be at the top of Mt. Everest and how it can be seen at the top of Mt. Everest without having to dig to find it.

Stage 3 – Learning Plan
LESSON 1 (4 days) What is causing Mt. Everest and other mountains to move, grow, or shrink? 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. **LESSON 2 (2 days) How are earthquakes related to where mountains are located?** We develop a systems model to describe Earth's water system. We analyze data to determine what is normal and not normal about temperature and precipitation as it relates to floods and droughts. We do this with our community and six case sites in the United States 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. **LESSON 3 (2 days) How does what we find on and below Earth's surface compare in different places?** 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. **LESSON 4 (2 days) What is happening to Earths' surface and the material below it during an earthquake?** 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. **LESSON 5 (1 day) How does plate movement affect the land around mountains such as Mt. Everest?** 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. **LESSON 6 (3 days) How could plate movement help us explain how Mt. Everest and other locations are changing in elevation?** 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.

LESSON 7 (1 day) What happens at mountains where we see volcanic activity?
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.

LESSON 8 (2 days) What is occurring at locations where two plates are moving away from each other?
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.

LESSON 9 (1 day) What causes mountains to change?
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.

LESSON 10 (2 days) Where were Africa and South America in the past?
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.

LESSON 11 (2 days) Where were the other plates located in the distant past?
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.

LESSON 12 (1 day) Where did mountains that aren't at plate boundaries today, like the Appalachians and Urals, come from?
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.

LESSON 13 (1 day) What causes mountains to shrink in elevation?
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.

LESSON 14 (2 days) How is there an exposed marine fossil on Mt. Everest? And, what other remaining questions from our Driving Question Board can we now answer?
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.

Unit Plan Title	6.5 Natural Hazards (Phase II)
Suggested Time Frame	21 days

Overview / Rationale
Through a 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.

Stage 1 – Desired Results

Established Goals:

New Jersey Students Learning Standards in Science (2020)

- **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. *[Clarification Statement: Emphasis is on how some natural hazards, such as volcanic eruptions and severe weather, are preceded by phenomena that allow for reliable predictions, but others, such as earthquakes, occur suddenly and with no notice, and thus are not yet predictable. Examples of natural hazards can be taken from interior processes (such as earthquakes and volcanic eruptions), surface processes (such as mass wasting and tsunamis), or severe weather events (such as hurricanes, tornadoes, and floods). Examples of data can include the locations, magnitudes, and frequencies of the natural hazards. Examples of technologies can be global (such as satellite systems to monitor hurricanes or forest fires) or local (such as building basements in tornado-prone regions or reservoirs to mitigate droughts).]*
- **MS-ETS1-1:** Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
- **MS-ETS1-2:** Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

Essential Questions:	Enduring Understandings:
● What happens to a community when a tsunami occurs? ● Where do tsunamis happen and what causes them? ● What causes a tsunami to form and move? ● How can we forecast where and when tsunamis will happen and which communities are at risk?	● Triggered by a strong earthquake in the Pacific Ocean in 2011, a massive tsunami caused loss of life and damage to structures along Japan's entire east coast. ● Data reveal patterns in the locations and causes of tsunamis. ● Analyze and evaluate different wave models.

• How can we reduce damage from a tsunami wave? • How are tsunamis detected and warning signals sent? • What are ways we can communicate with people before and during a tsunami? • Which emergency communication systems are the most reliable in a hazard? • How can we model the systems put into place to protect communities? • How can we effectively prepare our communities for a natural hazard?	• An earthquake occurs that could affect communities around the Pacific Ocean. • Many design solutions exist to reduce the damage from tsunami waves. • A complex system exists to detect and warn people of tsunamis. • Communication systems warn people to respond when a tsunami approaches. • Different communication systems and signals have advantages and disadvantages in how they alert people. • Tsunami systems consist of many subsystems working together to meet the overall criteria of the community. • Local communities are at risk of other types of natural hazards.

Knowledge:
Students will know…

- A tsunami is a large wave or surge of water that results from the movement of the ocean floor (e.g., an earthquake).
- Tsunamis cause damage to communities through major flooding of low-lying areas, impacting homes and property and making it hard for people to live there.
- Proposed engineering solutions for tsunami response include a system of detection sensors, warning plans, and solutions for reducing damage.
- Though communities may be impacted by different kinds of natural hazards, a response to most hazards often requires engineers to design technologies that can detect, warn people, and reduce damage.
- Tsunamis form as a result of earthquakes, volcanic eruptions, and landslides.
- Not all earthquakes lead to tsunamis; stronger, shallow earthquakes tend to be 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.
- Physical waves form from a single point of disturbance or movement, and then move outward in a circular pattern from that point.
- The bigger the movement of the ocean floor, the greater the disturbance 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 water 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.

- 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.
- Locations close to water, at lower elevation, and with high population have greater risk for tsunami damage.
- 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.
- Tsunamis happen suddenly and can travel at high speeds over great distances. Depending on where the tsunami forms, communities may 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).
- Groups of people can be affected by hazards in different ways, depending on their access to (1) early warning information, (2) resources to protect themselves and property, and (3) ability to evacuate when necessary.
- Groups particularly at-risk during a hazard are older people, children, people who speak a different language, and those who are sick or require assistance.
- Effective plans account for the people living in a place and the resources communities need to respond appropriately.
- Communication strategies include educating the community before a natural hazard happens and alerting people when the hazard is happening.
- A variety of communication strategies (e.g., signs and symbols, warning sounds, multiple languages) are necessary to ensure that all people at risk understand how to respond quickly and safely in the event of a hazard.
- 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.
- 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.
- 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.

Skills:

Students will be able to…

- Ask questions that arise from careful observations of a sudden natural event that causes damage to communities.
- Apply scientific ideas to design an object, tool, process, or system that detects a tsunami when it starts (cause) and warns people or reduces damage to communities (effect).
- Use graphical displays (maps) of large data sets to identify spatial and temporal patterns in historical tsunami occurrence.
- Use digital tools, including maps and graphs, to analyze large data sets to identify cause-and-effect relationships between characteristics of related geologic forces and resulting tsunamis.
- Integrate quantitative and qualitative scientific information to connect cause-and-effect relationships to predict communities at risk for future tsunami occurrence.
- Analyze and interpret data from different wave models to identify patterns in how the tsunami wave forms and moves toward shore, changing height (amplitude) as it interacts with the ocean floor.
- Evaluate the limitations and benefits of different wave models for explaining how tsunamis form from a movement in the ocean floor (cause), and how they move and change as they approach the shore (effect).
- Apply scientific ideas to construct an explanation for how sudden changes in the ocean floor during an earthquake lead to the formation of a tsunami.
- Construct an explanation that includes qualitative relationships between variables (distance to epicenter, shoreline topography) that predicts which communities are most at risk for damage as a result of a sudden change.
- Make an oral argument based on a systematic evaluation process using relevant scientific principles to support or refute the ability of different existing solutions (structure) to mitigate the effects of tsunamis and meet the needs of at-risk communities (function).
- Critically read scientific text to understand how a system designed to detect tsunamis follows specific criteria (related to earthquake activity) and constraints (related to signal transmission).
- Integrate written text with multimedia displays of tsunami warning and preparedness systems to clarify additional ways communities at-risk of tsunami can mitigate potential future effects.
- Evaluate communication systems, using a systematic process and agreed-upon criteria and constraints, to determine how well the system (structure) communicates with stakeholders (function).

- Use digital tools and/or mathematical concepts to integrate and synthesize information to compare the reliability of emergency communication systems.
- Construct a system model to represent the interactions of subsystems designed to detect, warn communities, and reduce damage from a tsunami hazard.
- Use digital tools to analyze patterns in large data sets (maps) of the history of natural hazards in regions and use this information to forecast future risk.
- Critically read scientific texts adapted for classroom use to obtain scientific and technical information related to predicting the locations and severity of a hazard and understanding the response systems designed to mitigate the effects.
- Communicate scientific and technical information in writing and/or oral presentations about a system designed to meet the criteria and constraints for communicating with identified stakeholder groups about a natural hazard.

Interdisciplinary Connections
New Jersey Student Learning Standards in English Language Arts (2016) RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts. *(MS-ESS3-2) (MS-ETS1-1) (MS-ETS1-2)* RST.6-8.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (MS-ESS3-2) *(MS-ETS1-2)* RST.6-8.9 Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic. (MS-ETS1-2) WHST.6-8.8 Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation. (MS-ETS1-1) WHST.6-8.9 Draw evidence from informational texts to support analysis, reflection, and research. (MS-ETS1-2) **New Jersey Student Learning Standards in Mathematics (2016)** MP.2 Reason abstractly and quantitatively. (MS-ESS3-2) (MS-ETS1-1) (MS-ETS1-2) 6.EE.B.6 Use variables to represent numbers and write expressions when solving a real-world or mathematical problem; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set. *(MS-ESS3-2)* 7.EE.B.4 Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities. *(MS-ESS3-2)* 7.EE.3 Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form (whole numbers, fractions, and decimals), using tools strategically. Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies. *(MS-ETS1-1)* (MS-ETS1-2)

Student Resources
Primary Source Readings ● 6.5 Natural Hazards Student Edition Secondary Source Readings ● Achieve3000 articles ○ Recipe for Disaster Relief ○ Storm Hits East Coast ○ A Tsunami, Where? ○ Shaking Stops, Twittering Begins ○ Japan's Seawalls ○ Getting Ready for Earthquakes Supporting Text pages ● Handouts - All student handouts are within the lesson folders Technology ○ Chromebook with internet access ○ Websites: ■ 6.5 L2 Tsunamis Dataset Visualization ○ Videos: ○ Unit 6.5 Student Video Playlist

Teacher Resources
Teachers can access OpenSciEd resources with an account at https://www.openscied.org/: ● **Texts:** ○ **6.5 Natural Hazards Teacher Edition** ○ **OpenSciEd Teacher Handbook** ○ **6.5 Elements of NGSS Dimensions** ○ **6.5 Natural Hazards Unit Overview Materials** ● **Supplemental Workbooks:** ○ Achieve3000 articles ■ Recipe for Disaster Relief ■ Storm Hits East Coast ■ A Tsunami, Where? ■ Shaking Stops, Twittering Begins ■ Japan's Seawalls ■ Getting Ready for Earthquakes ● **Technology** ● Chromebook with internet access ● Desktop with internet access ● SmartBoard/Promethean board ● 6.5 L2 Tsunamis Dataset Visualization

- [Unit 6.5 Teacher Video Playlist]
- [6.5 Natural Hazards Video Links]

Stage 2 – Assessment Evidence
Pre-Assessments: The student work in Lesson 1 should be considered a pre-assessment, as it is an opportunity to learn more about the ideas your students bring to this unit. Surfacing these ideas early on can help you to be strategic in building upon and leveraging student ideas across the unit. Students will spend time in Lesson 1 developing their ideas around initial design solutions for detecting tsunamis, warning people, and reducing damage. This is a good place to assess their thinking about what a design solution would need to be able to do to protect communities. You can leverage these ideas when they begin to evaluate design solutions in Lessons 5-7. The Driving Question Board is another opportunity for pre-assessment. Encourage students to generate open-ended questions, such as how and why questions. However, any questions students share, even if they are close-ended questions, can be valuable. Make note of any close-ended questions and use navigation time throughout the unit to have your students practice turning these questions into open-ended questions that can be tested through lesson investigations. ***Formative Assessments:*** This formative assessment can be used to understand how well students have developed ideas about (1) how tsunamis form, (2) how tsunamis move, and (3) which coastal communities might be at risk for damage. It also introduces students to their first experience evaluating the risk of different communities based on their characteristics. These initial ideas that students have for rating risk can be used and developed as they evaluate design solutions and community risk in Lessons 5-7. ***Summative Assessments:*** The final task for the unit challenges students to first investigate general regional patterns in risk for other natural hazards, as well as the risk of each natural hazard for their local community. Using this data and their wonderings about how other natural hazards impact communities, students make decisions about which natural hazards to investigate further to develop education and communication plans.

Stage 3 – Learning Plan
Lesson 1 (3 days) What happens to a community when a tsunami occurs? 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. **Lesson 2 (2 days) Where do tsunamis happen and what causes them?** 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. **Lesson 3 (3 days) What causes a tsunami to form and move?** 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 **Lesson 4 (1 day) How can we forecast where and when tsunamis will happen and which communities are at risk?** 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 **Lesson 5 (3 days) How can we reduce damage from a tsunami wave?** 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 **Lesson 6 (1 day) How are tsunamis detected and warning signals sent?** 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. **Lesson 7 (2 days) What are ways we can communicate with people before and during a tsunami?**

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.

Lesson 8 (1 day) Which emergency communication systems are the most reliable in a hazard?
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.

Lesson 9 (1 day) How can we model the systems put into place to protect communities?
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

Lesson 10 (4 days) How can we effectively prepare our communities for a natural hazard?
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.

Unit Plan Title	6.6 Cells and Development (Phase II)
Suggested Time Frame	25 days

Overview / Rationale
This unit on cells and systems begins with students reflecting about activities they do with their bodies and a time when something happened inside their body that prevented them from doing those activities. Students begin by investigating the structures impacted by injury in the foot which leads them to figure out that when one part of the system is injured or broken, the whole system is affected and can't function the way it used to.

Stage 1 – Desired Results	
Established Goals: ● **MS-LS1-1:** Conduct an investigation to provide evidence that living things are made of cells; either one cell or many different numbers and types of cells. *[Clarification Statement: Emphasis is on developing evidence that living things are made of cells, distinguishing between living and non-living things, and understanding that living things may be made of one cell or many and varied cells.]* ● **MS-LS1-2:** Develop and use a model to describe the function of a cell as a whole and ways the parts of cells contribute to the function. *[Clarification Statement: Emphasis is on the cell functioning as a whole system and the primary role of identified parts of the cell, specifically the nucleus, chloroplasts, mitochondria, cell membrane, and cell wall.] [Assessment Boundary: Assessment of organelle structure/function relationships is limited to the cell wall and cell membrane. Assessment of the function of the other organelles is limited to their relationship to the whole cell. Assessment does not include the biochemical function of cells or cell parts.]* ● **MS-LS1-3:** Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells. *[Clarification Statement: Emphasis is on the conceptual understanding that cells form tissues and tissues form organs specialized for particular body functions. Examples could include the interaction of subsystems within a system and the normal functioning of those systems.] [Assessment Boundary: Assessment does not include the mechanism of one body system independent of others. Assessment is limited to the circulatory, excretory, digestive, respiratory, muscular, and nervous systems.]* ● **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. [*Assessment Boundary: Assessment does not include mechanisms for the transmission of this information.*]	
Essential Questions: ● What happened within the student's foot so they could walk again?	**Enduring Understandings:** ● A middle school student injured his foot and could not walk. Over the next 4 months, the

• What do our bones, skin, and muscles do for us? • How can medical images and diagrams help us figure out more about the structures in our body? • Why is there blood in all of these places in the body? • What do nerves do, and why are they in different parts of the body? • What will we see if we look at skin, bone, and muscle with the microscope, too? • Are all things made of cells? • What happened as the skin on top of the foot healed? • What is happening at the site of an injury to fill the gap? What do cells need to grow and make more of themselves? • How do cells get what they need to grow? • How do the structures and systems in the body work together to heal the injury? • How is the process of growing similar to healing? • How can shifting our perceptions of ability and disability allow us to be more thoughtful about how we make our environments more accessible?	foot healed and the student could walk again. • A chicken wing shows the interactions between skin, muscle, and bone during movement. When the bone in the wing is damaged and broken, it cannot function the same as in an uninjured wing. • Medical images and scientific diagrams can be cross-referenced to identify structures within the body. • A blood sample that looks homogenous when newly drawn separates into distinct layers after being left to stand. When viewed with a microscope, blood smears from humans and other mammals contain three different round components. • Nerve cells branch out all over the body to create a system that allows signals to travel throughout the body, including to and from the brain. • Slides of human skin, bone, and muscle samples look different when viewed with a microscope, but each is composed of smaller structures arranged in repeating patterns • We analyze multiple microscopic images of some living and nonliving things as data to determine whether they are all made of cells. • A time-lapse video of skin healing after a bike crash shows the formation of new skin over time. • A gap in skin, muscle, or bone is filled in by the formation of new cells from old cells of the same type, but what do cells need in order to make more cells? • Bacteria, an organism made of one cell, make more of themselves when given nutrients. The more nutrients, the more the bacteria cells make. • Onion cell membranes shrink and expand in the presence of saltwater and plain water, respectively. • Systems in the body interact and work together for the body to be able to heal from injuries.

	● Children have smaller bones than adults and have growth plates in bones that fill in over time and become bone. ● People with different disabilities may have different ways of functioning but everyone has needs and our world should be accessible by all.

Knowledge:
Students will know…

- A student who was previously able to walk was injured in an accident and could no longer walk.
- More than one part of the patient's foot was injured in the same accident.
- 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.
- 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 (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.
- 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, muscle, and bone.
- 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 are structures that allow blood to move 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.
- There are nerve endings in skin, bones, muscles, and other parts of the body.
- Nerve cells have a very unique structure--they have long, thin "branches" or "tentacles" that extend from the center.
- Nerve cells 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 different parts of the body so that they can carry signals between the body and the brain.
- Bone, muscle, and skin have repeating patterns of microscopic structures called cells.
- The unique structures of the cells that make up these different parts of the body are related to their function:
- Many cells work together to form tissues in the body.

- Structure is the characteristic of something (the shape or way it's made or arranged) that supports its function.
- 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.
- New skin cells form from existing skin cells at the site of the injury, causing the wound to get smaller and smaller.
- 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.
- Cells need food to make more cells.
- Cells grow more and make more cells if they have access to more food.
- There are single-celled (unicellular) and many-celled (multicellular) living things.
- Cells are living things.
- All living things are made of cells.
- 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 and the plant maintain its shape.
- The cell membrane and cell wall are structures that act as barriers and allow things the cell needs (food, nutrients, etc.) or does not need into or out of the cell through tiny openings.
- 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.
- Children have growth plates in their skeletons which are gaps between their bones.
- The process that occurs when a person grows is similar to healing because
    - cells fill a gap in each tissue/body part as it heals (or grows), and
    - the same structures and systems that are needed to heal, are needed to grow.
- 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

Skills:

Students will be able to…

- Obtain information from images and doctor's notes to identify patterns between the relationship of important events (effect) and the evidence of interacting subsystems healing (cause).
- Develop an initial model of the healing process that occurs within and between multiple interacting systems and subsystems and restores the foot's function.

- Ask questions that arise from observations of injuries to multiple subsystems that result in the loss of function of the foot (larger complex system).
- Analyze and interpret data to highlight the interactions between subsystems (skin, muscle, bone) within the larger system (foot or wing).
- Revise the experimental design and conduct an investigation to predict the change in function of the chicken wing (effect) when parts are injured (cause).
- Critically read and interpret scientific texts (images and diagrams) adapted for classroom use to describe patterns to figure out that blood and nerves are present in skin, muscle, and bone of a human body.
- Collect data at different scales to answer scientific questions about the components found in blood.
- Critically read scientific text to make sense of patterns within structures we observe in the blood related to their function in the body.
- Gather and synthesize information from scientific text and other sources to describe the basic structure of nerves and nerve cells and explain how its structure supports both the function of those cells within the nervous system and the interactions that occur between nerves and other parts of the body (e.g., skin, bone, muscle).
- Analyze and interpret observational data of microscopic structures of skin, bone, and muscle, relating those structures to the functions of those parts of the body.
- Plan an investigation and construct an argument using evidence from the microscopic scale that all things are not made of cells.
- Develop a model at a zoomed-in scale to describe what changes happen to the structure and function of skin cells at the time of injury.
- Develop a model to predict how the interacting systems and subsystems of groups of skin cells work together to form or repair new tissues and organs.
- Analyze and interpret data from a video and microscopic images at varying spatial and time scales to conclude that new cells come from old cells following a predictable pattern of repeated steps.
- Analyze and interpret data for patterns to identify the relationship between the amount of food (cause) and the amount of bacteria made (effect) to provide evidence that cells need food to grow and make more of themselves.
- Construct a written argument using cause-and-effect relationships to conclude that the cells that make up multicellular organisms need food to make more cells, as do the cells of unicellular organisms.
- Construct an explanation to show that the structure of cell membranes and cell walls (tiny openings) let certain things in and out of cells (function).
- Apply scientific ideas and evidence to construct an explanation for how systems of the body interact to support the healing process in the foot at different scales.
  - Apply science ideas and evidence from classroom investigations to explain a common, real-world phenomenon in which the cells of living things serve particular functions as they interact with one another and other systems to make more cells and grow.
  - Analyze and interpret data to find similarities and differences in people's perceived abilities to function and meet their goals when having disabilities.
  - Define a design problem (inaccessibility of our school environment for people with disabilities) that can be solved through the development of small changes to the current

system (school environment) to improve its accessibility for many people, including those with disabilities.

Interdisciplinary Connections
New Jersey Student Learning Standards in English Language Arts (2016) WHST.6-8.7 Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration. (MS-LS1-1) SL.8.5 Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest. *(MS-LS1-2)* RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts. (MS-LS1-3) RI.6.8 Trace and evaluate the argument and specific claims in a text, distinguishing claims that are supported by reasons and evidence from claims that are not. (MS-LS1-3) WHST.6-8.1 Write arguments focused on discipline content. (MS-LS1-3) WHST.6-8.8 Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation. (MS-LS1-8) **New Jersey Student Learning Standards in Mathematics (2016)** 6.EE.C.9 Use variables to represent two quantities in a real-world problem that change in relationship to one another; write an equation to express one quantity, thought of as the dependent variable, in terms of the other quantity, thought of as the independent variable. Analyze the relationship between the dependent and independent variables using graphs and tables, and relate these to the equation. *(MS-LS1-1) (MS-LS1-2) (MS-LS1-3)*

Student Resources
Primary Source Readings ○ **6.6 Cells & Systems Student Edition** ● **Secondary Source Readings** ○ **Achieve3000 Articles** ■ **New Life Found in Old Park** ■ **Meet the Xenobots** ○ **ReadWorks.org** ■ **The Cells That Make Us** ■ **Operation!** ● **Supporting Text pages** ○ Handouts - All student handouts are within the lesson folders ● **Technology** ○ Chromebook with internet access ○ **Websites:** ■ **6.6 L4 Virtual Microscope Interactive – Cat & Human Blood**

- **6.6 L5 Virtual Microscope Interactive – Nerve**
    - **6.6 L6 Virtual Microscope Interactive – Parts of Body**
    - **6.6 Lesson11 Virtual Microscope Interactive – All Images**
    - **6.6 Lesson11 Virtual Microscope Interactive – Onion Skin**
    - **6.6 Lesson11 Virtual Microscope Interactive – Plants**
  - **Videos:**
- **Unit 6.6 Student Video Playlist**

Teacher Resources
Teachers can access OpenSciEd resources with an account at https://www.openscied.org/:

- **Texts:**
  - **6.6 Cells & Systems Teacher Edition**
  - **6.6 Elements of NGSS Dimensions**
  - **OpenSciEd Teacher Handbook**
  - **6.6 Cells & Systems Unit Overview Materials**
- **Supplemental Workbooks:**
- **Technology**
  - **Chromebook with internet access**
  - **Desktop with internet access**
  - **SmartBoard/Promethean board**
  - **Websites:**
    - **6.6 L4 Virtual Microscope Interactive – Cat & Human Blood**
    - **6.6 L5 Virtual Microscope Interactive – Nerve**
    - **6.6 L6 Virtual Microscope Interactive – Parts of Body**
    - **6.6 Lesson11 Virtual Microscope Interactive – All Images**
    - **6.6 Lesson11 Virtual Microscope Interactive – Onion Skin**
    - **6.6 Lesson11 Virtual Microscope Interactive – Plants**
  - **Videos:**
    - **Unit 6.6 Teacher Video Playlist**
    - **Unit 6.6 Cells Video Links**
    - To learn more about how a wound heals itself: https://www.youtube.com/watch?v=TLVwELDMDWs
    - To learn more about the connection of structure and function of cells in living things: http://www.bozemanscience.com/ngs-ls1a-structure-function
    - To learn more about how to support information processing in our body via the nervous system: http://www.bozemanscience.com/ngs-ls1d-information-processing
    - To learn more about resources (and how to use them) that can be used to support your students in discussing disabilities: https://thenoraproject.ngo/resources

Stage 2 – Assessment Evidence
Pre-Assessments: The student work in Lesson 1 available for assessment should be considered a pre-assessment. It is an opportunity to learn where students are coming in and what ideas they have that you can build on in this unit. The more ideas in your classroom, the better. Specifically, look for students' initial understandings of modeling, asking questions, scale, structure and function, and systems and system models. Collect students' initial models of what they see happening with the foot at a macroscopic level to pre-assess their fluency in three-dimensional learning. Look for students to include both macroscopic and microscopic elements in their initial models of the foot healing. See the related Assessment callout box in the Teacher Guide for additional guidance. The Driving Question Board is another opportunity for pre-assessment. Listen for questions that are open (how/why) and testable versus closed (yes/no) in the classroom. Also listen for questions that are specific to the injured foot healing and questions that are about related phenomena. See the related Assessment callout box in the Teacher Guide for additional guidance. ***Formative Assessments:*** Collect student responses for the two parts of the assessment and use Key: Are Other Things Made of Cells? to see possible student responses and provide feedback to students. This assessment will provide evidence on the progress students are making towards MS-LS1-1: Conduct an investigation to provide evidence that living things are made of cells; either one cell or many different numbers and types of cells. They will not yet be able to argue that all living things are made of cells, but they should be able to argue that parts of living things are made of cells while parts of non-living things are not made of cells. Collect students' exit tickets; in student responses look for students to pull in evidence from the lesson that supports the claim. Students share their argument with a peer to receive feedback using Self-Assessment and Peer Feedback. Using the feedback from their peers about this argument, students reflect on how they would revise their argument.

On *What do bacteria need to make more of themselves?*, students develop an argument for what bacteria need to make more bacteria after engaging with a whole class investigation to see if more bacteria are made when they are given food.

Students construct an explanation from evidence for what is happening when stuff gets into and out of cells. Use Data from *Investigating Red Onion Cells* to assess where students are at in their thinking about the structure of the cell and how things could get in and out of the cell.

Summative Assessments:
Students use the different events from the Healing Timeline as pieces of evidence that different parts of the student's body had healed. In their explanation they include the interactions between the systems that need to occur for that part to heal. Provide students feedback on their explanations using the single point rubric found in the answer key.

Performance Task(s):
The Progress Tracker is a thinking tool that was designed to help students keep track of important discoveries that the class makes while investigating phenomena. This tool can also be used to figure out how to prioritize and use those discoveries to develop a model to explain phenomena. It is important that what the students write in the Progress Tracker reflects their own thinking at that particular moment. We strongly suggest it is not collected for a summative "grade" other than for completion. The Progress Tracker is added to in Lessons 2, 4, 5, 6, 9, 10, 11, and 14.

Stage 3 – Learning Plan
Lesson 1 (4 days) What happened in the student's foot so they could walk again? 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. **Lesson 2 (2 days) What do our bones, skin, and muscles do for us?** 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. **Lesson 3 (1 day) How can medical images and diagrams help us figure out more about the structures in our body?**

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.

Lesson 4 (3 days) Why is there blood in all of these places in the body?
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.

Lesson 5 (2 days) What do nerves do, and why are they in different parts of the body?
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.

Lesson 6 (1 day) What will we see if we look at skin, bone, and muscle with the microscope, too?
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.

Lesson 7 (1 day) Are all things made of 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.

Lesson 8 (1 day) What happened as the skin on top of the foot healed?
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.

Lesson 9 (1 day) What is happening at the site of an injury to fill the gap?
We analyze a video and microscopic images of cells splitting and growing in different organisms. By observing this process at different spatial (zoomed in/out video and images) and time scales (full/half speed video), we make sense of how our body fills a gap at the site of an injury, such as broken skin or bone.

Lesson 10 (2 days) What do cells need to grow and make more of themselves?
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.

Lesson 11 (1 day) How do cells get what they need to grow?
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.

Lesson 12 (2 days) How do the structures and systems in the body work together to heal the injury?
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

Lesson 13 (1 day) How is the process of growing similar to healing?
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.

Lesson 14 (3 days) How can shifting our perceptions of ability and disability allow us to be more thoughtful about how we make our environments more accessible?
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.

Accommodations and Modifications:
Below please find a list of suggestions for accommodations and modifications to meet the diverse needs of our students. Teachers should consider this a resource and understand that they are not limited to the recommendations included below.
An accommodation changes HOW a student learns; the change needed does not alter the grade-level standard. A modification changes WHAT a student learns; the change alters the grade-level expectation.

Special Education and 504 Plans All modifications and accommodations must be specific to each individual child's IEP (Individualized Educational Plan) or 504 Plan.

- Provide redirection
- Provide notes and copies of handouts with
- Have student highlight rules in notes
- Pre-teach or preview vocabulary
- Have students repeat directions
- Pair visual prompts with verbal presentations
- Ask students to restate information, directions, and assignments
- Model skills/techniques to be mastered
- Provide a copy of class notes
- Emphasize key words or critical information by highlighting
- Use of graphic organizers
- Teachers should note any issue that may impact safety- ex. contact lenses, allergies.

English Language Learners:
All modifications and accommodations should be specific to each individual child's LEP level as determined by the WIDA screening or ACCESS, utilizing the WIDA Can Do Descriptors.
- Pre-teach or preview vocabulary
- Repeat or reword directions
- Have students repeat directions
- Use of small group instruction
- Scaffold language based on their Can Do Descriptors
- Alter materials and requirements according to Can Do Descriptors
- OpenSci Ed -All Student Handouts for Lesson 1 to 8 (Spanish Version)

Students at Risk of Failure:
- Use of self-assessment rubrics for check-in
- Pair visual prompts with verbal presentations
- Ask students to restate information and/or directions

● Opportunity for repetition and additional practice
● Model skills/techniques to be mastered
● Extended time
● Provide copy of class notes
● Strategic seating with a purpose
● Provide students opportunity to make corrections and/or explain their answers
● Support organizational skills

High Achieving:
Extension Activities
● Allow for student choice from a menu of differentiated outcomes; choices grouped by complexity of thinking skills; variety of options enable students to work in the mode that most interests them
● Allow students to pursue independent projects based on their individual interests
● Provide enrichment activities that include more complex material
● Allow opportunities for peer collaboration and team-teaching
● Set individual goals
● Conduct research and provide presentation of appropriate topics

NEPTUNE CITY SCHOOL DISTRICT
Office of the Chief School Administrator, Principal
210 West Sylvania Avenue
Neptune City, NJ 07753

An Affirmative Action Equal Opportunity Employer

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