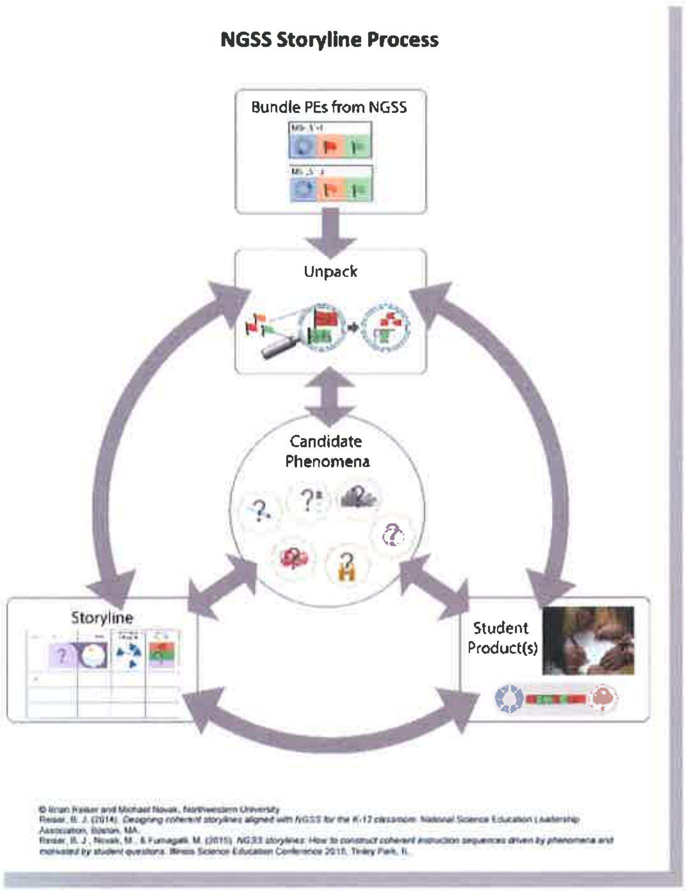
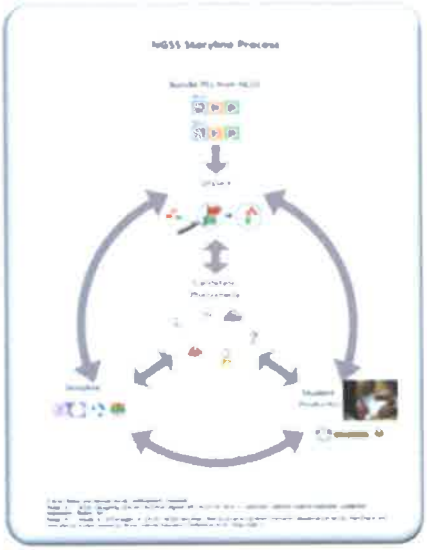
Foundational Services
Science

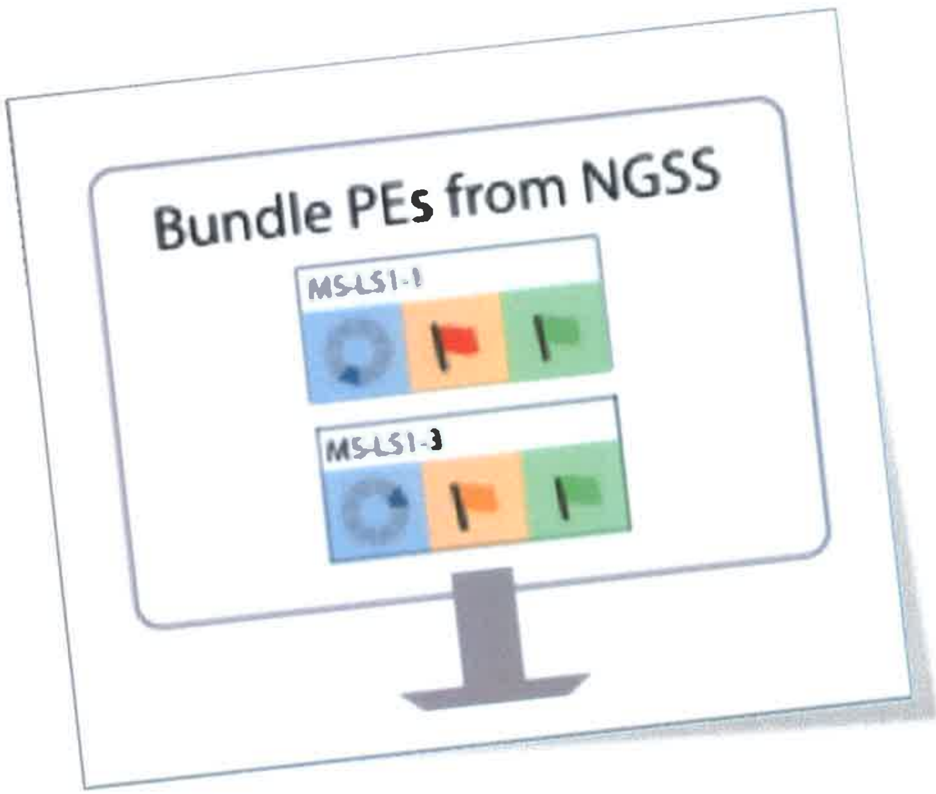
Developing and Evaluating Units of Study Aligned to NGSS



RESOURCES: The Process of Developing Storylines



Developing and Evaluating Units of Study Aligned to NGSS: The Process of Developing Storylines



Foundational Services

Science

4.Structure, Function, and Information Processing

4.Structure, Function, and Information Processing

Students who demonstrate understanding can:

4-PS4-2. Develop a model to describe that light reflecting from objects and entering the eye allows objects to be seen. [Assessment Boundary: Assessment does not include knowledge of specific colors reflected and seen, the cellular mechanisms of vision, or how the retina works.]

4-LS1-1. Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction. [Clarification Statement: Examples of structures could include thorns, stems, roots, colored petals, heart, stomach, lung, brain, and skin.] [Assessment Boundary: Assessment is limited to macroscopic structures within plant and animal systems.]

4-LS1-2. Use a model to describe that animals receive different types of information through their senses, process the information in their brain, and respond to the information in different ways. [Clarification Statement: Emphasis is on systems of information transfer.] [Assessment Boundary: Assessment does not include the mechanisms by which the brain stores and recalls information or the mechanisms of how sensory receptors function.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education:*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 3–5 builds on K–2 experiences and progresses to building and revising simple models and using models to represent events and design solutions. ▪ Develop a model to describe phenomena. (4-PS4-2) ▪ Use a model to test interactions concerning the functioning of a natural system. (4-LS1-2) **Engaging in Argument from Evidence** Engaging in argument from evidence in 3–5 builds on K–2 experiences and progresses to critiquing the scientific explanations or solutions proposed by peers by citing relevant evidence about the natural and designed world(s). ▪ Construct an argument with evidence, data, and/or a model. (4-LS1-1)	**PS4.B: Electromagnetic Radiation** ▪ An object can be seen when light reflected from its surface enters the eyes. (4-PS4-2) **LS1.A: Structure and Function** ▪ Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction. (4-LS1-1) **LS1.D: Information Processing** ▪ Different sense receptors are specialized for particular kinds of information, which may be then processed by the animal's brain. Animals are able to use their perceptions and memories to guide their actions. (4-LS1-2)	**Cause and Effect** ▪ Cause and effect relationships are routinely identified. (4-PS4-2) **Systems and System Models** ▪ A system can be described in terms of its components and their interactions. (4-LS1-1), (LS1-2)

Connections to other DCIs in this grade-level: N/A

Articulation of DCIs across grade-levels: **1.PS4.B** (4-PS4-2); **1.LS1.A** (4-LS1-1); **1.LS1.D** (4-LS1-2); **3.LS3.B** (4-LS1-1); **MS.PS4.B** (4-PS4-2); **MS.LS1.A** (4-LS1-1),(4-LS1-2); **MS.LS1.D** (4-PS4-2),(4-LS1-2)

Common Core State Standards Connections:

ELA/Literacy –

W.4.1 Write opinion pieces on topics or texts, supporting a point of view with reasons and information. (4-LS1-1)

SL.4.5 Add audio recordings and visual displays to presentations when appropriate to enhance the development of main ideas or themes. *(4-PS4-2),(4-LS1-2)*

Mathematics –

MP.4 Model with mathematics. *(4-PS4-2)*

4.G.A.1 Draw points, lines, line segments, rays, angles (right, acute, obtuse), and perpendicular and parallel lines. Identify these in two-dimensional figures. *(4-PS4-2)*

4.G.A.3 Recognize a line of symmetry for a two-dimensional figure as a line across the figure such that the figure can be folded across the line into matching parts. Identify line-symmetric figures and draw lines of symmetry. *(4-LS1-1)*

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

MS.Space Systems

MS.Space Systems

Students who demonstrate understanding can:

MS-ESS1-1. Develop and use a model of the Earth-sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons. [Clarification Statement: Examples of models can be physical, graphical, or conceptual.]

MS-ESS1-2. Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system. [Clarification Statement: Emphasis for the model is on gravity as the force that holds together the solar system and Milky Way galaxy and controls orbital motions within them. Examples of models can be physical (such as the analogy of distance along a football field or computer visualizations of elliptical orbits) or conceptual (such as mathematical proportions relative to the size of familiar objects such as students' school or state).] [Assessment Boundary: Assessment does not include Kepler's Laws of orbital motion or the apparent retrograde motion of the planets as viewed from Earth.]

MS-ESS1-3. Analyze and interpret data to determine scale properties of objects in the solar system. [Clarification Statement: Emphasis is on the analysis of data from Earth-based instruments, space-based telescopes, and spacecraft to determine similarities and differences among solar system objects. Examples of scale properties include the sizes of an object's layers (such as crust and atmosphere), surface features (such as volcanoes), and orbital radius. Examples of data include statistical information, drawings and photographs, and models.] [Assessment Boundary: Assessment does not include recalling facts about properties of the planets and other solar system bodies.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Developing and Using Models
Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.
- Develop and use a model to describe phenomena. (MS-ESS1-1),(MS-ESS1-2)

Analyzing and Interpreting Data
Analyzing data in 6–8 builds on K–5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.
- Analyze and interpret data to determine similarities and differences in findings. (MS-ESS1-3)

Disciplinary Core Ideas

ESS1.A: The Universe and Its Stars
- Patterns of the apparent motion of the sun, the moon, and stars in the sky can be observed, described, predicted, and explained with models. (MS-ESS1-1)
- Earth and its solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe. (MS-ESS1-2)

ESS1.B: Earth and the Solar System
- The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them. (MS-ESS1-2),(MS-ESS1-3)
- This model of the solar system can explain eclipses of the sun and the moon. Earth's spin axis is fixed in direction over the short-term but tilted relative to its orbit around the sun. The seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas of Earth across the year. (MS-ESS1-1)
- The solar system appears to have formed from a disk of dust and gas, drawn together by gravity. (MS-ESS1-2)

Crosscutting Concepts

Patterns
- Patterns can be used to identify cause and effect relationships. (MS-ESS1-1)

Scale, Proportion, and Quantity
- Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. (MS-ESS1-3)

Systems and System Models
- Models can be used to represent systems and their interactions. (MS-ESS1-2)

Connections to Engineering, Technology, and Applications of Science

Interdependence of Science, Engineering, and Technology
- Engineering advances have led to important discoveries in virtually every field of science and scientific discoveries have led to the development of entire industries and engineered systems. (MS-ESS1-3)

Connections to Nature of Science

Scientific Knowledge Assumes an Order and Consistency in Natural Systems
- Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation. (MS-ESS1-1),(MS-ESS1-2)

Connections to other DCIs in this grade-band: **MS.PS2.A** (MS-ESS1-1),(MS-ESS1-2); **MS.PS2.B** (MS-ESS1-1),(MS-ESS1-2); **MS.ESS2.A** (MS-ESS1-3)

Articulation of DCIs across grade-bands: **3.PS2.A** (MS-ESS1-1),(MS-ESS1-2); **5.PS2.B** (MS-ESS1-1),(MS-ESS1-2); **5.ESS1.A** (MS-ESS1-2); **5.ESS1.B** (MS-ESS1-1),(MS-ESS1-2),(MS-ESS1-3); **HS.PS2.A** (MS-ESS1-1),(MS-ESS1-2); **HS.PS2.B** (MS-ESS1-1),(MS-ESS1-2); **HS.ESS1.A** (MS-ESS1-2); **HS.ESS1.B** (MS-ESS1-1),(MS-ESS1-2),(MS-ESS1-3); **HS.ESS2.A** (MS-ESS1-3)

Common Core State Standards Connections:

ELA/Literacy –

RST.6-8.1	Cite specific textual evidence to support analysis of science and technical texts. (MS-ESS1-3)
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-ESS1-3)
SL.8.5	Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest. *(MS-ESS1-1),(MS-ESS1-2)*

Mathematics –

MP.2	Reason abstractly and quantitatively. (MS-ESS1-3)
MP.4	Model with mathematics. *(MS-ESS1-1),(MS-ESS1-2)*
6.RP.A.1	Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities. *(MS-ESS1-1),(MS-ESS1-2).*(MS-ESS1-3)
7.RP.A.2	Recognize and represent proportional relationships between quantities. *(MS-ESS1-1),(MS-ESS1-2).*(MS-ESS1-3)
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-ESS1-2)*
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-ESS1-2)*

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.
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3.Weather and Climate

3.Weather and Climate

Students who demonstrate understanding can:

3-ESS2-1. Represent data in tables and graphical displays to describe typical weather conditions expected during a particular season. [Clarification Statement: Examples of data could include average temperature, precipitation, and wind direction.] [Assessment Boundary: Assessment of graphical displays is limited to pictographs and bar graphs. Assessment does not include climate change.]

3-ESS2-2. Obtain and combine information to describe climates in different regions of the world.

3-ESS3-1. Make a claim about the merit of a design solution that reduces the impacts of a weather-related hazard.* [Clarification Statement: Examples of design solutions to weather-related hazards could include barriers to prevent flooding, wind resistant roofs, and lightning rods.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Analyzing and Interpreting Data

Analyzing data in 3–5 builds on K–2 experiences and progresses to introducing quantitative approaches to collecting data and conducting multiple trials of qualitative observations. When possible and feasible, digital tools should be used.

- Represent data in tables and various graphical displays (bar graphs and pictographs) to reveal patterns that indicate relationships. (3-ESS2-1)

Engaging in Argument from Evidence

Engaging in argument from evidence in 3–5 builds on K–2 experiences and progresses to critiquing the scientific explanations or solutions proposed by peers by citing relevant evidence about the natural and designed world(s).

- Make a claim about the merit of a solution to a problem by citing relevant evidence about how it meets the criteria and constraints of the problem. (3-ESS3-1)

Obtaining, Evaluating, and Communicating Information

Obtaining, evaluating, and communicating information in 3–5 builds on K–2 experiences and progresses to evaluating the merit and accuracy of ideas and methods.

- Obtain and combine information from books and other reliable media to explain phenomena. (3-ESS2-2)

Disciplinary Core Ideas

ESS2.D: Weather and Climate

- Scientists record patterns of the weather across different times and areas so that they can make predictions about what kind of weather might happen next. (3-ESS2-1)
- Climate describes a range of an area's typical weather conditions and the extent to which those conditions vary over years. (3-ESS2-2)

ESS3.B: Natural Hazards

- A variety of natural hazards result from natural processes. Humans cannot eliminate natural hazards but can take steps to reduce their impacts. (3-ESS3-1) *(Note: This Disciplinary Core Idea is also addressed by 4-ESS3-2.)*

Crosscutting Concepts

Patterns

- Patterns of change can be used to make predictions. (3-ESS2-1),(3-ESS2-2)

Cause and Effect

- Cause and effect relationships are routinely identified, tested, and used to explain change. (3-ESS3-1)

Connections to Engineering, Technology, and Applications of Science

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

- Engineers improve existing technologies or develop new ones to increase their benefits (e.g., better artificial limbs), decrease known risks (e.g., seatbelts in cars), and meet societal demands (e.g., cell phones). (3-ESS3-1)

Connections to Nature of Science

Science is a Human Endeavor

- Science affects everyday life. (3-ESS3-1)

Connections to other DCIs in third grade: N/A

Articulation of DCIs across grade-levels: **K.ESS2.D** (3-ESS2-1); **K.ESS3.B** (3-ESS3-1); **K.ETS1.A** (3-ESS3-1); **4.ESS2.A** (3-ESS2-1); **4.ESS3.B** (3-ESS3-1); **4.ETS1.A** (3-ESS3-1); **5.ESS2.A** (3-ESS2-1); **MS.ESS2.C** (3-ESS2-1),(3-ESS2-2); **MS.ESS2.D** (3-ESS2-1),(3-ESS2-2); **MS.ESS3.B** (3-ESS3-1)

Common Core State Standards Connections:

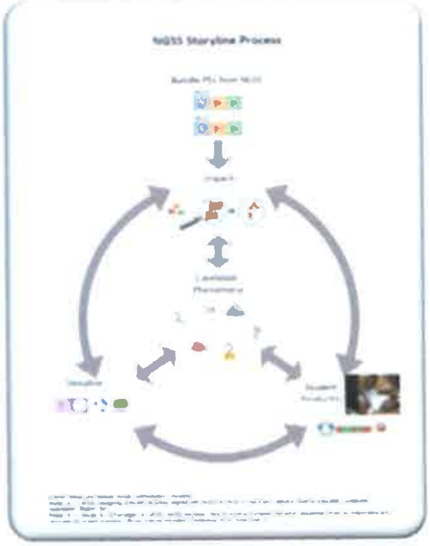
ELA/Literacy –

RI.3.1 Ask and answer questions to demonstrate understanding of a text, referring explicitly to the text as the basis for the answers. *(3-ESS2-2)*
RI.3.9 Compare and contrast the most important points and key details presented in two texts on the same topic. (3-ESS2-2)
W.3.1 Write opinion pieces on topics or texts, supporting a point of view with reasons. *(3-ESS3-1)*
W.3.7 Conduct short research projects that build knowledge about a topic. *(3-ESS3-1)*
W.3.9 Recall information from experiences or gather information from print and digital sources; take brief notes on sources and sort evidence into provided categories. (3-ESS2-2)

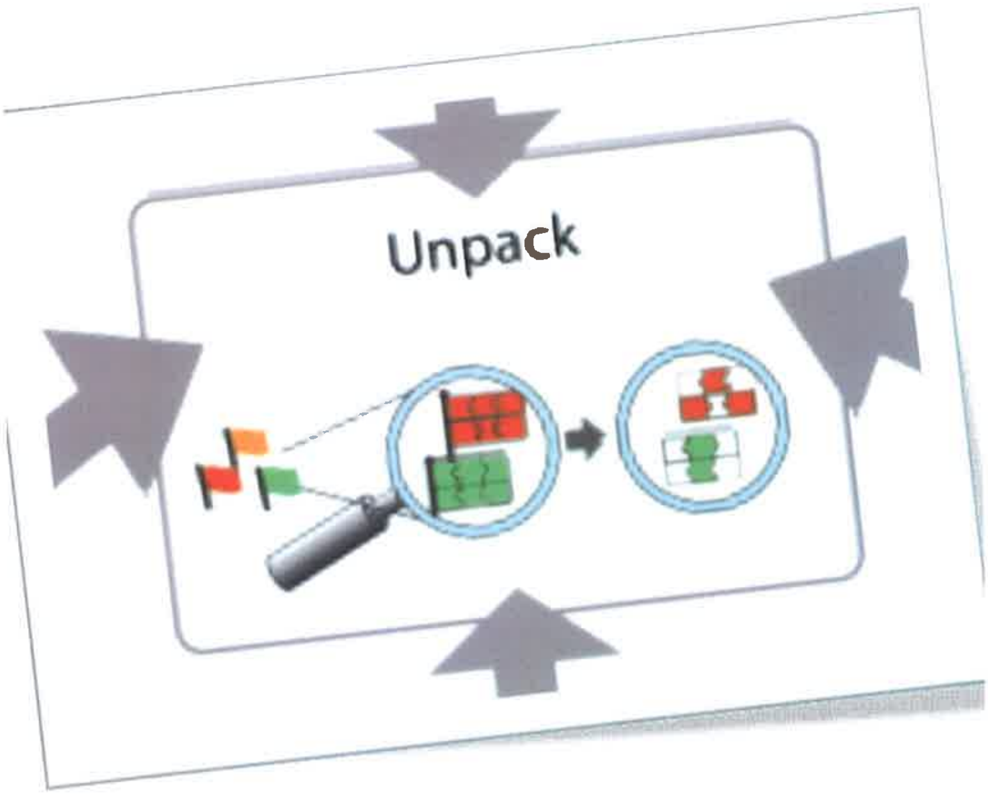
Mathematics –

MP.2 Reason abstractly and quantitatively. (3-ESS2-1),(3-ESS2-2),*(3-ESS3-1)*
MP.4 Model with mathematics. (3-ESS2-1),(3-ESS2-2), *(3-ESS3-1)*
MP.5 Use appropriate tools strategically. *(3-ESS2-1)*
3.MD.A.2 Measure and estimate liquid volumes and masses of objects using standard units of grams (g), kilograms (kg), and liters (l). Add, subtract, multiply, or divide to solve one-step word problems involving masses or volumes that are given in the same units, e.g., by using drawings (such as a beaker with a measurement scale) to represent the problem. *(3-ESS2-1)*
3.MD.B.3 Draw a scaled picture graph and a scaled bar graph to represent a data set with several categories. Solve one- and two-step "how many more" and "how many less" problems using information presented in bar graphs. (3-ESS2-1)

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

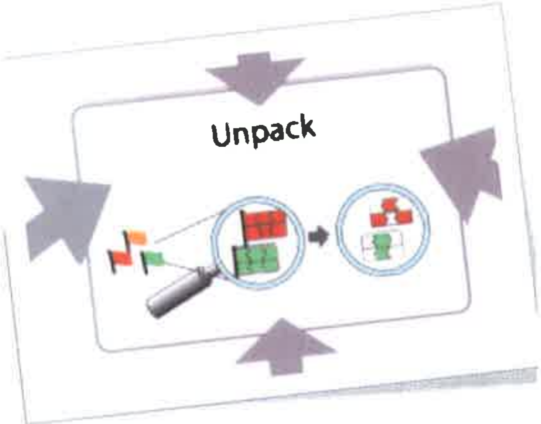


Developing and Evaluating Units of Study Aligned to NGSS: The Process of Developing Storylines



Foundational Services

Science



Sample 1:

Space Systems

ESS1.A: The Universe and Its Stars

&

ESS1.B: Earth and the Solar System

Foundational Services
Science

etary resources of water, arable land, plants and animals, minerals, and hydrocarbons. Only in the relatively recent past have people begun to recognize the dramatic role humans play as an essentially geological force on the surface of Earth, affecting large-scale conditions and processes.

Core Idea ESS1 Earth's Place in the Universe

What is the universe, and what is Earth's place in it?

The planet Earth is a tiny part of a vast universe that has developed over a huge expanse of time. The history of the universe, and of the structures and objects within it, can be deciphered using observations of their present condition together with knowledge of physics and chemistry. Similarly, the patterns of motion of the objects in the solar system can be described and predicted on the basis of observations and an understanding of gravity. Comprehension of these patterns can be used to explain many Earth phenomena, such as day and night, seasons, tides, and phases of the moon. Observations of other solar system objects and of Earth itself can be used to determine Earth's age and the history of large-scale changes in its surface.

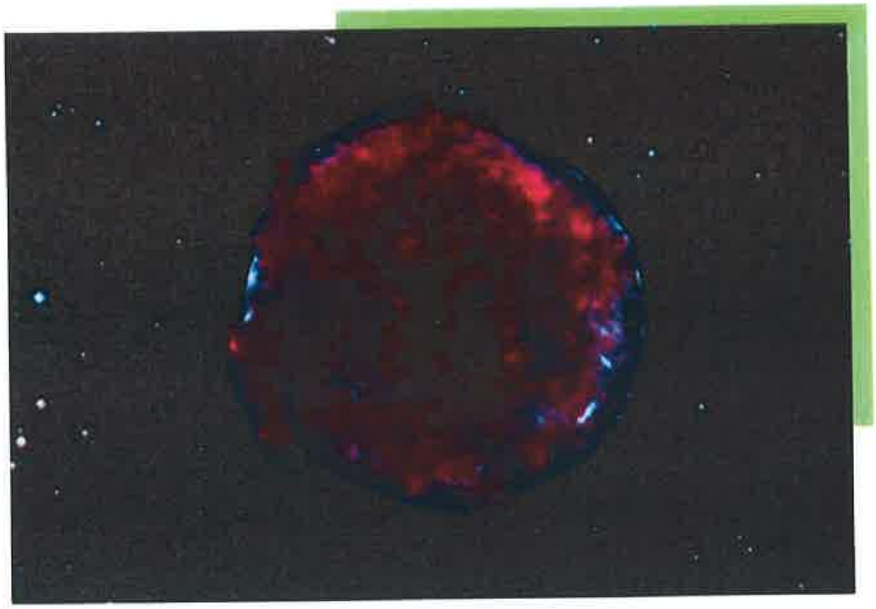
ESS1.A: THE UNIVERSE AND ITS STARS

What is the universe, and what goes on in stars?

The sun is but one of a vast number of stars in the Milky Way galaxy, which is one of a vast number of galaxies in the universe.

The universe began with a period of extreme and rapid expansion known as the Big Bang, which occurred about 13.7 billion years ago. This theory is supported by the fact that it provides explanation of observations of distant galaxies receding from our own, of the measured composition of stars and nonstellar gases, and of the maps and spectra of the primordial radiation (cosmic microwave background) that still fills the universe.

Nearly all observable matter in the universe is hydrogen or helium, which formed in the first minutes after the Big Bang. Elements other than these remnants of the Big Bang continue to form within the cores of stars. Nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and the process releases the energy seen as starlight. Heavier elements are produced when certain massive stars achieve a supernova stage and explode.



Stars' radiation of visible light and other forms of energy can be measured and studied to develop explanations about the formation, age, and composition of the universe. Stars go through a sequence of developmental stages—they are formed; evolve in size, mass, and brightness; and eventually burn out. Material from earlier stars that exploded as supernovas is recycled to form younger stars and their planetary systems. The sun is a medium-sized star about halfway through its predicted life span of about 10 billion years.

Grade Band Endpoints for ESS1.A

By the end of grade 2. Patterns of the motion of the sun, moon, and stars in the sky can be observed, described, and predicted. At night one can see the light coming from many stars with the naked eye, but telescopes make it possible to see many more and to observe them and the moon and planets in greater detail.

By the end of grade 5. The sun is a star that appears larger and brighter than other stars because it is closer. Stars range greatly in their size and distance from Earth.

By the end of grade 8. Patterns of the apparent motion of the sun, the moon, and stars in the sky can be observed, described, predicted, and explained with models. The universe began with a period of extreme and rapid expansion known as the Big Bang. Earth and its solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe.

By the end of grade 12. The star called the sun is changing and will burn out over a life span of approximately 10 billion years. The sun is just one of more than 200 billion stars in the Milky Way galaxy, and the Milky Way is just one of hundreds of billions of galaxies in the universe. The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth.

ESS1.B: EARTH AND THE SOLAR SYSTEM

What are the predictable patterns caused by Earth's movement in the solar system?

The solar system consists of the sun and a collection of objects of varying sizes and conditions—including planets and their moons—that are held in orbit around the sun by its gravitational pull on them. This system appears to have formed from a disk of dust and gas, drawn together by gravity.

Earth and the moon, sun, and planets have predictable patterns of movement. These patterns, which are explainable by gravitational forces and conservation laws, in turn explain many large-scale phenomena observed on Earth. Planetary motions around the sun can be predicted using Kepler's three empirical laws, which can be explained based on Newton's theory of gravity. These orbits may also change somewhat due to the gravitational effects from, or collisions with, other bodies. Gradual changes in the shape of Earth's orbit around the sun (over hundreds of thousands of years), together with the tilt of the planet's spin axis (or axis of rotation), have altered the intensity and distribution of sunlight falling on Earth. These phenomena cause cycles of climate change, including the relatively recent cycles of ice ages.

Gravity holds Earth in orbit around the sun, and it holds the moon in orbit around Earth. The pulls of gravity from the sun and the moon cause the patterns of ocean tides. The moon's and sun's positions relative to Earth cause lunar and solar eclipses to occur. The moon's monthly orbit around Earth, the relative positions of the sun, the moon, and the observer and the fact that it shines by reflected sunlight explain the observed phases of the moon.

Even though Earth's orbit is very nearly circular, the intensity of sunlight falling on a given location on the planet's surface changes as it orbits around the sun. Earth's spin axis is tilted relative to the plane of its orbit, and the seasons are

Earth and the moon, sun, and planets have predictable patterns of movement. These patterns, which are explainable by gravitational forces and conservation laws, in turn explain many large-scale phenomena observed on Earth.

a result of that tilt. The intensity of sunlight striking Earth's surface is greatest at the equator. Seasonal variations in that intensity are greatest at the poles.

Grade Band Endpoints for ESS1.B

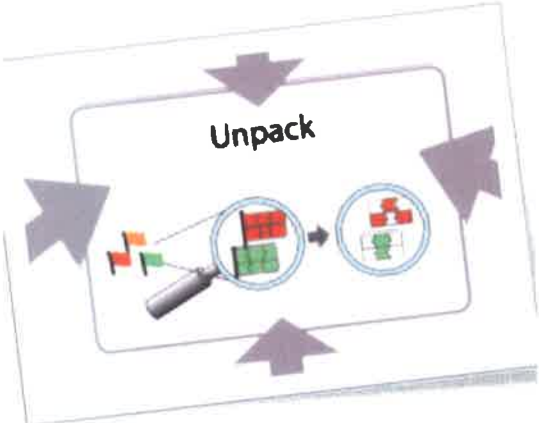
By the end of grade 2. Seasonal patterns of sunrise and sunset can be observed, described, and predicted.

By the end of grade 5. The orbits of Earth around the sun and of the moon around Earth, together with the rotation of Earth about an axis between its North and South poles, cause observable patterns. These include day and night; daily and seasonal changes in the length and direction of shadows; phases of the moon; and different positions of the sun, moon, and stars at different times of the day, month, and year.

Some objects in the solar system can be seen with the naked eye. Planets in the night sky change positions and are not always visible from Earth as they orbit the sun. Stars appear in patterns called constellations, which can be used for navigation and appear to move together across the sky because of Earth's rotation.

By the end of grade 8. The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them. This model of the solar system can explain tides, eclipses of the sun and the moon, and the motion of the planets in the sky relative to the stars. Earth's spin axis is fixed in direction over the short term but tilted relative to its orbit around the sun. The seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas of Earth across the year.

By the end of grade 12. Kepler's laws describe common features of the motions of orbiting objects, including their elliptical paths around the sun. Orbits may change due to the gravitational effects from, or collisions with, other objects in the solar system. Cyclical changes in the shape of Earth's orbit around the sun, together with changes in the orientation of the planet's axis of rotation, both occurring over tens to hundreds of thousands of years, have altered the intensity and distribution of sunlight falling on Earth. These phenomena cause cycles of ice ages and other gradual climate changes.



Sample 2:

Light

PS4.B: Electromagnetic Radiation

(e.g., a picture stored as the values of an array of pixels); in this form, it can be stored reliably in computer memory and sent over long distances as a series of wave pulses.

Resonance is a phenomenon in which waves add up in phase in a structure, growing in amplitude due to energy input near the natural vibration frequency. Structures have particular frequencies at which they resonate. This phenomenon (e.g., waves in a stretched string, vibrating air in a pipe) is used in speech and in the design of all musical instruments.

PS4.B: ELECTROMAGNETIC RADIATION

→ aka Light

What is light?
How can one explain the varied effects that involve light?
What other forms of electromagnetic radiation are there?

*At what level does light become Electromagnetic Radiation?

* what is the difference between these models? wave vs particles

Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave pattern of changing electric and magnetic fields or, alternatively, as particles. Each model is useful for understanding aspects of the phenomenon and its interactions with matter, and quantum theory relates the two models. Electromagnetic

↳ what is this really? Do students need to know?

By understanding wave properties and the interactions of electromagnetic radiation with matter, scientists and engineers can design systems for transferring information across long distances, storing information, and investigating nature on many scales—some of them far beyond direct human perception.

* Model of ER
① to explain Phenomenon
② to explain interactions with matter

waves can be detected over a wide range of frequencies, of which the visible spectrum of colors detectable by human eyes is just a small part. Many modern technologies are based on the manipulation of electromagnetic waves.

All electromagnetic radiation travels through a vacuum at the same speed, called the speed of light. Its speed in any given medium depends on its wavelength and the properties of that medium. At the surface between two media, like any wave, light can be reflected, refracted (its path bent), or absorbed. What occurs depends on properties of the surface and the wavelength of the light. When shorter wavelength electromagnetic radiation (ultraviolet, X-rays, gamma rays) is absorbed in matter, it can ionize atoms and cause damage to living cells. However, because X-rays can travel through soft body matter for some distance but are more rapidly absorbed by denser matter, particularly bone, they are useful for medical imaging. Photovoltaic materials emit electrons when they absorb light of a high-enough frequency. This phenomenon is used in barcode scanners and "electric eye" systems, as well as in solar cells. It is best explained using a particle model of light.

Any object emits a spectrum of electromagnetic radiation that depends on its temperature. In addition, atoms of each element emit and preferentially absorb characteristic frequencies of light. These spectral lines allow identification of the presence of the element, even in microscopic quantities or for remote objects, such as a star. Nuclear transitions that emit or absorb gamma radiation also have distinctive gamma ray wavelengths, a phenomenon that can be used to identify and trace specific radioactive isotopes.

Grade Band Endpoints for PS4.B

By the end of grade 2. Objects can be seen only when light is available to illuminate them. Very hot objects give off light (e.g., a fire, the sun).

Some materials allow light to pass through them, others allow only some light through, and others block all the light and create a dark shadow on any surface beyond them (i.e., on the other side from the light source), where the light cannot reach. Mirrors and prisms can be used to redirect a light beam. (Boundary: The idea that light travels from place to place is developed through experiences with light sources, mirrors, and shadows, but no attempt is made to discuss the speed of light.)

By the end of grade 5. A great deal of light travels through space to Earth from the sun and from distant stars.

An object can be seen when light reflected from its surface enters the eyes; the color people see depends on the color of the available light sources as well as the properties of the surface. (Boundary: This phenomenon is observed, but no attempt is made to discuss what confers the color reflection and absorption properties on a surface. The stress is on understanding that light traveling from the object to the eye determines what is seen.)

Because lenses bend light beams, they can be used, singly or in combination, to provide magnified images of objects too small or too far away to be seen with the naked eye.

By the end of grade 8. 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.

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. Lenses and prisms are applications of this effect.

A wave model of light is useful for explaining brightness, color, and the frequency-dependent bending of light at a surface between media (prisms). However, because light can travel through space, it cannot be a matter wave, like sound or water waves.

By the end of grade 12. Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave of changing electric and magnetic fields or as particles called photons. The wave model is useful for explaining many features of electromagnetic radiation, and the particle model explains other features. Quantum theory relates the two models. (Boundary: Quantum theory is not explained further at this grade level.)

Because a wave is not much disturbed by objects that are small compared with its wavelength, visible light cannot be used to see such objects as individual

• Speed of Light

• Electromagnetic Spectrum

atoms. All electromagnetic radiation travels through a vacuum at the same speed, called the speed of light. Its speed in any other given medium depends on its wavelength and the properties of that medium.

When light or longer wavelength electromagnetic radiation is absorbed in matter, it is generally converted into thermal energy (heat). Shorter wavelength electromagnetic radiation (ultraviolet, X-rays, gamma rays) can ionize atoms and cause damage to living cells. Photovoltaic materials emit electrons when they absorb light of a high-enough frequency.

Atoms of each element emit and absorb characteristic frequencies of light, and nuclear transitions have distinctive gamma ray wavelengths. These characteristics allow identification of the presence of an element, even in microscopic quantities.

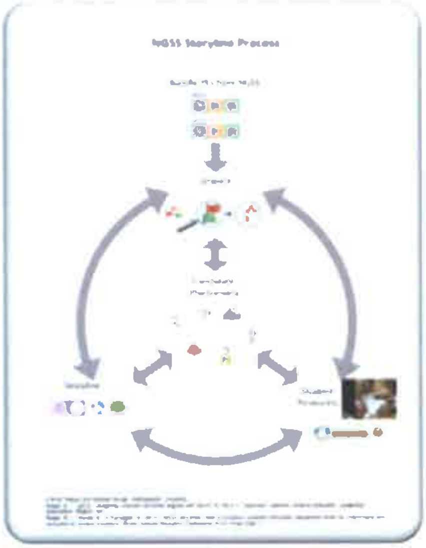
PS4.C: INFORMATION TECHNOLOGIES AND INSTRUMENTATION

How are instruments that transmit and detect waves used to extend human senses?

Understanding of waves and their interactions with matter has been used to design technologies and instruments that greatly extend the range of phenomena that can be investigated by science (e.g., telescopes, microscopes) and have many useful applications in the modern world.

Light waves, radio waves, microwaves, and infrared waves are applied to communications systems, many of which use digitized signals (i.e., sent as wave pulses) as a more reliable way to convey information. Signals that humans cannot sense directly can be detected by appropriately designed devices (e.g., telescopes, cell phones, wired or wireless computer networks). When in digitized form, information can be recorded, stored for future recovery, and transmitted over long distances without significant degradation.

Medical imaging devices collect and interpret signals from waves that can travel through the body and are affected by, and thus gather information about, structures and motion within it (e.g., ultrasound, X-rays). Sonar (based on sound pulses) can be used to measure the depth of the sea, and a system based on laser pulses can measure the distance to objects in space, because it is



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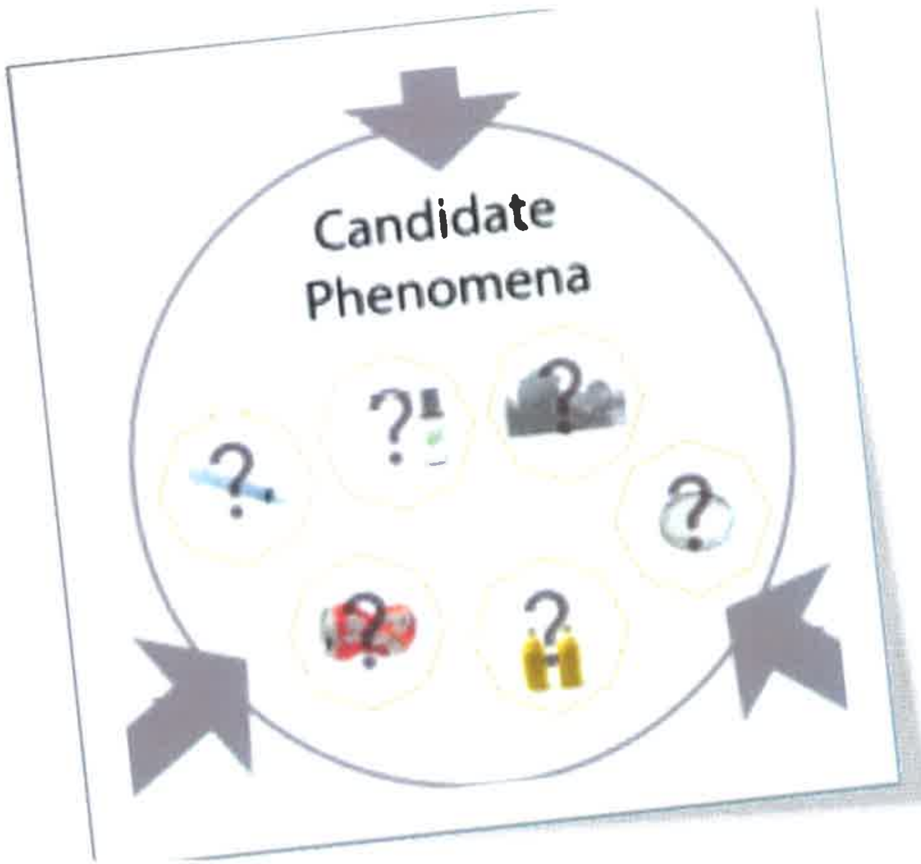


Foundational Services Science

Candidate Phenomena – Initial Thoughts

Fourth Grade – Light

Seeing imaginary friends – real or not

Seeing in the dark – read story
mines
caves

Comparison b/t humans and animals

Scenarios with components missing
- blind
- no light
- missing object
- blocked path

- stars, moon, sun

Candidate Phenomena – Initial Thoughts

Middle School – Space

Observing...

- tides
- eclipses
- motions of planets
- seasons – sun in sky
  temperatures
- planets moving w/o colliding
- number of stars
- moon phases

Power of 10

Images from Space – real or not real?

Moon during day.

Candidate Phenomena – Building Towards Lessons

Fourth Grade – Light

Scientific Idea	Phenomenon	Apparatus
This is the "Science." • This is the Scientific Principle students need to learn. • Based on the Disciplinary Core Ideas.	This is reoccurring event that can be observed. • This is: "Wow! How did that happen? " • The event that needs to be explained.	These are the physical materials the students will investigate with and model from in order to explain the phenomenon. • Objects • Lab Equipment

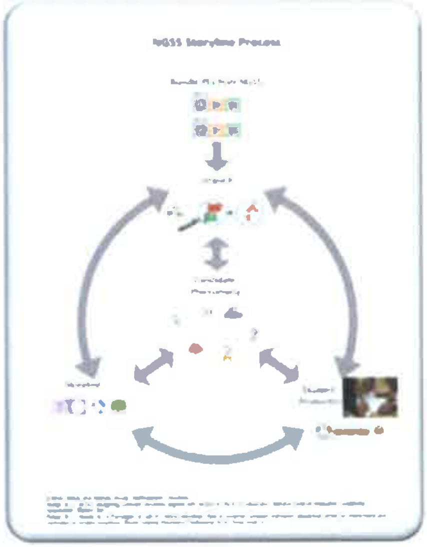
In order to see an object, light must bounce of an object into our eye. The path must be clear.	I cannot see objects when something blocks the object.	Objects around the room.
In order to see an object, light must bounce of an object into our eye.	Sight (Not being able to see in the dark.)	Light Box
In order to see an object, light must bounce of an object into our eye. The path must be clear.	I cannot see objects when something blocks the object.	Light Box with divider
Some objects allow light to pass through.	I cannot see objects when something blocks the object that is see through.	Light Box with clear divider

Candidate Phenomena – Building Towards Lessons

Middle School – Space

Scientific Idea	Phenomenon	Apparatus
This is the "Science." • This is the Scientific Principle students need to learn. • Based on the Disciplinary Core Ideas.	This is reoccurring event that can be observed. • This is: "Wow! How did that happen? " • The event that needs to be explained.	These are the physical materials the students will investigate with and model from in order to explain the phenomenon. • Objects • Lab Equipment

Due to the Earth, Moon, and Sun System, the moon has lunar phases.	The moon isn't the same shape every day. The moon has a pattern of shapes.	Flashlight, globe/student, ping pong ball.
Due to the Earth, Moon, and Sun System, solar and lunar eclipses occur.	In the middle of the day, the earth suddenly becomes dark and the sun disappears.	Flashlight, globe/student, ping pong ball.
Due to the rotation and revolution of the moon, the same side of the moon is always facing the Earth.	Pictures of the surface of the moon always show the same features.	Flashlight, globe/student, ping pong ball with images.
Due to the Earth, Moon, and Sun System, light from the sun bounces off the moon and travels to Earth for us to see an image of the moon.	I can see the moon at night even though it is dark out. But, the moon is not a star.	Flashlight, globe/student, ping pong ball.



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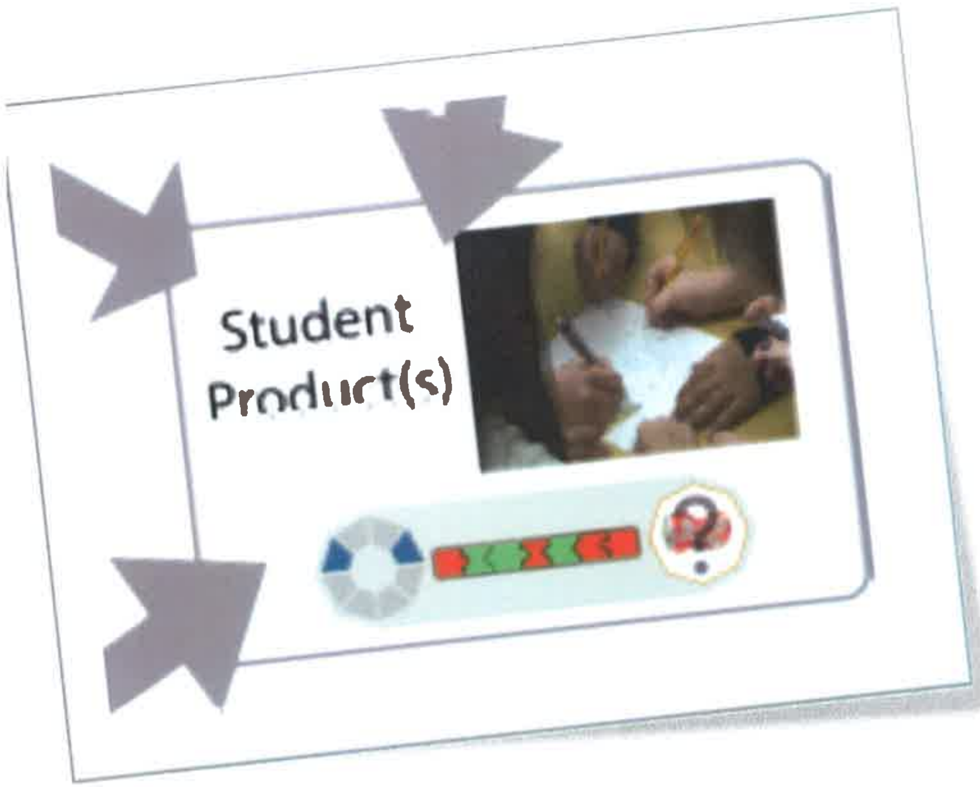

Foundational Services Science

NEXT GENERATION SCIENCE STANDARDS For States, By States

Unless otherwise specified, "descriptions" referenced in the evidence statements could include but are not limited to written, oral, pictorial, and kinesthetic descriptions.

3-ESS2-1 Earth's Systems

Students who demonstrate understanding can:

3-ESS2-1. **Represent data in tables and graphical displays to describe typical weather conditions expected during a particular season.** [Clarification Statement: Examples of data could include average temperature, precipitation, and wind direction.] [*Assessment Boundary: Assessment of graphical displays is limited to pictographs and bar graphs. Assessment does not include climate change.*]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data Analyzing data in 3–5 builds on K–2 experiences and progresses to introducing quantitative approaches to collecting data and conducting multiple trials of qualitative observations. When possible and feasible, digital tools should be used. • Represent data in tables and various graphical displays (bar graphs and pictographs) to reveal patterns that indicate relationships.	**ESS2.D: Weather and Climate** • Scientists record patterns of the weather across different times and areas so that they can make predictions about what kind of weather might happen next.	**Patterns** • Patterns of change can be used to make predictions.

Observable features of the student performance by the end of the grade:			
1	Organizing data		
	a	Students use graphical displays (e.g., table, chart, graph) to organize the given data by season using tables, pictographs, and/or bar charts, including:	
		i.	Weather condition data from the same area across multiple seasons (e.g., average temperature, precipitation, wind direction).
		ii.	Weather condition data from different areas (e.g., hometown and nonlocal areas, such as a town in another state).
2	Identifying relationships		
	a	Students identify and describe* patterns of weather conditions across:	
		i.	Different seasons (e.g., cold and dry in the winter, hot and wet in the summer; more or less wind in a particular season).
		ii.	Different areas (e.g., certain areas (defined by location, such as a town in the Pacific Northwest), have high precipitation, while a different area (based on location or type, such as a town in the Southwest) have very little precipitation).
3	Interpreting data		
	a	Students use patterns of weather conditions in different seasons and different areas to predict:	
		i.	The typical weather conditions expected during a particular season (e.g., "In our town in the summer it is typically hot, as indicated on a bar graph over time, while in the winter it is typically cold; therefore, the prediction is that next summer it will be hot and next winter it will be cold.").
		ii.	The typical weather conditions expected during a particular season in different areas.

NEXT GENERATION SCIENCE STANDARDS For States, By States

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3-ESS2-2 Earth's Systems

Students who demonstrate understanding can:

3-ESS2-2. Obtain and combine information to describe climates in different regions of the world.

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Obtaining, Evaluating, and Communicating Information Obtaining, evaluating, and communicating information in 3–5 builds on K–2 experiences and progresses to evaluating the merit and accuracy of ideas and methods. • Obtain and combine information from books and other reliable media to explain phenomena.	**ESS2.D: Weather and Climate** • Climate describes a range of an area's typical weather conditions and the extent to which those conditions vary over years.	**Patterns** • Patterns of change can be used to make predictions.

Observable features of the student performance by the end of the grade:			
1	Obtaining information		
	a	Students use books and other reliable media to gather information about:	
		i.	Climates in different regions of the world (e.g., equatorial, polar, coastal, mid-continental).
		ii.	Variations in climates within different regions of the world (e.g., variations could include an area's average temperatures and precipitation during various months over several years or an area's average rainfall and temperatures during the rainy season over several years).
2	Evaluating information		
	a	Students combine obtained information to provide evidence about the climate pattern in a region that can be used to make predictions about typical weather conditions in that region.	
3	Communicating information		
	a	Students use the information they obtained and combined to describe*:	
		i.	Climates in different regions of the world.
		ii.	Examples of how patterns in climate could be used to predict typical weather conditions.
		iii.	That climate can vary over years in different regions of the world.

**Unless otherwise specified, "descriptions" referenced in the evidence statements could include but are not limited to written, oral, pictorial, and kinesthetic descriptions.*

3-ESS3-1 Earth and Human Activity

Students who demonstrate understanding can:

3-ESS3-1. Make a claim about the merit of a design solution that reduces the impacts of a weather-related hazard.* [Clarification Statement: Examples of design solutions to weather-related hazards could include barriers to prevent flooding, wind resistant roofs, and lighting rods.]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Engaging in Argument from Evidence
Engaging in argument from evidence in 3–5 builds on K–2 experiences and progresses to critiquing the scientific explanations or solutions proposed by peers by citing relevant evidence about the natural and designed world(s).

- Make a claim about the merit of a solution to a problem by citing relevant evidence about how it meets the criteria and constraints of the problem.

Disciplinary Core Ideas

ESS3.B: Natural Hazards

- A variety of natural hazards result from natural processes. Humans cannot eliminate natural hazards but can take steps to reduce their impacts. *(Note: This Disciplinary Core Idea is also addressed by 4-ESS3-2.)*

Crosscutting Concepts

Cause and Effect

- Cause and effect relationships are routinely identified, tested, and used to explain change.

Connections to Engineering, Technology, and Applications of Science

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

- Engineers improve existing technologies or develop new ones to increase their benefits (e.g., better artificial limbs), decrease known risks (e.g., seatbelts in cars), and meet societal demands (e.g., cell phones).

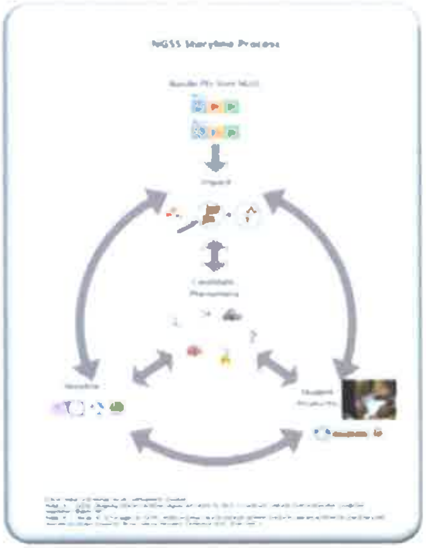
Connections to Nature of Science

Science is a Human Endeavor

- Science affects everyday life.

Observable features of the student performance by the end of the grade:

1	Supported claims		
	a	Students make a claim about the merit of a given design solution that reduces the impact of a weather-related hazard.	
2	Identifying scientific evidence		
	a	Students describe* the given evidence about the design solution, including evidence about:	
		i.	The given weather-related hazard (e.g., heavy rain or snow, strong winds, lightning, flooding along river banks).
		ii.	Problems caused by the weather related hazard (e.g., heavy rains cause flooding, lightning causes fires).
		iii.	How the proposed solution addresses the problem (e.g., dams and levees are designed to control flooding, lightning rods reduce the chance of fires) [note: mechanisms are limited to simple observable relationships that rely on logical reasoning].
3	Evaluating and critiquing evidence		
	a	Students evaluate the evidence using given criteria and constraints to determine:	
		i.	How the proposed solution addresses the problem, including the impact of the weather-related hazard after the design solution has been implemented.
		ii.	The merits of a given solution in reducing the impact of a weather-related hazard (i.e., whether the design solution meets the given criteria and constraints].
		iii.	The benefits and risks a given solution poses when responding to the societal demand to reduce the impact of a hazard.



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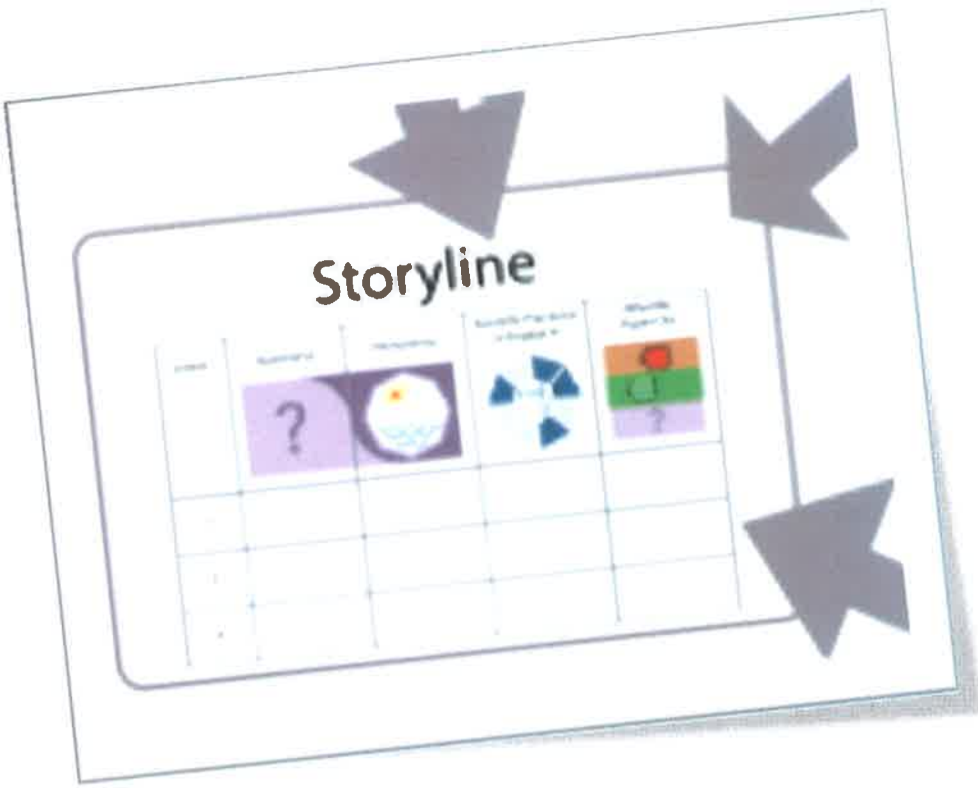

Foundational Services
Science

NGSS Storyline: Weather & Climate

Level: Third Grade

PEs:

- 3-ESS2-1 Represent data in tables and graphical displays to describe typical weather conditions expected during a particular season. [Clarification Statement: Examples of data could include average temperature, precipitation, and wind direction.] [Assessment Boundary: Assessment of graphical displays is limited to pictographs and bar graphs. Assessment does not include climate change.]
- 3-ESS2-2 Obtain and combine information to describe climates in different regions of the world.
- 3-ESS3-1 Make a claim about the merit of a design solution that reduces the impacts of a weather-related hazard.* [Clarification Statement: Examples of design solutions to weather-related hazards could include barriers to prevent flooding, wind resistant roofs, and lightning rods.]

SEPs:

- Analyzing and Interpreting Data-Analyzing data in 3-5 builds on K-2 experiences and progresses to introducing quantitative approaches to collecting data and conducting multiple trials of qualitative observations. When possible and feasible, digital tools should be used.
  - Represent data in tables and various graphical displays (bar graphs and pictographs) to reveal patterns that indicate relationships (3-ESS2-1)
  - Analyze and interpret data to make sense of phenomena, using logical reasoning, mathematics, and/or computation. [Added per author's discretion]
- Obtaining, Evaluating, and Communicating Information-Obtaining, evaluating, and communicating information in 3-5 builds on K-2 experiences and progresses to evaluating the merit and accuracy of ideas and methods.
  - Obtain and combine information from books and other reliable media to explain phenomena (3-ESS2-2)
  - Read and comprehend grade appropriate complex texts and/or other reliable media to summarize and obtain scientific and technical ideas and describe how they are supported by evidence. [Added per author's discretion]
  - Compare and/or combine across complex texts and/or other reliable media to support the engagement in other scientific and/or engineering practices. [Added per author's discretion]
- Engaging in Argument from Evidence-Engaging in argumentation from evidence in 3-5 builds on K-2 experiences and progresses to critiquing the scientific explanations or solutions proposed by peers by citing relevant evidence about the natural and designed world(s).
  - Make a claim about the merit of a solution to a problem by citing relevant evidence about how it meets the criteria and constraints of a problem (3-ESS3-1)
  - Compare and refine arguments based on an evaluation of the evidence presented. [Added per author's discretion]
  - Respectfully provide and receive critiques from peers about a proposed procedure, explanation, or model by citing relevant evidence and posing specific questions. [Added per author's discretion]
  - Construct and/or support an argument with evidence, data, and/or a model. [Added per author's discretion]

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DCIs:

- ESS2.D: Weather and Climate-Scientists record patterns of the weather across different times and areas so that they can make predictions about what kind of weather might happen next (3-ESS2-1); Climate describes a range of an area's typical weather conditions and the extent to which those conditions vary over years (3-ESS2-2).
- ESS3.B: Natural Hazards-A variety of natural hazards result from natural processes. Humans cannot eliminate natural hazards but can take steps to reduce their impacts (3-ESS3-1).

CCCs:

- Systems and System Models-A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems. [Added per author's discretion]
- Patterns-Patterns of change can be used to make predictions (3-ESS2-1) (3-ESS2-2); Similarities and differences in patterns can be used to sort, classify, communicate and analyze simple rates of change for natural phenomena and designed products [Added per author's discretion]; Patterns can be used as evidence to support an explanation [Added per author's discretion]
- Cause and Effect-Cause and effect relationships are routinely identified, tested, and used to explain change. (3-ESS3-1)

Nature of Science: Science is a Human Endeavor-Science affects everyday life (3-ESS3-1)
Science, Tech, Society, and the Environment: influence of science, engineering and technology on society and the natural world-Engineers improve existing technologies or develop new ones to increase their benefits (e.g., better artificial limbs), decrease known risks (e.g., seatbelts in cars), and meet societal demands (e.g., cell phones) (3-ESS3-1)

SD 129 ELA Connection:

- Reading Street Unit 4-Week 2: Hottest, Coldest, Highest Deepest (Tentatively moved to Unit 3: Features Within Informational Text-per recommendation of 3rd Grade ELA Committee)

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Driving Question: How can we prevent damage caused by extreme weather?
Anchoring Event: Extreme Weather Intro.
https://www.youtube.com/watch?v=OPVzW0OoO6s
https://www.youtube.com/watch?v=b1OFJRm-PFE

Question(s)	Phenomena/ Problem	Scientific Practice(s)	What we want kids to figure out (DCIs)	Crosscutting Concepts, NOS, & STSE	Integration Into Language Arts and Math CCSS
1. Where does water come from in nature?	Buffalo Blizzard Fox River Student-Developed Water Cycle Diagram	**Obtain and combine information from books and other reliable media to explain phenomena** (3-ESS2-2)	Water in nature is constantly moving through the water cycle, and comes down as precipitation. Scientists record patterns of the weather across different times and areas so that they can make predictions about what kind of weather might happen next (3-ESS2-1)	**A system is a group of related parts that make up a whole and can carry out functions its individual parts cannot.** **A system can be described in terms of its components and their interactions.**	Speaking and Listening -SL.3.1 Collaborative Discussion
2. What does precipitation look like in our town?	Patterns in Local Weather Weather and Climate Data Compilation	**Represent data in tables and/or various graphical displays (bar graphs, pictographs and/or pie charts) to reveal patterns that indicate relationships** (3-ESS2-1) **Analyze and interpret data to make sense of phenomena, using logical reasoning, mathematics, and/or computation.**	Weather patterns in Aurora make up our climate **Scientists record patterns of the weather across different times and areas so that they can make predictions about what kind of weather might happen next** (3-ESS2-1) **Climate describes a range of an area's typical weather conditions** and the extent to which those conditions vary over years (ESS2.D)	**Patterns can be used as evidence to support an explanation.**	Math -3.MD.B.3 Graphing -3.MD.B.4 Measurement -CCSS.MP4 Graphing & Interpreting

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3. Is the weather always like this?	Climate Data	**Represent data in tables and/or various graphical displays (bar graphs, pictographs and/or pie charts) to reveal patterns that indicate relationships** (3-ESS2-1) **Analyze and interpret data to make sense of phenomena, using logical reasoning, mathematics, and/or computation.**	**Climate describes a range of an area's typical weather conditions and the extent to which those conditions vary over years** (ESS2.D)	**Similarities and differences in patterns can be used to sort, classify, communicate and analyze simple rates of change for natural phenomena** and designed products. **Patterns can be used as evidence to support an explanation.**	Math -3.MD.B.3 Graphing -3.MD.B.4 Measurement -CCSS.MP4 Graphing & Interpreting
4. What is the climate like in other towns?	Regional Climate Data	**Compare and/or combine across complex texts and/or other reliable media to support the engagement in other scientific and/or engineering practices.** **Analyze and interpret data to make sense of phenomena, using logical reasoning, mathematics, and/or computation.**	Weather patterns in New York and San Diego make up their climate **Scientists record patterns of weather across different times and areas so that they can make predictions about what kind of weather might happen next** (ESS2.D) **Climate describes a range of an area's typical weather conditions and the extent to which those conditions vary over years** (ESS2.D)	**Patterns of change can be used to make predictions** (3-ESS2-1 & 3-ESS2-2) **Patterns can be used as evidence to support an explanation.**	Reading -RI.3.9 Compare & Contrast Math -CCSS.MP4 Graphing & Interpreting

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5. What happens when the weather gets crazy?	Hurricane Katrina Enrichment/Extension: -Buffalo, NY Snowstorm -California Fires http://cdfdata.fire.ca.gov/incidents/incidents_current	**Read and comprehend grade appropriate complex texts and/or other reliable media to summarize and obtain scientific and technical ideas and describe how they are supported by evidence.**	**A variety of natural hazards result from natural processes.** Humans cannot eliminate natural hazards but can take steps to reduce their impacts (3-ESS3-1)	**Cause and effect relationships are routinely identified, tested, and used to explain change** (3-ESS3-1) Science as a Human Endeavor: -Science affects everyday life	Speaking and Listening -SL.3.1 Collaborative Discussion
6. How can we prevent damage caused by extreme weather?	Hurricane Katrina	**Compare and refine arguments based on an evaluation of the evidence presented.** **Respectfully provide and receive critiques from peers about a proposed procedure, explanation, or model by citing relevant evidence and posing specific questions.** **Construct and/or support an argument with evidence, data, and/or a model.** **Make a claim about the merit of a solution to a problem by citing relevant evidence about how it meets the criteria and constraints of the problem** (3-ESS3-1)	**A variety of natural hazards result from natural processes. Humans cannot eliminate natural hazards but can take steps to reduce their impacts** (3-ESS3-1)	**Cause and effect relationships are routinely identified, tested, and used to explain change** (3-ESS3-1) **Patterns of change can be used to make predictions** (3-ESS2-1 & 3-ESS2-2) Influence of ETS: -Engineers improve existing technologies or develop new ones to increase their benefits (e.g., better artificial limbs), decrease known risks (e.g., seatbelts in cars), and meet societal demands (e.g., cell phones) Science as a Human Endeavor: -Science affects everyday life	Reading -RI.3.3 Cause & Effect -RI.3.8 Sequence Writing -W.3.1 Opinion Writing -W.3.4 Organization -W.3.5 Editing -W.3.7 Research Projects -W.3.8 Gather Information

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Continued Learning…
Research what changes have taken place with New Orleans levees in the Post-Katrina era: look for evidence of any student-suggested changes in design.

Potential Assessments
3-ESS2-1: Provided with a set of weather data (temperature **or** precipitation only) students can create a bar graph to represent data and analyze patterns.
3-ESS2-2: Provided with two sets of weather data (temperature and precipitation records) students can compare and contrast the climates of two different regions of the world (or country)
3-ESS3-1: Given an article describing a natural disaster (i.e. Illinois tornadoes 11/17/13) students can assess the merit of the attempted solutions and give recommendations for future modifications

Necessary Materials
-materials to make a precipitation measure (rain gauge, snow board…) -materials for levee engineering (trays, soil, clay, rocks, sand, etc)

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3rd Grade NGSS Storyline: WATER

Introduction

Connection to previous lesson(s): [Connection to previous lesson(s) to be further developed to demonstrate coherence between units of instruction at 3rd Grade]

Storyline Objectives: The objective of this course of inquiry is to engage students in a deeper understanding of weather and climate. Through construction of the pieces of the water cycle, investigation of local and national weather, and inquiry around weather-related disasters, students will explore underlying patterns that weather and climate scientists use to drive their work. Additionally, they will engage in engineering to better understand and eventually construct potential design solutions to mitigate damage caused by extreme weather.

Assessment: Options for assessments are listed in Storyline and may be integrated into instruction at the discretion of the teacher. At any point during discussion or investigation, students may be formally or informally assessed on their demonstration of the Performance Expectations, or any of the associated Common Core State Standards. Assessments are not limited to those enumerated in the Storyline.

ELA Integration: During the course of implementation, you can choose a chapter book about Hurricane Katrina to use during read aloud that will help in building background knowledge-and also sow the seeds for the culminating activity. Some options include I Survived Hurricane Katrina by Lauren Tarshis, or Upside Down in the Middle of Nowhere by Julie T. Lamana.

The following teacher guide should be used to facilitate discussion throughout the implementation process-in order to support student discovery, and guide their line of inquiry. However-this guide is intended as a support to teacher planning and implementation (**not as a script**), and may be used only as a reference as teachers grow more comfortable leading their students in asking driving questions to guide the storyline.

(Note: an anchor chart or focus wall may be used during course of discussion to highlight vocabulary or concepts [i.e. water cycle, climate, etc.])

(Note: it is critical to use Storyline document to guide instruction, and as a reference for which SEPs, DCIs, and CCCs to focus on during each band of instruction)

Introduction

During introduction students will be exposed to Anchoring Event: Extreme Blizzards in Buffalo, NY https://www.youtube.com/watch?v=OPVzW0OoO6s Students will then be asked to generate a list of questions related to the phenomenon, and the teacher will introduce the common, over-arching Driving Question: How can we prevent damage caused by extreme weather? (2nd clip extension if necessary) https://www.youtube.com/watch?v=b1OFJRm-PFE

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Teacher dialogue box:

- **Now that we've seen our Anchoring Event, I'm sure you've got a lot of questions, take a few moments to work with your team, make a list of as many questions as you think of related to what we saw**
  - Students will respond with a highly varied list of questions, some relating to weather, some to damage, some to snow, some to storms
- **Now that we've got our list, I'm noticing some similarities, for example, a lot of you seem focused on all of the damage that weather like this might cause. So I think our Driving Question is something like: How can we prevent damage caused by extreme weather?**
  - Can create an anchor chart/focus wall to track progress in unit
- **Now that we've got a good driving question for our unit, let's try to go back to the very beginning of what happened.**

Band 1: Where does water come from in nature?

Purpose: Construct a common understanding of where precipitation comes from, and how water moves through the water cycle.

Introduction: This activity is focused on students developing their own understanding of what the water cycle is: water comes out of the sky as precipitation, melts and collects as water on the ground, evaporates back into the sky, and then condenses again as clouds-and eventually falling again as precipitation.

To frame this discussion, teacher will lead students in a discussion surrounding the question for the band: Where does water come from in nature? Students will share any existing understanding, and use that to develop a diagram of the water cycle. Once this is built, teacher will use the guided inquiries and discussions modeled below to work with students to fill in any missing pieces of their water cycle diagrams.

As a wrap-up, teacher will guide discussion around next steps to lead students to Band 2 question: What does the water cycle look like in our town?

Vocabulary: water cycle, precipitation, collection, evaporation, condensation, weather, cloud, blizzard, rain, hail, snow, sleet,

(Note: Below is an extremely detailed representation of teacher dialogue guiding students through a discussion. Subsequent teacher dialogue boxes will be less detailed to allow for teacher autonomy and creativity in guiding discussion)

Teacher dialogue box:

- **Ok, to address our Driving Question: How can we prevent damage caused by extreme weather, I'd like for us to take one step back. So there's one thing that it looks like our question is assuming. Our question assumes, or says, that we're seeing some kind of extreme weather. What was the extreme weather that we saw in our Anchoring Event?**
  - Students will offer responses like: a blizzard, lots of snow, wind, cold, etc.
- **Good-our main takeaway from the blizzard in Buffalo was that there was so much snow that houses and cars were just buried in it, it was a disaster. Now-how did it get there?**
  - It was snowing, there was a blizzard, it came from the clouds, it fell from the sky, it was blowing all over the place, the wind blew it
- **So all that snow, that covered an entire city, came out of the sky? Okay, this is interesting…so you're saying that there was all this snow in the clouds, and then it just fell**

out and there was this great big natural disaster. Ok. So there's snow in the sky? What else is up there?
    - Clouds, birds, wind, rain, tornados, hail, lightning
    - Optional video to show if students are unable to identify where water comes from: Sid the Science Kid Video (PBS) http://pbskids.org/video/?category=Sid%20the%20Science%20Kid&pid=Bjq_Kg7MDqhiLYlaxnV_uBMVkhq72f7a
- **There's rain up there too! That's right-and that comes down on us too! Are there other things up in the sky that come down when the weather gets bad?**
    - Snow, rain, sleet, hail, sleet, mist, fog (students may not have the words for these, may have to 'look up' on google)
- **That's a ton of stuff! That's crazy! That's a lot of different stuff, right? Snow, rain, hail, mist-those are all very different because some of them are frozen, and some of them are just liquid. But I wonder if there's something about them that's the same, maybe that would help us understand what's going on better. What do you think they all have in common?**
    - They all fall out of the sky, they all happen in bad weather/during a storm, they all get you wet, they're all water (may take some conversation moves to get them to ID that they're all water…i.e. what happens to snow when it melts, can you eat snow? What is hail? What is ice made of? Are they all made of water?)
- **This is great, guys-there's got to be a word for all of these things, let's look really quick and see if we can find a word for all of these things at once (Google all of them-find multiple links for 'definition of precipitation')**
- **Ok great, all this water up in the sky is called precipitation. Let's get that on the board. (Put up on anchor chart, wall, etc.)**
- **So the precipitation hangs out up in the clouds, and then sometimes it falls down all over us, sometimes it's snow, sometimes it's rain, sometimes it's hail, but it's up in the sky and it falls down on us.**
- **(The following is an attempt to get students to ask the question-how did all that water get into the sky?) I'm going to be honest, this has me pretty confused-there's all of this precipitation, water, up in the sky, and it falls down sometimes-fine, I've seen snow and rain before, that I understand. But I feel like there's something we're not addressing. There's ALL THIS WATER UP IN THE SKY! When there's water in the sink, it's because I turned on the faucet and put it there. If there's water in the tub it's because it's bath time and I turned on the faucet and put it there. If there's water on the ground it's because it was raining, and the precipitation put it there! What do you guys think? Do you have any questions about all that water up there?**
    - Why is there water in the sky? How did water get in the sky? Is the water going to fall out? How much water is in the sky? Who put the water in the sky? Are the clouds water?
- **That's what I was wondering! There's enough water in the sky over Buffalo, NY for a blizzard to cover your house, but how did it get there!? What do we think? Work with your team, share some of your prior knowledge on this, let's see if we have an expert that can explain how water gets into the sky.**
    - If students know about evaporation and condensation: add to diagram, name it: Water Cycle, then allow them to flesh out details
    - If students don't know about evaporation and condensation, pull in resources (books, articles, etc.) to fill in gaps in understanding and share knowledge to flesh out diagram, then name it: Water Cycle
        - Extension opportunity: develop and engage students in a guided inquiry about evaporation [and condensation] to build their understanding (see example: http://www.inquiryinaction.org/classroomactivities/activity.php?id=33)

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- **Ok, so now we've encountered a really important question: Where does water come from in nature? With our detailed understanding of the water cycle, have we answered that question?**
    - Yes, we now know that in nature water comes from the water cycle. Precipitation comes from the sky because it evaporated from the ground.
- **Great, we know that water in nature moves through the water cycle, and that's where precipitation comes from. Now how could we study this in real life? I know that we've seen some precipitation not too long ago, right?**
    - Yes, it rained yesterday; it snowed last weekend; etc.
- **It did _______ yesterday, good. How could we study that?**
    - Go out and look at it, catch it, watch it
- **How do you think scientists study precipitation? How do they know how much snow or rain falls?**
    - they catch it, they measure it
- **Ok, then we have to figure out a way to catch it and measure it, then we can see what the water cycle looks like in our town, right? (We want to know what precipitation looks like in our town)**

At the conclusion of this band, students should have developed a basic understanding of the water cycle, and understand that water comes down as precipitation.

Band 2: What does precipitation look like in our town?

Purpose: Students gather data about local weather using a device created by the class that is monitored by teacher and/or students. Students will also look at professional data from the area to look for weather patterns that describe our climate.

Introduction: First, teacher will connect to previous learning, and identification of Band 2 question: What does precipitation look like in our town? Then guide students to act like scientists, collecting water data to answer the Band 2 Question.

Vocabulary: snow board, rain gauge, observation, graph, pattern, analyze, evidence, season, investigate, data, compare, contrast, prediction

Investigation: Gathering and analyzing weather data

After guiding students to gather weather data, as a class construct the necessary device to track precipitation (snow board, rain gauge, etc.). Each day, check in on calendar, noting precipitation to build a data set. At end of time period (1-4 weeks) graph data and look for patterns.

(**Note: if not possible to track data long term**, establish purpose and engage students in data collection, then gather sample data from Midwest Regional Climate Center: http://mrcc.isws.illinois.edu/CLIMATE/ for graphing-Aurora, IL Station ID: 110338) (For example: since we can't stop instruction for four weeks, how can we look at that data? To generate student need to gather historical data)

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Teacher dialogue box:

- **Ok, now that we have a really good set of reliable data (either our own, or from MRCC), we want to be able to look for patterns. Let's graph our data to make it even easier to find patterns. (connect this to math instruction, CCSS 3.MD.B.3)**
- When students have graphed data, guide discussion around patterns-collect observations about the data:
  - What kinds of precipitation are we seeing? Why do you think that is?
  - How much precipitation is there? Why do you think that is?
  - Are there any patterns that you're noticing?
- Share out observations-use questioning to build need to investigate more data:
  - Is the precipitation in our data always the same?
  - Is precipitation here in aurora always like that?
  - When is it different?
- Once students ID that there are different weather patterns, pivot to study of 3 month weather data for Winter vs Summer-repeat observation gathering while students gather ideas on Venn diagram template.
- Have students share out big takeaways on posted class Venn diagram (board, chart paper, computer doc…)
  - **So what does this tell us about weather in Aurora?**
    - There's different kinds; sometimes it snows; sometimes it rains; winter; summer
  - Establish common understanding: based on observations, summer is warm with rain, winter is cold with snow.
  - **We think it's warm/cold because of the precipitation---could we look at that to get a better understanding of what the weather is like in Aurora?**
- This conversation drives student need for temperature data-use for confirming investigation-look at graphs of same period with extra layer of temperature data, add to Venn diagram.
  - **We found a lot of differences looking at Winter and Summer. If we looked at Spring and Fall would there be that many differences?**
    - (have students share ideas-fall and spring are more comparable)
  - **So what is weather?** (Temperature and precipitation) **And we notice that it's different at different times of the year-we've got a cold winters with snow, and warm summers with some rain…so can we make a prediction for what we think the weather will be next year?** (Allow students to predict what the weather will be like next year during those seasons)
  - **How were you able to make your predictions?** (We know it's cold in winter…we know it's warm in summer…we saw the data said there's snow in winter…) **So you're saying it's always kind of hot in summer, and always kind of cold in winter? How do you know? Could we prove it?**
  - Generate student need to gather historical data, use to generate Band 3 Question: Is the weather always like this?

At the end of this band students should have figured out that weather patterns in our town make up our climate, and that climate describes a range of typical weather conditions.

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Band 3: Is the weather always like this?

Purpose: Students will continue to analyze patterns in weather data using sets gathered from the Midwest Regional Climate Center (or NOAA http://www.ncdc.noaa.gov/cdo-web/search). Using this data, they will develop their understanding of climate as the typical expected weather for an area based on historical patterns.

Introduction: First the teacher will connect to previous learning surrounding studies of data, and revisit the Band 3 question: Is the weather always like this? Then they will introduce the necessary data sets for the investigation.

Vocabulary: weather, climate, graph, pattern, analyze, evidence, season

Investigation: Analyzing historical weather data

After revisiting previous patterns discovered through analyzing data, students will again make observations about historical weather data and make judgements about the area's climate.

Teacher dialogue box:

- Present data sets from 10-50 years ago (any range) and have them work through second confirming investigation-collecting observations around historical data sets to compare to current data.
  - Generate definition of climate-what weather is like over long periods of time.
  - **Let's focus on our winter climate here, what are we noticing?**
    - Always cold, lots of snow; snow; low temperatures
  - **And we know it's usually going to be that way because of the data we just studied.**
  - **Ok good, so lots of snow, gotta be very cold outside-where else would you see weather like this in January and February?**
    - Buffalo, NY; Canada; Wisconsin; Chicago; New York; North Pole
  - **Great-lots of places have cold winter climates, and they end up with snow during January and February. So is it like this everywhere in America during January and February?**
    - Yes; no; some places; not in Florida; Mexico; California; Arizona
  - **Interesting-how could we compare our climates?**
    - Visit, read about them, ask someone, look at weather, look at data, look at precipitation, look at temperature
- **Looks great, so since we're going to look at data from different places, what could our question be?**
  - What is the climate like in other towns?

At the conclusion of this band, students should have figured out that climate describes an area's typical weather conditions, and the extent to which those conditions vary over years.

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Band 4: What is the climate like in other towns?

Purpose: Students will compare and contrast weather/climate data from different parts of the country to draw conclusions about climate.

Introduction: Revisit previous lesson and established Band 3 Question: What does the water cycle look like in other towns? Remind students that the weather data we've looked at has helped us understand the climate of Aurora: it's hot and rains in summer, and it's cold and snows in the winter.

Vocabulary: weather, climate, season, region, observation, compare, contrast, pattern, predict

Investigation: Comparing weather data from different places

Now that students have established that we'll look at data from other places, present data from Aurora and two other places mentioned (i.e. Buffalo, California [San Diego is good], Phoenix, AZ, Miami, FL, etc.). [Classes have the option to partner with schools in another region-supported by video chats, i.e. Skype, Google Hangouts…] Data can be gathered from the MRCC, or from the NOAA http://www.ncdc.noaa.gov/cdo-web/search Allow students time to work in teams to gather observations about the data sets, then share with them a triple Venn diagram to categorize their observations. As a class, complete triple Venn diagram to compare and contrast the three regions and their climates.

Teacher dialogue box:

- **Now that you guys have made some observations about the data, let's try comparing and contrasting it to see how our climate compares to theirs.**
  - What observations did you make about the data?
  - Did you notice any patterns in the data?
  - What do you think that tells you about the climate there?
  - Is that similar to another place we studied? How?
  - Is that different from another place that we studied? How?
  - Are there any connections in what you observed?
  - Do all three places have anything in common? How are they the same?
  - What are the connections between (A) and (B)? (B) and (C)? (C) and (A)?
  - Why do you think there are those connections?
  - Would you like to live there? Why?
- **Okay, we've done an incredible job of comparing and contrasting these different climates, have we answered our question: What does the climate look like in other towns?**
  - Yes, in different towns the climate is really different; yes, in different towns the climate can sometimes be the same
- **Great, I agree. And now that we know so much about what weather and climate look like, I'm noticing a pattern too. All of the data we looked at was pretty standard: some snow in winter, some rain in summer, that's all pretty much what you'd expect, right? Do you think it always looks this nice and easy?**
  - Maybe, yes, no-because sometimes there's a blizzard like in Buffalo
- **That's what I was thinking-sometimes there's a big blizzard, or a storm, and then the water cycle gets out of hand. That's gotta be our next question then, right? What happens when the weather gets crazy?**

At the conclusion of this band students should understand that climate varies in different regions, and we can make generalizations and compare climates based on our observations and patterns in data.

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Band 5: What happens when the weather gets crazy?

Purpose: Draw students back to extreme weather study with Katrina phenomenon-then get students to find cause of Katrina disaster through research.

Introduction: After revisiting previous discussions that built understanding of weather, remind students of current question: What happens when the water cycle gets out of hand? Then present them with the Katrina data (modified to match snow data for effect [at February temperatures, Katrina's rain data should be multiplied by 20 to account for difference between rain and snowfall]). Then show students news reports about Katrina, and engage them in Band 4 Question.

Vocabulary: hurricane, Hurricane Katrina, disaster, flood, levee, evidence, cause, effect

Resources:

http://www.ncdc.noaa.gov/extremeevents/specialreports/Hurricane-Katrina.pdf
https://www.youtube.com/watch?v=HbJaMWw4-2Q
http://www.history.com/topics/hurricane-katrina

Teacher dialogue box:

- **Alright, now we've seen some really incredible weather that's absolutely an example of what happens when the water cycle gets out of hand. But even with all of that-I just can't help but wonder, why was Katrina so bad? Do you think that was the first hurricane that had ever happened down there?**
    - No, hurricane season, they get hurricanes every year, yes, maybe, it was big
- **Okay, so it seems like they probably get hurricanes every year-that's probably a weather pattern for them, just like we have weather patterns in Aurora. But if that's the case, then I wonder why it was SO bad! If they're used to hurricanes, then I wonder why this one was so bad, what do you think?**
    - This was really big, lots of rain, lots of wind, powerful, they weren't ready, too much water, etc.
- **These are all good ideas guys, I wonder if we could do some research and really figure out what the cause was for such a huge natural disaster**

Give students articles to work through in teams, pulling out important information to try to find the cause of the disaster-guide students to the breaking point: the destruction of the levees that led to the flooding of the city, then regroup for discussion. Share out and collect observations and take-aways, drive discussion to levees:

- **I think you guys are right-yes there was a lot of powerful wind, yes there was a TON of rain, but it looks like when the levees broke, that's when everything got really bad. Why did they break?**
    - Water got underneath, powerful waves, crumbled, broke up, built on top of sandy soil
- **Ok, so it seems like they had some problems when they were made, then when it came time for them to protect people, they didn't do what they were supposed to. Now thinking back for a minute, have we answered our question: What happens when the water cycle gets out of hand?**
    - Yes, when the water cycle gets out of hand there's a big disaster, there's flooding, people get hurt, people die, people's houses get destroyed, people need lots of help, etc.
- **Absolutely, when the weather gets crazy, there are lots of different consequences-that's our next question, then: How can we prevent damage caused by extreme weather?**

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At the conclusion of this band, students should understand that extreme weather can be very dangerous, and causes a lot of damage and destruction. In the case of Hurricane Katrina, the breaking levees caused the flooding that turned the hurricane into a terrible natural disaster.

Band 6: How can we prevent damage caused by extreme weather?

Purpose: Students will engage in experimentation and modeling to better understand why the levees broke, and to design potential solutions for how to better construct levees to prevent damage from future extreme weather.

Introduction: After connecting to previous instruction, and the reason for the flooding that caused the Katrina disaster, turn to the Band 5 Question: How can we prevent damage caused by extreme weather?

Vocabulary: Hurricane Katrina, extreme weather, precipitation, flooding, levee, engineering, design, test, cause, effect, prevent, construct, model, recommend, solution, evaluate, compare, contrast, summarize

Investigation: To better understand what happened in the Katrina disaster, students will build models of levees, and mimic flooding them to test their resilience. They will then construct and test new designs and models to make suggestions for how to better construct levees.

Teacher dialogue box:

- **So we know that in the Katrina disaster, there was so much precipitation that the levees broke open, and the city flooded. To better understand that, let's recreate similar conditions here in the classroom.**
- Work with students through guided inquiry: creating Pre-Katrina levees in trays, constructed on sandy soil. Test levees with water to look for leaking and breakage.
- **What are some things that you noticed during our investigation of the Katrina levees?**
    - The levee didn't work, the water was leaking, the levee broke, the monopoly house on the other side of the levee got all wet, etc.
- **Great, so we're seeing the same thing that we read about in our articles. But now I want to start thinking like an engineer. If there's some problem with these levees, then I want to know how to fix it.**
- Guide student teams through engineering process: working with given materials to design and test new levees: will updated designs prevent water leakage?
    - What are some of the variables that you tried?
    - How did that work?
    - Why do you think using that material did/didn't work?
    - Do you think that material would be good for making a levee? Why?
    - Do you think that material would hold up for a long time?
    - Are these materials effective for constructing levees?
    - What other materials do you think an engineering team would need to make an effective levee?
- Wrap-up investigation by revisiting Driving Question: How can we prevent damage caused by extreme weather?

At the conclusion of this band, students should understand that the failure of the Katrina levees is something that engineers can address, and that applying understanding of different designs can help to prevent the damage caused by extreme weather events like Hurricane Katrina.

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Conclusion: As a conclusion, students will present their takeaways from the Levee Engineering lab. After presenting, they will compare potential solutions and determine the most successful design and its components. As a final reflection, have students summarize their takeaways in a written response to the Driving Question: How can we prevent damage caused by extreme weather. Encourage them to use the knowledge gained in the unit, referring to your anchor charts/displays to enrich their discussion of the Driving Question.

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Title: ______________________ Scientist: ________________

Scale

Labels

Total Precipitation: ______

Title: ______________________ Scientist: ________________

Scale

Labels

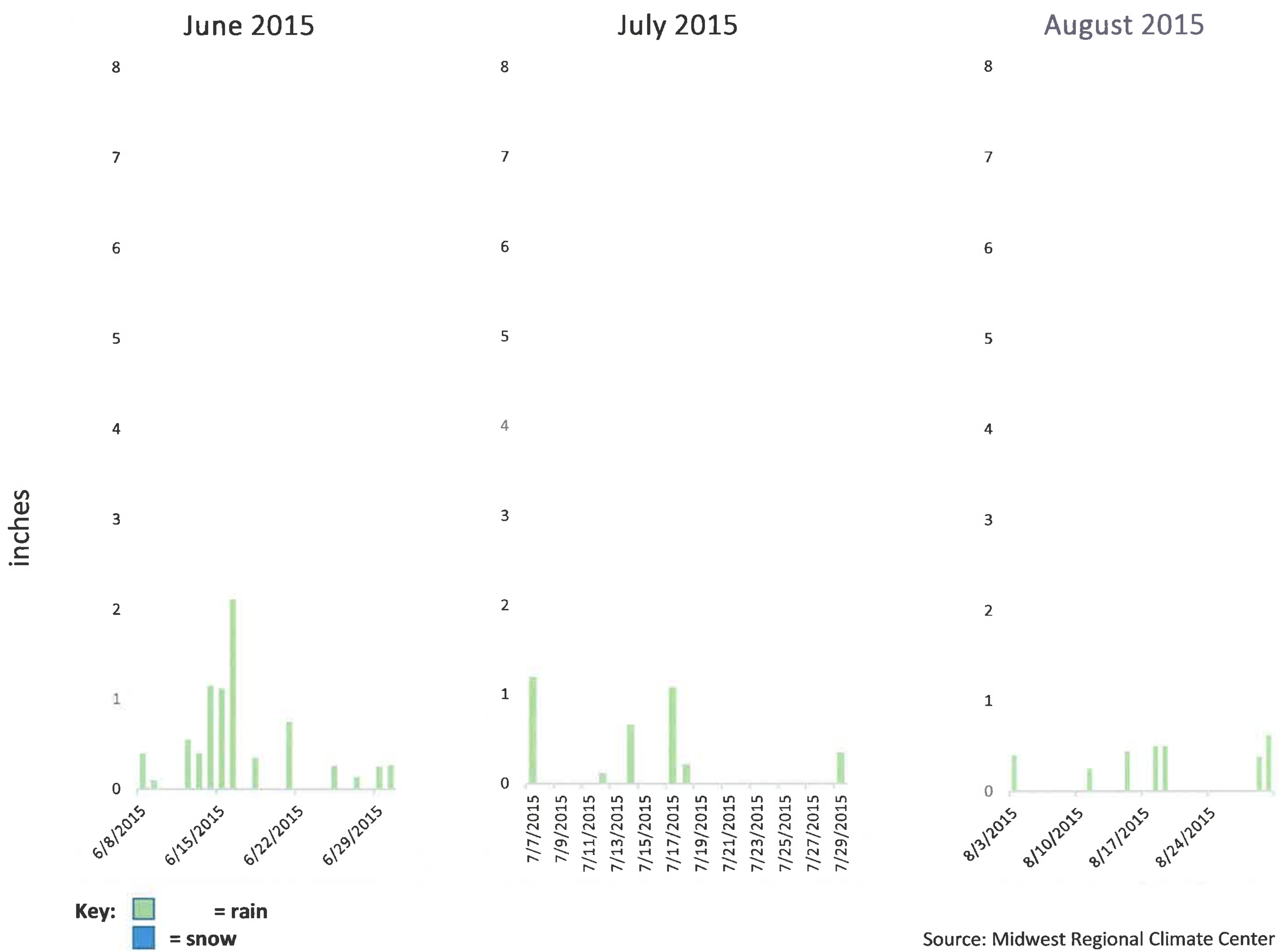
Total Precipitation: _____

January 2015 Aurora, Illinois

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
				1	2	3
4	5 3" snow	6	7	8 1" snow	9	10
11 1 1/2" snow	12	13 flurries	14	15	16	17
18	19 flurries	20	21 flurries	22	23	24
25 flurries	26 flurries	27	28	29	30	31 flurries
1 snow starts	2 8 1/2" snow	3	4			

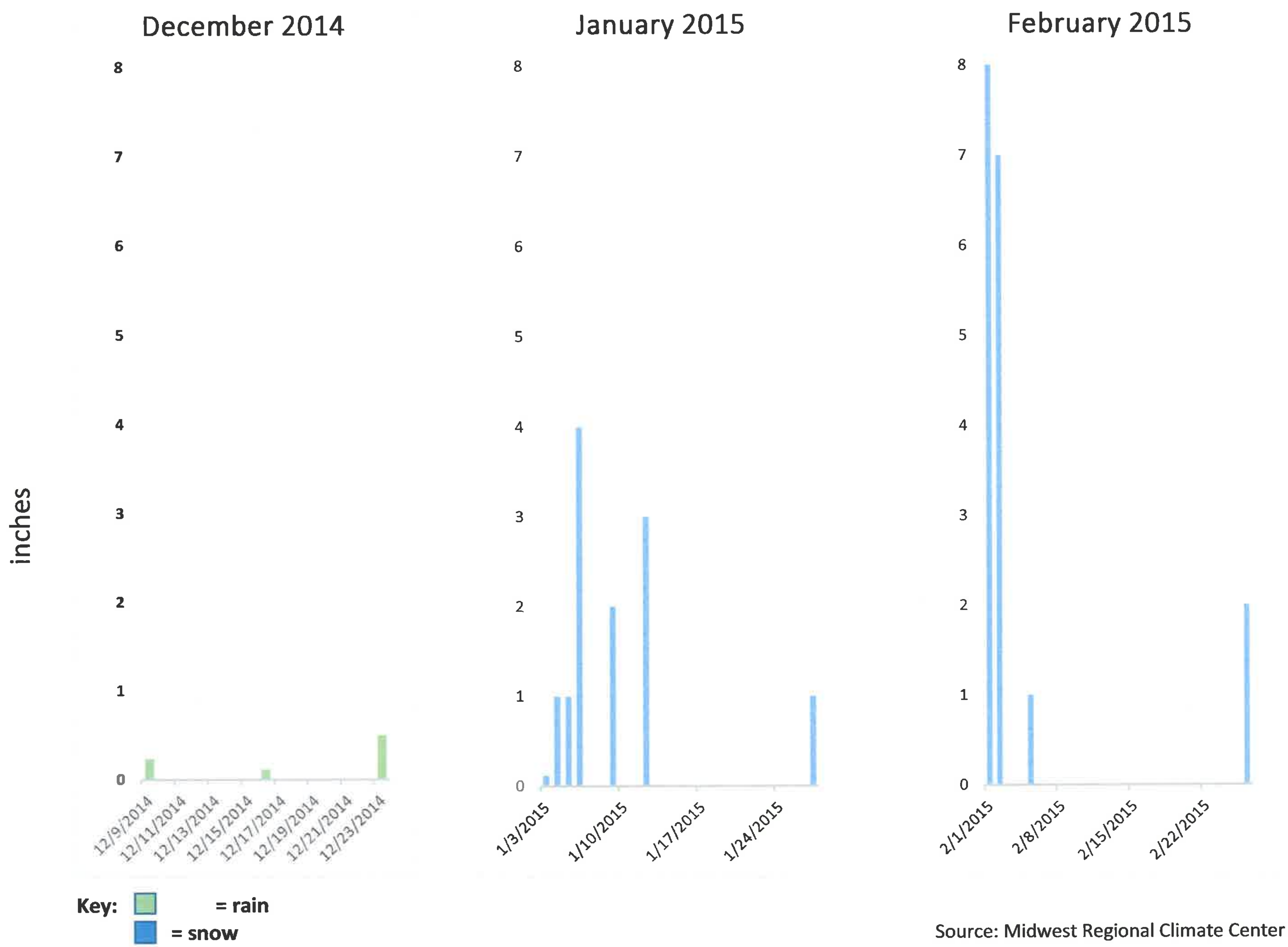
Total Precipitation:
14 inches of snow

PROFESSIONAL DATA: AURORA, IL



Source: Midwest Regional Climate Center

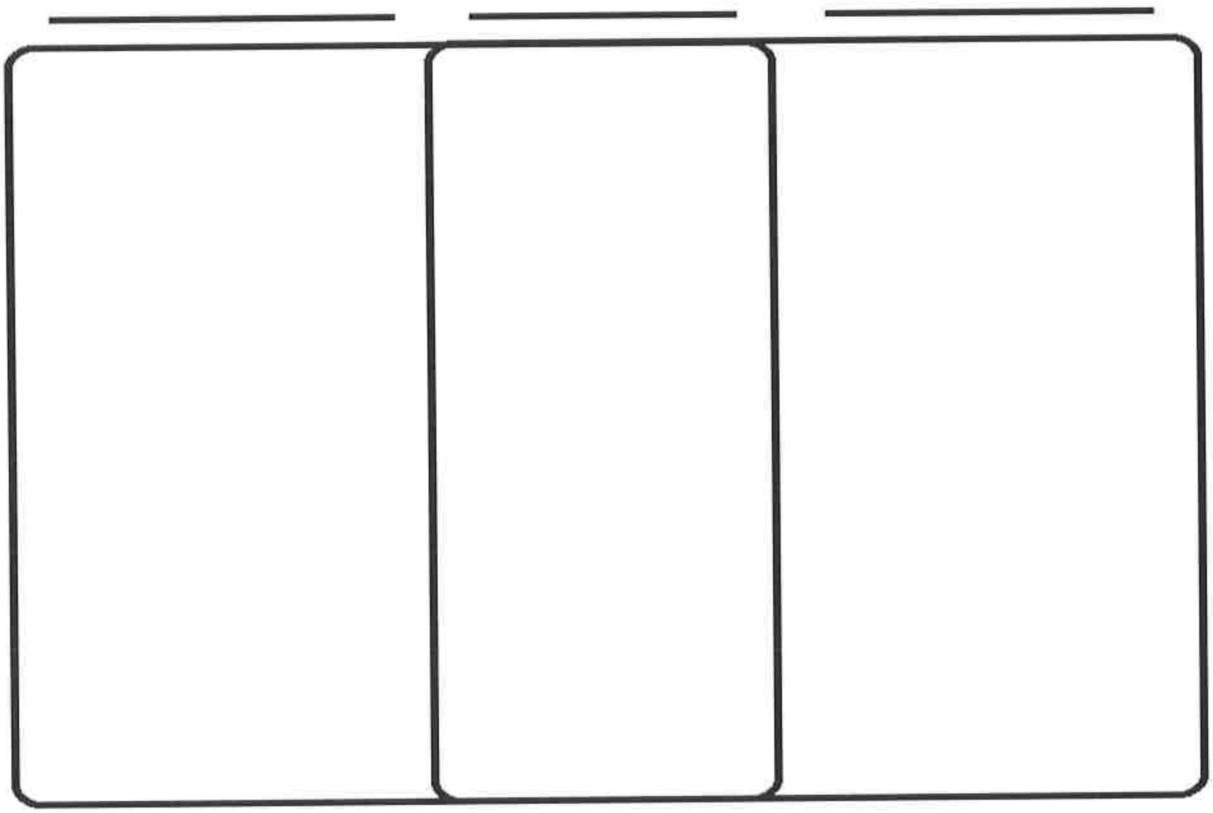
PROFESSIONAL DATA: AURORA, IL



Source: Midwest Regional Climate Center

Comparing and Contrasting Observations

Use the Venn diagram below to compare and contrast data set 1 to data set 2:



What observations did you and your team make about the data?

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What does this data tell us about weather in Aurora?

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