

Cedar Grove School District

Cedar Grove, NJ

2017 | Grade 8

Science



Approved by the Cedar Grove Board of Education

Superintendent of Schools
Mr. Michael J. Fetherman

Board of Education
Mrs. Christine Dye, President
Mr. Frank Mandala, Vice-President
Mr. Peter Prvulovic
Mr. David Schoner
Mr. Vincent Vollero

Science – Grade 8

**This curriculum was written in accordance with the
NEW JERSEY STUDENT LEARNING STANDARDS
for SCIENCE.**

These standards can be viewed at <http://www.state.nj.us/education/cccs/2016/science/>

Grade 8 - Science

Unit 1: Chapter 13

Instructional Time: 20 -25 days

Why aren't minerals and groundwater distributed evenly across the world?

Students construct an understanding of the ways that human activities affect Earth's systems. Students use practices to understand the significant and complex issues surrounding human uses of land, energy, mineral, and water resources and the resulting impacts on the development of these resources. Students also understand that the distribution of these resources is uneven due to past and current geosciences processes or removal by humans. The crosscutting concepts of *patterns, cause and effect, and stability and change* are called out as organizing concepts for these disciplinary core ideas. In this unit of study students are expected to demonstrate proficiency in *asking questions, analyzing and interpreting data, constructing explanations, and designing solutions*. Students are also expected to use these practices to demonstrate understanding of the core ideas.

Student Learning Objectives

New Jersey Student Learning Standards/ NGSS

MS-ESS3-1	Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes.
MS-ESS3-2	Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.
MS-ESS3-4	Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects
MS-ESS3-5	Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.

Enduring Understandings

- Earth's minerals are not evenly distributed across the world.
- Earth's minerals, energy, and groundwater resources are the result of past and current geoscience processes.
- Catastrophic events can be forecasted by using data from natural hazards to develop better technologies to mitigate their effects.
- Earth's resources need to be managed better.
- Global temperatures have risen over the past century.
- Global temperatures rising can be substantiated by basic chemistry.

Essential Questions

- Why aren't minerals and groundwater distributed evenly across the world?
- How can we predict and prepare for natural disasters?
- How might we treat resources if we thought about the Earth as a spaceship on an extended survey of the solar system? (How would astronauts manage their resources?)
- How can basic chemistry be used to explain the mechanisms that control the global temperature the atmosphere?

Concepts

- Part A:** *Why aren't minerals and groundwater distributed evenly across the world?*
- Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources.
 - All human activities draw on Earth's land, ocean, atmosphere, and biosphere resources and have both short and long-term consequences, positive as well as negative, for the health of people and the natural environment.
 - Minerals, fresh water, and biosphere resources are distributed unevenly around the planet as a result of past geologic processes.
 - Cause-and-effect relationships may be used to explain how uneven distributions of Earth's mineral, energy, and groundwater resources have resulted

Formative Assessment

- Part A:** *Why aren't minerals and groundwater distributed evenly across the world?*
- Students who understand the concepts can:*
- Construct a scientific explanation based on valid and reliable evidence of how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geosciences processes.
 - Obtain evidence from sources, which must include the student's own experiments.
 - Construct a scientific explanation based on the assumption that theories and laws that describe the current geosciences process operates today as they did in the past and will continue to do so in the future.
- Part B:** *How can we predict and prepare for natural*

from past and current geosciences processes.

- Resources that are unevenly distributed as a result of past processes include but are not limited to petroleum, metal ores, and soil.
- Mineral, fresh water, ocean, biosphere, and atmosphere resources are limited, and many are not renewable or replaceable over human lifetimes.
- The distribution of some of Earth's land, ocean, atmosphere, and biosphere resources are changing significantly due to removal by humans.

Part B: *How can we predict and prepare for natural disasters?*

- Natural hazards can be the result of interior processes, surface processes, or severe weather events.
- 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 without notice, and thus are not yet predictable.
- Mapping the history of natural hazards in a region, combined with an understanding of related geologic forces, can help forecast the locations and likelihoods of future events.
- Data on natural hazards can be used to forecast future catastrophic events and inform the development of technologies to mitigate their effects.
- Data on natural hazards can include the locations, magnitudes, and frequencies of the natural hazards.
- Graphs, charts, and images can be used to identify patterns of natural hazards in a region.
- Graphs, charts, and images can be used to understand patterns of geologic forces that can help forecast the locations and likelihoods of future events.
- Technologies that can be used to mitigate the effects of natural hazards can be global or local.
- Technologies used to mitigate the effects of natural hazards vary from region to region and over time.

Part C: *How might we treat resources if we thought about the Earth as a spaceship on an extended survey of the solar system? (How would astronauts manage their resources?)*

- All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment.
- Increases in human population and per-capita consumption of natural resources impact Earth's systems.

disasters?

Students who understand the concepts can:

- Analyze and interpret data on natural hazards to determine similarities and differences and to distinguish between correlation and causation.

Part C: *How might we treat resources if we thought about the Earth as a spaceship on an extended survey of the solar system? (How would astronauts manage their resources?)*

Students who understand the concepts can:

- Construct an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.

Part D: *How can basic chemistry be used to explain the mechanisms that control the global temperature the atmosphere?*

Students who understand the concepts can:

- Ask questions to identify and clarify a variety of evidence for an argument about the factors that have caused the rise in global temperatures over the past century.
- Ask questions to clarify human activities and natural processes that are major factors in the current rise in Earth's mean surface temperature.

- Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise.
- Cause and effect relationships may be used to predict how increases in human population and per-capita consumption of natural resources impact Earth's systems.
- The consequences of increases in human populations and consumption of natural resources are described by science.
- Science does not make the decisions for the actions society takes.
- Scientific knowledge can describe the consequences of human population and per-capita consumption of natural resources impact Earth's systems but does not necessarily prescribe the decisions that society takes.

Part D: *How can basic chemistry be used to explain the mechanisms that control the global temperature the atmosphere?*

- Stability in Earth's surface temperature might be disturbed either by sudden events or gradual changes that accumulate over time.
- Human activities and natural processes are examples of factors that have caused the rise in global temperatures over the past century.
- Human activities play a major role in causing the rise in global temperatures.
- Human activities, such as the release of greenhouse gases from burning fossil fuels, are major factors in the current rise in Earth's mean surface temperature (global warming).
- Reducing the level of climate change and reducing human vulnerability to whatever climate changes do occur depend on understanding of climate science, engineering capabilities, and other kinds of knowledge, such as understanding of human behavior, and on applying that knowledge wisely in decisions and activities.
- Evidence that some factors have caused the rise in global temperature over the last century can include tables, graphs, and maps of global and regional temperatures, atmospheric levels of gases such as carbon dioxide and methane, and the rates of human activities.

Suggested Learning Activities

Students will begin by building on their prior knowledge that human activities affect the Earth. Students will describe how human activities have positive as well as negative impacts on land, ocean, atmosphere, and biosphere resources.

In this unit of study, students will build upon this knowledge by examining the causes of the uneven distribution of resources on Earth. Students can then write an informative text to explain the causes of uneven distributions of Earth's minerals, energy, and groundwater resources. These causes can include past and current geosciences processes as well

as human removal of resources. The written text needs to include specific evidence to support the student's explanation. Students will use variables to represent numbers and write expressions. They will convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.

Students will perform investigations to gather data showing how natural processes can lead to the uneven distributions of Earth's mineral, energy, and groundwater resources. The resources considered should include but not be limited to petroleum, metal ores, and soil. An example of an investigation could include using models of different layers of sediment that will show the uneven distribution of groundwater as it permeates through different types of soil and rock. A saturated mineral solution (i.e. salt) can be poured over the sedimentary layers and then evaporated to leave behind a deposit. Students could then take core samples using straws to gather data from the model.

Emphasis is on how these resources, including land, ocean, atmosphere, biosphere, mineral, and fresh water, are limited and typically are nonrenewable, and how their distributions are significantly changing as a result of removal by humans. Students will use variables to represent quantities and construct simple equations and inequalities to solve problems by reasoning about the quantities.

Students may use maps showing the current global distribution of different resources along with maps showing past global distribution of the same resources to gather data. Students could use these data to create mathematical expressions that could show the impact of current human consumption on possible future resource distribution (renewable and nonrenewable energy resources). In addition, students could use maps of different geosciences processes alongside other data to explain the uneven distributions of Earth's resources.

Students will continue to learn about Earth's systems as they consider how natural hazards can be the result of interior processes, surface processes, or severe weather events. They will learn that 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 without notice, and thus are not yet predictable. Students will also look at how technology can be used to predict natural hazards to reduce their impacts. Last, students will examine evidence of natural processes and human activities that have caused global climate change.

Students can analyze maps, charts, and images of natural hazards to look for patterns in past occurrences of catastrophic events. Data on natural hazards can include the locations, magnitudes, and frequencies of the natural hazards. Students can use these data to make reliable predictions of future catastrophic events.

Students can also look at past occurrences of catastrophic events to determine how those events have influenced the development of technologies scientists use to predict future events. It might be useful to include local catastrophic events, since the technology used to predict and diminish effects of future events varies from region to region over time. Some of the data students might analyze could include locations, magnitudes, and frequencies of the natural hazards.

Students will continue their study of Earth's systems and processes by investigating the impact of sudden events or gradual changes that accumulate over time and affect the stability of Earth's surface temperature.

Students will cite specific textual evidence to support an argument about the role of human activity and natural processes in the gradual increase in global temperatures over the past century.

Students can ask questions to clarify how human activities, such as the release of greenhouse gases from the burning of fossil fuels, play major roles in the rise in global temperatures. Students can also ask questions about how natural events, such as volcanic activity, also contribute to the rise in global temperature. Students can look at a variety of sources for evidence, such as tables, graphs, and maps of global and regional temperatures; atmospheric levels of gases, such as carbon dioxide and methane; and rates of human activities, to support an argument that global temperatures have risen over the past century. Students can use these data to write mathematical expressions that show relationships between these variables.

Students will examine a variety of changes that humans have made to Earth's natural systems and determine whether these changes have positive impacts, negative impacts, or some combination of positive and negative impacts. As part of this study, students will collect evidence to support arguments they develop about the impact of the modifications to Earth's systems. Students will consider how a variety of human actions can impact an ecosystem. Among the human actions considered will be human population growth and the consumption of resources from the ecosystem. Students will prepare a report on the system and describe how the system is impacted. Evidence must be recorded to support

their arguments and must be presented in both an oral and a written format.

Students can cite specific textual evidence to develop an argument about the need to reduce the level of climate change due to human activity. The argument can include the need for reduction in human vulnerability to whatever climate change occurs as a result of natural events.

Performance Expectations

Science and Engineering Practices	DCI	Crosscutting Concepts
<p><u>Constructing Explanations and Designing Solutions</u></p> <ul style="list-style-type: none"> Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students’ own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (MS-ESS3-1) <p><u>Engaging in Argument from Evidence</u></p> <ul style="list-style-type: none"> Construct an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. (MS-ESS3-4) 	<p><u>ESS3.A: Natural Resources</u></p> <ul style="list-style-type: none"> Humans depend on Earth’s land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geologic processes. (MS-ESS3-1) <p><u>ESS3.B: Natural Hazards</u></p> <ul style="list-style-type: none"> Mapping the history of natural hazards in a region, combined with an understanding of related geologic forces can help forecast the locations and likelihoods of future events. (MS-ESS3-2) <p><u>ESS3.C: Human Impacts on Earth Systems</u></p> <ul style="list-style-type: none"> Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise. (MS-ESS3-4) <p><u>ESS3.D: Global Climate Change</u></p> <ul style="list-style-type: none"> Human activities, such as the release of greenhouse gases from burning fossil fuels, are major factors in the current rise in Earth’s mean surface temperature (global warming). Reducing the level of climate change and reducing human vulnerability to whatever climate changes do occur depend on the understanding of climate science, engineering capabilities, and other kinds of knowledge, such as 	<p><u>Patterns</u></p> <ul style="list-style-type: none"> Graphs, charts, and images can be used to identify patterns in data. (MS-ESS3-2) <p><u>Cause and Effect</u></p> <ul style="list-style-type: none"> Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-ESS3-1),(MS-ESS3-4) <p><u>Stability and Change</u></p> <ul style="list-style-type: none"> Stability might be disturbed either by sudden events or gradual changes that accumulate over time. (MS-ESS3-5) <p>-----</p> <p><i>Connections to Engineering, Technology, and Applications of Science</i></p> <p><u>Influence of Science, Engineering, and Technology on Society and the Natural World</u></p> <ul style="list-style-type: none"> All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment. (MS-ESS3-1),(MS-ESS3-4) The uses of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time. (MS-ESS3-2) <p>-----</p> <p><i>Connections to Nature of Science</i></p> <p><u>Science Addresses Questions About the Natural and Material World</u></p> <p>Scientific knowledge can describe the</p>

	understanding of human behavior and on applying that knowledge wisely in decisions and activities. (MS-ESS3-5)	consequences of actions but does not necessarily prescribe the decisions that society takes. (MS-ESS3-4)
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Cross-Curricular Connections

English/Language Arts Standards	Mathematics Standards
<ul style="list-style-type: none"> • Cite specific textual evidence to support analysis of how the uneven distributions of Earth’s mineral, energy, and groundwater resources are the result of past and current geosciences processes. • Write informative/explanatory texts examining how the uneven distributions of Earth’s mineral, energy, and groundwater resources are the result of past and current geosciences processes. Convey ideas, concepts, and information through the selection, organization, and analysis of relevant content. • Draw evidence from informational texts to support analysis, reflection, and research on how the uneven distributions of Earth’s mineral, energy, and groundwater resources are the result of past and current geosciences processes. • Cite specific textual evidence in data used to support the analysis of natural hazards and to forecast future catastrophic events and inform the development of technologies to mitigate their effects. • Integrate quantitative or technical information about natural hazards and forecasting future catastrophic events that is expressed visually (e.g., in a flowchart, diagram, model, graph, or table). Use the integrated text and visual displays to analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects. • Cite specific textual evidence to support an argument about the role of human activity and natural processes in the gradual increase in global temperatures over the past century. 	<ul style="list-style-type: none"> • Use variables to represent numbers and write expressions for how the uneven distributions of Earth’s mineral, energy, and groundwater resources are the result of past and current geosciences processes. Convey ideas, concepts, and information through the selection, organization, and analysis of relevant content. • Use variables to represent quantities for how the distribution of Earth’s mineral, energy, and groundwater resources are significantly changing as a result of removal by humans. Construct simple equations and inequalities to solve problems by reasoning about the quantities. • Analyze and interpret data on natural hazards by reasoning abstractly (manipulating symbols abstractly) and quantitatively (while attending to the meaning of those symbols) to forecast future catastrophic events and inform the development of technologies to mitigate their effects. • Use variables to represent numbers and write expressions for the locations, magnitudes, and frequencies of natural hazards and how these data can be used to forecast future catastrophic events and inform the development of technologies to mitigate their effects. The variable can represent an unknown number or, depending on the purpose at hand, any number in a specified set. • Use variables to represent quantities for the location, magnitudes, and frequencies of natural hazards and how these data can be used to forecast future catastrophic events and inform the development of technologies to mitigate their effects. Construct simple equations and inequalities to solve problems by reasoning about the quantities. • Students will clarify evidence of the factors that have caused the rise in global temperatures over the past century, reasoning abstractly (manipulating symbols abstractly) and quantitatively (while attending to the meaning of those symbols). • Use variables to represent numbers and write expressions for data found in tables, graphs, and maps of global and regional temperatures; atmospheric levels of gases such as carbon dioxide and methane’ and the rates of human activities. The variable can represent an unknown number or, depending on the purpose at hand, any number in a specified set.

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| | <ul style="list-style-type: none">• Use variables to represent quantities found in tables, graphs, and maps of global and regional temperatures, atmospheric levels of gases such as carbon dioxide and methane, and the rates of human activities. Construct simple equations and inequalities to solve problems by reasoning about the quantities. |
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21st Century Career Ready Practices	
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| <ul style="list-style-type: none">• CRP1. Act as a responsible and contributing citizen and employee.• CRP2. Apply appropriate academic and technical skills.• CRP3. Attend to personal health and financial well-being.• CRP4. Communicate clearly and effectively and with reason.• CRP5. Consider the environmental, social and economic impacts of decisions.• CRP6. Demonstrate creativity and innovation.• CRP8. Utilize critical thinking to make sense of problems and persevere in solving them.• CRP11. Use technology to enhance productivity.• CRP12. Work productively in teams while using cultural global competence. | |
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Grade 8 - Science

Unit 2: Chapter 13 & 15

Instructional Time: 20 - 25 days

*If no one was there, how do we know the Earth's history?
What provides the forces that drive Earth's systems?*

Students examine geoscience data in order to understand processes and events in Earth's history. Important crosscutting concepts in this unit are *scale, proportion, and quantity, stability and change, and patterns* in relation to the different ways geologic processes operate over geologic time. An important aspect of the history of Earth is that geologic events and conditions have affected the evolution of life, but different life forms have also played important roles in altering Earth's systems. Students understand how Earth's geosystems operate by modeling the flow of energy and cycling of matter within and among different systems. Students investigate the controlling properties of important materials and construct explanations based on the analysis of real geoscience data. Students are expected to demonstrate proficiency in *analyzing and interpreting* data and *constructing explanations*. They are also expected to use these practices to demonstrate understanding of the core ideas.

Student Learning Objectives

New Jersey Student Learning Standards/ NGSS

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.
MS-ESS2-1	Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process.
MS-ESS2-2	Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.
MS-ESS2-3	Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of the past plate motions.

Enduring Understandings

- Earth is 4.6 billion years old.
- Earth has cycles that cycle and recycle Earth's materials.
- Matter cannot be created or destroyed; it just changes form.
- Erosion and weathering are the main drive of the cycling of materials.
- Earth systems changes do not have to occur in similar time scales.
- Earth's surface has changed over time due to different geoscience processes.
- Data from plate motion explains the distribution of fossils and rocks.

Essential Questions

- How do we know that the Earth is approximately 4.6-billion-year-old history?
- What drives the cycling of Earth's materials?
- Do all of the changes to Earth systems occur in similar time scales?
- How is it possible for the same kind of fossils to be found in New Jersey and in Africa?

Concepts

Part A: *How do we know that the Earth is approximately 4.6-billion-year-old history?*

- The geologic time scale is used to organize Earth's 4.6-billion-year-old history.
- Rock formations and the fossils they contain are used to establish relative ages of major events in Earth's history.
- The geologic time scale interpreted from rock strata provides a way to organize Earth's history.
- Analyses of rock strata and the fossil record provide only relative dates, not an absolute scale.
- Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. Energy drives the process that

Formative Assessment

Part A: *How do we know that the Earth is approximately 4.6-billion-year-old history?*

Students who understand the concepts are able to:

- Construct a scientific explanation based on valid and reliable evidence from rock strata obtained from sources (including the students' own experiments).
- Construct a scientific explanation based on rock strata and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.
- Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process.

results in the cycling of Earth's materials.

Part B: *What drives the cycling of Earth's materials?*

- The processes of melting, crystallization, weathering, deformation, and sedimentation act together to form minerals and rocks through the cycling of Earth's materials.
- All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems.
- Energy flowing and matter cycling within and among the planet's systems derive from the sun and Earth's hot interior.
- Energy that flows and matter that cycles produce chemical and physical changes in Earth's materials and living organisms.
- Explanations of stability and change in Earth's natural systems can be constructed by examining the changes over time and processes at different scales, including the atomic scale.

Part C: *Do all of the changes to Earth systems occur in similar time scales?*

- Geoscience processes have changed Earth's surface at varying time and spatial scales.
- Processes change Earth's surface at time and spatial scales that can be large or small; many geoscience processes usually behave gradually but are punctuated by catastrophic events.
- Geoscience processes shape local geographic features.
- The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years.
- Interactions among Earth's systems have shaped Earth's history and will determine its future.
- Water's movements—both on the land and underground—cause weathering and erosion, which change the land's surface features and create underground formations.
- Time, space, and energy phenomena within Earth's systems can be observed at various scales using models to study systems that are too large or too small.

Part D: *How is it possible for the same kind of fossils to be found in New Jersey and in Africa?*

- Tectonic processes continually generate new sea floor at ridges and destroy old sea floor at trenches.
- Maps of ancient land and water patterns, based on investigations of rocks and fossils, make clear how Earth's plates have moved great distances, collided, and spread apart.
- Patterns in rates of change and other numerical relationships can provide information about past plate motions.
- The distribution of fossils and rocks, continental shapes,

Part B: *What drives the cycling of Earth's materials?*

Students who understand the concepts are able to:

- Construct a scientific explanation for how geoscience processes have changed Earth's surface at varying time and spatial scales based on valid and reliable evidence obtained from sources (including the students' own experiments).
- Construct a scientific explanation for how geoscience processes have changed Earth's surface at varying time and spatial scales based on the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.
- Collect evidence about processes that 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).
- Collect evidence about processes that change Earth's surface at time and spatial scales that can be 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.

Students who understand the concepts are able to:

- Analyze and interpret data such as distributions of fossils and rocks, continental shapes, and seafloor structures to provide evidence of past plate motions.
- Analyze how science findings have been revised and/or reinterpreted based on new evidence about past plate motions.

and seafloor structures to provide evidence of past plate motions.

- 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) provide evidence of past plate motions.

Suggested Learning Activities

Within this unit, students will use the geologic time scale to organize Earth's 4.6-billion-year-old history. They will cite specific textual evidence from science and technical texts to support analysis of rock strata to show how the geologic time scale is used to organize Earth's 4.6-billion-year-old history. They will use analysis of rock formations and the fossils they contain to establish relative ages of major events in Earth's history. Examples of Earth's major events could include the Ice Age or the earliest fossils of *Homo sapiens*, or the formation of Earth and the earliest evidence of life. Emphasis should be on analyses of rock strata providing only relative dates, not an absolute scale. Students can use variables to represent numbers or quantities and write expressions when solving problems while constructing their explanations. Examples can include the formation of mountain chains and ocean basins, the evolution or extinction of particular living organisms, or significant volcanic eruptions.

Students will develop and use models to describe the cycling of Earth materials and the flow of energy that drives this process. This energy comes from the heat of the core of the Earth, which is transferred to the mantle. Convection currents within the mantle then drive the movement of tectonic plates. 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. Students can generate models to demonstrate the rock cycle, with specific focus on the processes causing change. Students can analyze pictures and rock samples that demonstrate various processes of melting, crystallization, weathering, deformation, and sedimentation.

Students will construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales. 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). Further emphasis is on how many geoscience processes (such as earthquakes, volcanoes, and meteor impacts) usually behave gradually but are punctuated by catastrophic events. Students can gather data and plot volcanoes and earthquakes in order to collect evidence to support the idea that these interactions among Earth's systems have shaped Earth's history and will determine its future. Additional examples can include changes on Earth's surface from weathering and deposition by the movements of water, ice, and wind. Emphasis is also on geoscience processes that shape local geographic features.

Students convey ideas, concepts, and information through the selection, organization, and analysis of relevant content, and they may use multimedia components and visual displays. Students can also compare and contrast the information gained from experiments, simulations, video, or multimedia sources showing evidence of past plate motion with that gained by reading a text on the same topic. They use informative/explanatory texts to examine evidence for how geoscience processes have changed and reason abstractly and quantitatively when analyzing this evidence. They may integrate quantitative or technical information expressed in a flowchart, diagram, model, graph, or table. They can also use variables to represent numbers or quantities and write expressions when solving problems while constructing their explanations.

Students will analyze and interpret data on the distribution of fossils and rocks, and they will look at the continental shapes and sea floor structures to provide evidence of past plate motions. Maps of ancient land and water patterns, based on investigations of rocks and fossils, make clear how Earth's plates have moved great distances, collided, and spread apart. Tectonic processes continually generate new ocean sea floor at ridges and destroy old sea floor at trenches. Examples of the 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). Students may use numerical relationships, symbols, and words while analyzing patterns in rates of change on Earth's crust. Students can use variables to represent numerical data and write expressions or construct simple equations and inequalities when solving a problems involved in the analysis of data about past plate motions. Applying interpreted data on the distribution of fossils and rocks, continental shapes, and seafloor structures, students can

provide evidence of past plate motions.

Performance Expectations

Science and Engineering Practices	DCI	Crosscutting Concepts
<p>Developing and Using Models</p> <ul style="list-style-type: none"> Develop and use a model to describe phenomena. (MS-ESS2-1) <p>Constructing Explanations and Designing Solutions</p> <ul style="list-style-type: none"> Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe nature operate today as they did in the past and will continue to do so in the future. (MS-ESS1-4),(MS-ESS2-2) <p>Analyzing and Interpreting Data</p> <ul style="list-style-type: none"> Analyze and interpret data to provide evidence for phenomena. (MS-ESS2-3) 	<p>ESS1.C: The History of Planet Earth</p> <ul style="list-style-type: none"> The geologic time scale interpreted from rock strata provides a way to organize Earth's history. Analyses of rock strata and the fossil record provide only relative dates, not an absolute scale. (MS-ESS1-4) <p>ESS2.A: Earth's Materials and Systems</p> <ul style="list-style-type: none"> All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the sun and Earth's hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth's materials and living organisms. (MS-ESS2-1) The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future. (MS-ESS2-2) <p>ESS2.B: Plate Tectonics and Large-Scale System Interactions</p> <ul style="list-style-type: none"> Maps of ancient land and water patterns, based on investigations of rocks and fossils, make clear how Earth's plates have moved great distances, collided, and spread apart. (MS-ESS2-3) 	<p>Stability and Change</p> <ul style="list-style-type: none"> Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and processes at different scales, including the atomic scale. (MS-ESS2-1) <p>Scale Proportion and Quantity</p> <ul style="list-style-type: none"> Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. (MS-ESS1-4),(MS-ESS2-2) <p>Patterns</p> <ul style="list-style-type: none"> Patterns in rates of change and other numerical relationships can provide information about natural systems. (MS-ESS2-3) <p>-----</p> <p>Connections to Nature of Science</p> <p>Scientific Knowledge is Open to Revision in Light of New Evidence</p> <ul style="list-style-type: none"> Science findings are frequently revised and/or reinterpreted based on new evidence. (MS-ESS2-3)

Cross-Curricular Connections

English/Language Arts Standards	Mathematics Standards
<ul style="list-style-type: none"> Cite specific textual evidence based on evidence from rock strata for how the geologic time scale is used to organize Earth's 4.6-billion-year-old history to support analysis of science and technical texts. Write informative/explanatory texts to examine evidence from rock strata for how the geologic time scale is used to organize Earth's 4.6 billion-year-old history and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content. Cite specific textual evidence for how geoscience processes have changed Earth's surface at varying time 	<ul style="list-style-type: none"> Use variables to represent numbers and write expressions when solving problems while constructing explanations from evidence from rock strata for how the geologic time scale is used to organize Earth's 4.6-billion-year-old history; understand that a variable can represent an unknown number or, depending on the purpose at hand, any number in a specific set. Use variables to represent quantities in a real-world or mathematical problem when solving problems while constructing explanations from evidence from rock strata for how the geologic time scale is used to organize Earth's 4.6-billion-year-old history, and

<p>and spatial scales to support analysis of science and technical texts.</p> <ul style="list-style-type: none"> • Use informative/explanatory texts to examine evidence for how geoscience processes have changed Earth’s surface at varying time and spatial scales and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content. • Include multimedia components and visual displays in presentations about evidence for how geoscience processes have changed Earth’s surface at varying time and spatial scales to clarify claims and findings and emphasize salient points. • Cite specific textual evidence of past plate motion to support analysis of science texts. • Integrate quantitative or technical information about evidence of past plate motions expressed in words in a text with a version of that information expressed in a flowchart, diagram, model, graph, or table. • Compare and contrast the information gained from experiments, simulations, video, or multimedia sources showing evidence of past plate motion with that gained from reading a text on the same topic. 	<p>construct simple equations and inequalities to solve problems by reasoning about the quantities.</p> <ul style="list-style-type: none"> • Reason abstractly and quantitatively when analyzing evidence for how geoscience processes have changed Earth’s surface at varying time and spatial scales. • Use variables to represent numbers and write expressions when solving a real-world or mathematical problem involving evidence for how geoscience processes have changed Earth’s surface at varying time and spatial scales. Understand that a variable can represent an unknown number or, depending on the purpose at hand, any number in a specified set. • Use variables to represent quantities in a real-world or mathematical problem involving evidence for how geoscience processes have changed Earth’s surface at varying time and spatial scales, and construct simple equations and inequalities to solve problems by reasoning about the quantities. • Use numbers, symbols, and words while analyzing and interpreting data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of past plate motions. • Use variables to represent numerical data and write expressions when solving a problems involved in the analysis of data about past plate motions. Understand that a variable can represent an unknown number or, depending on the purpose at hand, any number in a specified set. • Use variables to represent quantities when analyzing data about past plate motions and construct simple equations and inequalities to solve problems by reasoning about the quantities.
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21st Century Career Ready Practices

- **CRP2.** Apply appropriate academic and technical skills.
- **CRP4.** Communicate clearly and effectively and with reason.
- **CRP5.** Consider the environmental, social and economic impacts of decisions.
- **CRP6.** Demonstrate creativity and innovation.
- **CRP8.** Utilize critical thinking to make sense of problems and persevere in solving them.
- **CRP11.** Use technology to enhance productivity.

Grade 8 - Science

Unit 3: Chapter 16

Instructional Time: 5- 10 days

How do we know when an organism (fossil) was alive?
How do we know that birds and dinosaurs are related?

In this unit of study, students analyze graphical displays and gather evidence from multiple sources in order to develop an understanding of how fossil records and anatomical similarities of the relationships among organisms and species describe biological evolution. Students search for patterns in the evidence to support their understanding of the fossil record and how those patterns show relationships between modern organisms and their common ancestors. The crosscutting concepts of *cause and effect*, *patterns*, and *structure and function* are called out as organizing concepts for these disciplinary core ideas. Students use the practices of *analyzing graphical displays* and *gathering, reading, and communicating information*. Students are also expected to use these practices to demonstrate understanding of the core ideas.

Student Learning Objectives

New Jersey Student Learning Standards/ NGSS

MS-LS4-1	Analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth under the assumption that natural laws operate today as in the past.
MS-LS4-2	Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships.

Enduring Understandings

- There are fossil records that document the existence, diversity, extinction, and change of many life forms throughout the history of life on Earth.
- Using index fossils shows that birds and dinosaurs are more related than originally thought.
- Bones and structures of organisms can be used as evidence to show that they are related.
- Science assumes that objects and events in evolutionary history occur in consistent patterns that are understandable through measurement and observation.

Essential Questions

- How do we know when an organism (fossil) was alive?
- How do we know that birds and dinosaurs are related?
- Other than bones and structures being similar, what other evidence is there that birds and dinosaurs are related?

Concepts

- Part A: How do we know when an organism (fossil) was alive?**
- The fossil record documents the existence, diversity, extinction, and change of many life forms throughout the history of life on Earth.
 - The collection of fossils and their placement in chronological order as identified through the location of sedimentary layers in which they are found or through radioactive dating is known as the fossil record.
 - Relative fossil dating is achieved by examining the fossil's relative position in sedimentary rock layers.
 - Objects and events in the fossil record occur in consistent patterns that are understandable through measurement and observation.
 - Patterns exist in the level of complexity of anatomical structures in organisms and the chronological order of fossil appearance in rock

Formative Assessment

- Part A: How do we know when an organism (fossil) was alive?**
- Students who understand the concepts can:*
- Use graphs, charts, and images to identify patterns within the fossil record.
 - Analyze and interpret data within the fossil record to determine similarities and differences in findings.
 - Make logical and conceptual connections between evidence in the fossil record and explanations about the existence, diversity, extinction, and change in many life forms throughout the history of life on Earth.
- Part B: How do we know that birds and dinosaurs are related?**
- Students who understand the concepts can:*
- Apply scientific ideas to construct explanations for evolutionary relationships.

<p>layers.</p> <ul style="list-style-type: none"> ● Patterns can occur within one species of organism or across many species. <p>Part B: <i>How do we know that birds and dinosaurs are related?</i></p> <ul style="list-style-type: none"> ● Similarities and differences exist in the gross anatomical structures of modern organisms. ● There are anatomical similarities and differences among modern organisms and between modern organisms and fossil organisms. ● Similarities and differences exist in the gross anatomical structures of modern organisms and their fossil relatives. ● Similarities and differences in the gross anatomical structures of modern organisms enable the reconstruction of evolutionary history and the inference of lines of evolutionary descent. ● Patterns and anatomical similarities in the fossil record can be used to identify cause-and-effect relationships. ● Science assumes that objects and events in evolutionary history occur in consistent patterns that are understandable through measurement and observation. <p>Part C: <i>Other than bones and structures being similar, what other evidence is there that birds and dinosaurs are related?</i></p> <ul style="list-style-type: none"> ● Relationships between embryos of different species show similarities in their development. ● General patterns of relatedness among embryos of different organisms can be inferred by comparing the macroscopic appearance of diagrams or pictures. ● Pictorial data can be used to identify patterns of similarities in embryological development across multiple species. ● Similarities in embryological development across multiple species show relationships that are not evident in the fully formed organisms. 	<ul style="list-style-type: none"> ● Apply the patterns in gross anatomical structures among modern organisms and between modern organisms and fossil organisms to construct explanations of evolutionary relationships. ● Apply scientific ideas about evolutionary history to construct an explanation for evolutionary relationships evidenced by similarities or differences in the gross appearance of anatomical structures. <p>Part C: <i>Other than bones and structures being similar, what other evidence is there that birds and dinosaurs are related?</i></p> <p><i>Students who understand the concepts can:</i></p> <ul style="list-style-type: none"> ● Use diagrams or pictures to identify patterns in embryological development across multiple species. ● Analyze displays of pictorial data to identify where the embryological development is related linearly and where that linear nature ends. ● Infer general patterns of relatedness among embryos of different organisms by comparing the macroscopic appearance of diagrams or pictures.
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Suggested Learning Activities

Prior to middle school, students know that some living organisms resemble organisms that once lived on Earth. Fossils provide evidence about the types of organisms and environments that existed long ago. In this unit of study, students will build on this knowledge by examining how the fossil record documents the existence, diversity, extinction, and change of many life forms through Earth’s history. The fossil record and comparisons of anatomical similarities between organisms and their embryos enable the inference of lines of evolutionary descent.

Students analyze images or data to identify patterns in the locations of fossils in layers of sedimentary rock. They can use their understanding of these patterns to place fossils in chronological order. Students may make connections between their studies of plate movement in grade 7 and the possible shifting of layers of sedimentary rock to explain inconsistencies in the relative chronological order of the fossil record as it is seen today.

Students can analyze data on the chronology of the fossil record based on radioactive dating. An explanation of radioactive dating can be provided to students along with data, but students are not expected to complete any

calculations. Information can be provided in the form of data tables correlating fossil age with half-life. This information could also be presented in the form of a graph.

Students may analyze images from the fossil record to identify patterns of change in the complexity of the anatomical structures in organisms. For example, students can observe pictures of fossilized organisms with similar evolutionary histories in order to compare and contrast changes in their anatomical structures over time. Students may be placed in groups, with each group examining changes in anatomical structures over time within one evolutionary lineage (e.g., the whale, the horse, cycads). Once students have identified patterns of change within one evolutionary lineage, they can meet with students from other groups to discuss patterns of change across multiple evolutionary lineages. Students could then present their findings using a variety of media choices (PowerPoint, poster, short skit or play, comic strip, etc.). This activity would provide application of the real-world phenomenon that life on Earth changes over time.

Students could be provided with multimedia experiences in order to analyze visual displays of the embryological development of different species. They can analyze the linear and nonlinear relationships among the embryological developments of different species. For example, students can analyze data about embryological development to determine whether development across species shares a similar rate, similar size of embryos, or similar characteristics over a period of time. If these characteristics are consistent across species, a linear relationship can be inferred. At the point where the rate, size, or general characteristics of development diverge, the relationship can then be classified as nonlinear.

Students can integrate the patterns they identified in the fossil record by studying sedimentary rock images and radioactive dating data provided by the teacher and the relationships they discovered through their study of embryological development with evidence from informational texts to develop an explanation of changes in life forms throughout the history of life on Earth. This explanation could be presented in the form of a claim, with students required to cite evidence from their studies of diagrams, images, and texts to explain that life on Earth has changed over time.

Performance Expectations		
Science and Engineering Practices	DCI	Crosscutting Concepts
<p>Analyzing and Interpreting Data</p> <ul style="list-style-type: none"> Analyze displays of data to identify linear and nonlinear relationships. (MS-LS4-3) Analyze and interpret data to determine similarities and differences in findings. (MS-LS4-1) <p>Constructing Explanations and Designing Solutions</p> <ul style="list-style-type: none"> Apply scientific ideas to construct an explanation for real-world phenomena, examples, or events. (MS-LS4-2) <p>-----</p> <p>Connections to Nature of Science</p> <p>Scientific Knowledge is Based on Empirical Evidence Science knowledge is based upon logical and conceptual connections between evidence and explanations. (MS-LS4-1)</p>	<p>LS4.A: Evidence of Common Ancestry and Diversity</p> <ul style="list-style-type: none"> The collection of fossils and their placement in chronological order (e.g., through the location of the sedimentary layers in which they are found or through radioactive dating) is known as the fossil record. It documents the existence, diversity, extinction, and change of many life forms throughout the history of life on Earth. (MS-LS4-1) Anatomical similarities and differences between various organisms living today and between them and organisms in the fossil record, enable the reconstruction of evolutionary history and the inference of lines of evolutionary descent. (MS-LS4-2) Comparison of the embryological development of different species also reveals similarities that show relationships not evident in the 	<p>Patterns</p> <ul style="list-style-type: none"> Patterns can be used to identify cause and effect relationships. (MS-LS4-2) Graphs, charts, and images can be used to identify patterns in data. (MS-LS4-1),(MS-LS4-3) <p>Cause and Effect</p> <ul style="list-style-type: none"> Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability. (MS-LS4-4),(MS-LS4-5),(MS-LS4-6) <p>-----</p> <p>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-LS4-1),(MS-LS4-2)</p>

Cross-Curricular Connections**English/Language Arts Standards**

- Cite specific textual evidence to support the analysis of patterns found in the fossil record to document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth.
- Use scientific, precise details in the explanations.
- Integrate quantitative or technical information about the fossil record that is expressed in words into a version of that information expressed visually in the form of a flowchart, diagram, model, graph, or table.
- Attending to the precise details of explanations or descriptions, cite specific textual evidence to support analysis of science texts' information on the relationships between the anatomical similarities and differences among modern organisms and between modern and fossil organisms and their fossil relationships.
- Write informative/explanatory text examining anatomical similarities and differences among modern organisms and between modern and fossil organisms and their fossil relationships. The text should convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.
- Draw evidence from informational texts to support an analysis of, reflection on, and research about anatomical similarities and differences among modern organisms and between modern and fossil organisms used to infer evolutionary relationships.
- Engage in a range of collaborative discussions about the anatomical similarities and differences among modern organisms and between modern and fossil organisms used to infer evolutionary relationships. Discussions must provide opportunities for students to clearly express their own ideas and exchange ideas with others. The discussions may be one on one, in groups, or led by the teacher.
- Present claims and findings to explain the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships.
- Emphasize the important points in a focused, coherent manner with relevant evidence, valid reasoning, and well-chosen details. During the presentation, students must use appropriate eye contact, adequate volume, and clear pronunciation.
- Cite specific textual evidence to support the analysis of pictorial data comparing patterns of similarities in embryological development across multiple species to identify relationships not evident in the fully formed anatomy. Attention must be paid to the precise details

Mathematics Standards

- Use variables to represent numbers and write expressions to represent patterns of changes in the level of complexity of anatomical structures in organisms and the chronological order of fossil appearances in the rock record to document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth, under the assumption that natural laws operate today as in the past. Understand that a variable can represent an unknown number or, depending on the purpose at hand, any number in a specified set.
- Use variables to represent numbers and write expressions showing patterns that can be used to identify cause-and-effect relationships among the anatomical similarities and differences among modern organisms and between modern and fossil organisms. This representation will be used to infer evolutionary relationships. Understand that a variable can represent an unknown number or, depending on the purpose at hand, any number in a specified set.

of explanation or descriptions.

- Integrate quantitative or technical information about general patterns of relatedness among embryos of different organisms expressed in words in a text with a version expressed in a flowchart, diagram, model, graph, or table.
- Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with the information gained from reading a text about embryological development across multiple species in order to identify relationships not evident in the fully formed anatomy.

21st Century Career Ready Practices

- **CRP2.** Apply appropriate academic and technical skills.
- **CRP4.** Communicate clearly and effectively and with reason.
- **CRP6.** Demonstrate creativity and innovation.
- **CRP7.** Employ valid and reliable research strategies.
- **CRP8.** Utilize critical thinking to make sense of problems and persevere in solving them.
- **CRP10.** Plan education and career paths aligned to personal goals.
- **CRP11.** Use technology to enhance productivity.
- **CRP12.** Work productively in teams while using cultural global competence.

Grade 8 - Science

Unit 4: Chapter 18

Instructional Time: 20 - 25 days

What happens to ecosystems when the environment changes?

Students build on their understandings of the transfer of matter and energy as they study patterns of interactions among organisms within an ecosystem. They consider biotic and abiotic factors in an ecosystem and the effects these factors have on a population. They construct explanations for the interactions in ecosystems and the scientific, economic, political, and social justifications used in making decisions about maintaining biodiversity in ecosystems. The crosscutting concept of *stability and change* provide a framework for understanding the disciplinary core ideas.

This unit includes a two-stage engineering design process. Students first evaluate different engineering ideas that have been proposed using a systematic method, such as a tradeoff matrix, to determine which solutions are most promising. They then test different solutions, and combine the best ideas into a new solution that may be better than any of the preliminary ideas. Students demonstrate grade appropriate proficiency in *asking questions, designing solutions, engaging in argument from evidence, developing and using models, and designing solutions*. Students are also expected to use these practices to demonstrate understanding of the core ideas.

Student Learning Objectives

New Jersey Student Learning Standards/ NGSS

MS-LS2-4	Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.
MS-LS2-5	Evaluate competing design solutions for maintaining biodiversity and ecosystem services.
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-ETS1-3	Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

Enduring Understandings

Essential Questions

- One change to an ecosystem can disrupt the whole system.
- Ecosystems have a finite amount of energy that flows throughout the ecosystem.
- Disruptions of any physical or biological components of an ecosystem can change the population in the ecosystem.
- Ecosystems exhibit diversity.
- The health of an ecosystem can be judged by the ecosystem's biodiversity.
- Changes in the biodiversity of an ecosystem can change the resources that humans rely on.

- How can a single change to an ecosystem disrupt the whole system?
- What limits the number and variety of living things in an ecosystem?
- What human resources can be lost when an ecosystem is no longer in balance?
- How can populations be disrupted when the physical or biological components change in the ecosystem?

Concepts

Formative Assessment

Part A: *How can a single change to an ecosystem disrupt the whole system?*

- Ecosystems are dynamic in nature.
- The characteristics of ecosystems can vary over time.
- Disruptions to any physical or biological component of an ecosystem can lead to shifts in all the ecosystem's populations.
- Small changes in one part of an ecosystem might cause large changes in another part.
- Patterns in data about ecosystems can be recognized and used to make warranted inferences about changes

Part A: *How can a single change to an ecosystem disrupt the whole system?*

Students who understand the concepts are able to:

- Construct an argument to support or refute an explanation for the changes to populations in an ecosystem caused by disruptions to a physical or biological component of that ecosystem. Empirical evidence and scientific reasoning must support the argument.
- Use scientific rules for obtaining and evaluating empirical evidence.

in populations.

- Evaluating empirical evidence can be used to support arguments about changes to ecosystems.

Part B: *What limits the number and variety of living things in an ecosystem?*

- Biodiversity describes the variety of species found in Earth's terrestrial and oceanic ecosystems.
- The completeness, or integrity, of an ecosystem's biodiversity is often used as a measure of its health.
- Changes in biodiversity can influence humans' resources, such as food, energy, and medicines.
- Changes in biodiversity can influence ecosystem services that humans rely on.
- There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem.
- A solution needs to be tested and then modified on the basis of the test results, in order to improve it.
- Models of all kinds are important for testing solutions.
- The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution.
- Small changes in one part of a system might cause large changes in another part.
- Scientific knowledge can describe the consequences of actions but does not necessarily prescribe the decisions that society takes.

- Recognize patterns in data and make warranted inferences about changes in populations.
- Evaluate empirical evidence supporting arguments about changes to ecosystems.

Part B: *What limits the number and variety of living things in an ecosystem?*

Students who understand the concepts are able to:

- Construct a convincing argument that supports or refutes claims for solutions about the natural and designed world(s).
- Develop a model to generate data to test ideas about designed systems, including those representing inputs and outputs.
- Create design criteria for design solutions for maintaining biodiversity and ecosystem services.
- Evaluate competing design solutions based on jointly developed and agreed-upon design criteria.

Suggested Learning Activities

At the beginning of this unit of study, students will begin to collect empirical evidence that will be used to argue that physical or biological components of an ecosystem affect populations. Students will evaluate existing solutions for maintaining biodiversity and ecosystem services to determine which solutions are most promising. As part of their evaluation, students will develop a probability and use it to determine the probability that designed systems, including those representing inputs and outputs, will maintain biodiversity and ecosystem services. They will develop mathematical model(s) to generate data to test the designed systems and compare probabilities from the models to observe frequencies. If the agreement is not good, they will explain possible sources of the discrepancy.

Distinguish among facts, reasoned judgment based on research findings, and speculation During this process, students will distinguish among facts reasoned judgment based on research findings, and speculation while reading text about maintaining biodiversity and ecosystem services. Examples of ecosystem services could include water purification, nutrient recycling, and prevention of soil erosion.

After determining that ecosystems are dynamic in nature, students may construct an argument to support an explanation for how shifts (large and/or small) in populations are caused by change to physical or biological components in ecosystems (e.g., gas explosions, tornados, mining, oil spills, clear cutting, hurricanes, volcanoes, etc.).

Students will study the variety of species found in terrestrial and oceanic ecosystems and use the data they gather to make decisions about the health of the ecosystem. Students may compare, through observations and data analysis, the biodiversity before and after events affecting a specific area—for examples, the Pinelands, that were lost due to the creation of the reservoir; the underground coal fires in Centralia, PA, that caused people to abandon the town; the volcanic eruption in Mt. St. Helen's, WA; the nuclear reactor meltdown in Chernobyl, Ukraine.

Students should recognize patterns in data about changes to components in ecosystems and make inferences about how these changes contribute to changes in the biodiversity of populations. Students should investigate and design investigations to test their ideas and develop possible solutions to problems caused when changes in the biodiversity of an ecosystem affect resources (food, energy, and medicine) as well as ecosystem services (water purification, nutrient recycling, soil erosion prevention) available to humans. Students can then construct arguments using evidence to support recognized patterns of change in factors such as global temperatures and their effect on populations and the environment. As part of their argument, students need to note how small changes in one part of an ecosystem might cause large changes in another part. While collecting evidence for their arguments about maintaining biodiversity, students will trace and evaluate specific claims in a text, distinguishing claims that are supported by reasons and evidence from claims that are not. Students will evaluate the argument and claims in text, assess whether the reasoning is sound and the evidence is relevant and sufficient to support the claims.

As a culmination of this unit of study, students will take the evidence they have collected and their understanding of how changes in the biodiversity of populations can impact ecosystem services and use that evidence and understanding to evaluate competing design solutions. Students will include multimedia components and visual displays as part of their argument about competing design solutions based on jointly developed and agreed-upon design criteria to clarify evidence used in their arguments. The multimedia component and visual displays should clarify claims and findings and emphasize salient points in their argument.

Students will use a systematic process for evaluating their design solutions with respect to how well they meet the criteria and constraints. Students may determine the systematic process they will use, or the teacher can determine a process for students to use to evaluate ecosystem services. Any process used should include mathematical models that generates data for the iterative testing of competing design solutions involving a proposed object, tool, or process maintaining biodiversity and ecosystem services and quantitative reasoning (with amounts, numbers, sizes) and abstract reasoning (with variables). Ecosystem services could include water purification, nutrient recycling, and prevention of soil erosion. For this unit of study, design solution constraints could include scientific, economic, and social considerations. After determining the process for evaluating the design solutions and establishing the criteria and constraints, students will compare competing design solutions to determine the optimal solution.

Performance Expectations		
Science and Engineering Practices	DCI	Crosscutting Concepts
<p><u>Engaging in Argument from Evidence</u></p> <ul style="list-style-type: none"> Construct an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. (MS-LS2-4) Evaluate competing design solutions based on jointly developed and agreed-upon design criteria. (MS-LS2-5) <p><u>Asking Questions and Defining Problems</u></p> <ul style="list-style-type: none"> Define a design problem that can be solved through the development of an object, tool, process or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions. (MS-ETS1-1) <p><u>Developing and Using Models</u></p>	<p><u>LS2.C: Ecosystem Dynamics, Functioning, and Resilience</u></p> <ul style="list-style-type: none"> Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations. (MS-LS2-4) Biodiversity describes the variety of species found in Earth’s terrestrial and oceanic ecosystems. The completeness or integrity of an ecosystem’s biodiversity is often used as a measure of its health. (MS-LS2-5) <p><u>LS4.D: Biodiversity and Humans</u></p> <ul style="list-style-type: none"> Changes in biodiversity can influence humans’ resources, such as food, energy, and medicines, as well as ecosystem services that humans rely on—for example, water purification and 	<p><u>Stability and Change</u></p> <ul style="list-style-type: none"> Small changes in one part of a system might cause large changes in another part. (MS-LS2-4),(MS-LS2-5) <p>-----</p> <p><i>Connections to Engineering, Technology, and Applications of Science</i></p> <p><u>Influence of Science, Engineering, and Technology on Society and the Natural World</u></p> <ul style="list-style-type: none"> The use of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time. (MS-LS2-5) <p>-----</p>

<ul style="list-style-type: none"> Develop a model to generate data to test ideas about designed systems, including those representing inputs and outputs. (MS-ETS1-4) <p>Analyzing and Interpreting Data</p> <ul style="list-style-type: none"> Analyze and interpret data to determine similarities and differences in findings. (MS-ETS1-3) 	<p>recycling. (secondary to MS-LS2-5)</p> <p>ETS1.B: Developing Possible Solutions</p> <ul style="list-style-type: none"> There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (secondary to MS-LS2-5) <p>ETS1.A: Defining and Delimiting Engineering Problems</p> <ul style="list-style-type: none"> 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 are likely to limit possible solutions. (MS-ETS1-1) <p>ETS1.B: Developing Possible Solutions</p> <ul style="list-style-type: none"> A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (MS-ETS1-4) There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (MS-ETS1-2), (MS-ETS1-3) Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. (MS-ETS1-3) Models of all kinds are important for testing solutions. (MS-ETS1-4) <p>ETS1.C: Optimizing the Design Solution</p> <ul style="list-style-type: none"> Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design. (MS-ETS1-3) 	<p>Connections to Nature of Science</p> <p>Scientific Knowledge Assumes an Order and Consistency in Natural Systems</p> <ul style="list-style-type: none"> Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation. (MS-LS2-3) <p>Scientific Knowledge is Based on Empirical Evidence</p> <ul style="list-style-type: none"> Science disciplines share common rules of obtaining and evaluating empirical evidence. (MS-LS2-4) <p>Science Addresses Questions About the Natural and Material World</p> <ul style="list-style-type: none"> Scientific knowledge can describe the consequences of actions but does not necessarily prescribe the decisions that society takes. (MS-LS2-5)
Cross-Curricular Connections		
English/Language Arts Standards	Mathematics Standards	
<ul style="list-style-type: none"> Distinguish among facts, reasoned judgment based on 	<ul style="list-style-type: none"> Model design solutions for maintaining biodiversity and 	

<p>research findings, and speculation when reading text about maintaining biodiversity and ecosystem services. Examples of ecosystem services could include water purification, nutrient recycling, and prevention of soil erosion.</p> <ul style="list-style-type: none"> • Trace and evaluate the argument and specific claims in a text <i>about maintaining biodiversity and ecosystem services</i>, distinguishing claims that are supported by reasons and evidence from claims that are not. Trace and evaluate the arguments about specific claims in a text and assess whether the reasoning is sound and the evidence is relevant and sufficient to support the claims. • Include multimedia components and visual displays <i>as part of an argument about competing design solutions based on jointly developed and agreed-upon design criteria</i> to clarify information. Include multimedia components and visual displays. The multimedia component and visual displays should clarify claims and findings and emphasize salient points in the presentation. 	<p>ecosystem services with mathematics. Use ratio and rate reasoning to evaluate competing design solutions for maintaining biodiversity and ecosystem services.</p> <ul style="list-style-type: none"> • Develop a model that generates data for the iterative testing of competing design solutions involving a proposed object, tool, or process that maintains biodiversity and ecosystem services, reasoning quantitatively (with amounts, numbers, sizes) and abstractly (with variables). • Develop a probability and use it to find the probability <i>that designed systems, including those representing inputs and outputs, will maintain biodiversity and ecosystem services</i>. Compare probabilities from the model to observe frequencies. If the agreement is not good, explain possible sources of the discrepancy.
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21st Century Career Ready Practices

- **CRP1.** Act as a responsible and contributing citizen and employee.
- **CRP4.** Communicate clearly and effectively and with reason.
- **CRP5.** Consider the environmental, social and economic impacts of decisions.
- **CRP6.** Demonstrate creativity and innovation.
- **CRP7.** Employ valid and reliable research strategies.
- **CRP8.** Utilize critical thinking to make sense of problems and persevere in solving them.
- **CRP9.** Model integrity, ethical leadership and effective management.
- **CRP10.** Plan education and career paths aligned to personal goals.
- **CRP11.** Use technology to enhance productivity.
- **CRP12.** Work productively in teams while using cultural global competence.

Grade 8 - Science

Unit 5: Chapter 20

Instructional Time: 20 - 25 days

How do we monitor the health of the environment (our life support system)?

Is it possible to predict and protect ourselves from natural hazards?

In this unit of study, students analyze and interpret data and design solutions to build on their understanding of the ways that human activities affect Earth’s systems. The emphasis of this unit is the significant and complex issues surrounding human uses of land, energy, mineral, and water resources and the resulting impacts of these uses. The crosscutting concepts of *cause and effect* and *the influence of science, engineering, and technology on society and the natural world* are called out as organizing concepts for these disciplinary core ideas.

Building on Unit 3, students define a problem by precisely specifying criteria and constraints for solutions as well as potential impacts on society and the natural environment; systematically evaluate alternative solutions; analyze data from tests of different solutions; combining the best ideas into an improved solution; and develop and iteratively test and improve their model to reach an optimal solution. In this unit of study students are expected to demonstrate proficiency in *analyzing and interpreting data* and *designing solutions*. Students are also expected to use these practices to demonstrate understanding of the core ideas.

Student Learning Objectives

New Jersey Student Learning Standards/ NGSS

MS-ESS3-3	Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
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.
MS-ETS1-3	Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

Enduring Understandings

- Humans have a huge impact on the environment.
- Humans have the ability to design solutions to limit human impact.
- Monitoring the scientific principles that can minimize the impact of humans on our environment.

Essential Questions

- How do we monitor the health of the environment (our life support system)?
- How can humans change health of the environment?
- How can we better monitor human impact on the environment?

Concepts

- Part A:** *How do we monitor the health of the environment (our life support system)?*
- Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species.
 - Changes to Earth’s environments can have different impacts (negative and positive) for different living things.
 - Typically as human populations and per capita consumption of natural resources increase, so do the negative impacts on Earth, unless the activities and technologies involved are engineered otherwise.
 - Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation.
 - The uses of technologies and any limitations on their use are driven by individual or societal needs, desires,

Formative Assessment

- Part A:** *How do we monitor the health of the environment (our life support system)?*
- Students who understand the concepts can:*
- Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time.

Suggested Learning Activities

Throughout this unit of study, students will be engaged in the engineering design process. Students can start by identifying a human impact on the environment that has resulted from human consumption of natural resources. Using what they have identified, students will begin to define the criteria and constraints of the design problem whose solution will help to monitor and minimize the human impact on the environment. Using informational texts to support this process is important. Students will draw evidence from these texts in order to support their analysis, reflection, and research.

When students consider criteria, they should conduct short research projects to examine factors such as societal and individual needs, cost effectiveness, available materials and natural resources, current scientific knowledge, and current advancements in science and technology. They should also consider limitations due to natural factors such as regional climate and geology. While conducting their research, students will need to gather their information from multiple print and digital sources and assess the credibility of each source.

When students quote or paraphrase the data and conclusions found in these resources, they will need to avoid plagiarism and provide basic bibliographic information for each source. After comparing the information gained from their research, experiments, simulations, video, or other multimedia sources, they will be able to determine precise design criteria and constraints that lead to a successful solution.

Students will need to jointly develop and agree upon the design criteria that will be used to evaluate competing existing design solutions (i.e., varying dam designs, irrigation systems, varying methods of reducing pollution, varying methods of urban development). Students can use a rubric, checklist, or decision tree to assist them in evaluating the design solution selected.

Students can be provided with data from tests performed on these existing design solutions. They will analyze and interpret these data to determine similarities and differences in findings. This is where they are deciding where different parts of the pre-existing solutions can be combined. For example, the building materials of a particular dam may be superior while the shape of another design may be more suitable. Students should consider the ratio relationship between the impacts that humans have on the environment and the impact that the design solution has on minimizing these impacts. Students will need to consider both qualitative and quantitative data when drawing conclusions about the various design solutions.

It is important that students handle mathematical data appropriately. They should use variables to represent quantities and construct simple equations and inequalities to solve problems. While analyzing numerical data, students will need to solve mathematical problems that show both positive and negative values and apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computations and estimation strategies. Support from mathematics teachers will help students with the mathematics required for this type of analysis.

Once students have evaluated competing solutions and analyzed and interpreted data showing the similarities and differences of these solutions, they may then begin designing their own solutions. It is important that students consider the benefits and risks of each existing design solution. The impact on the environment and human society must be considered in the design. The final goal for students is to identify the parts of each design solution that best fit their criteria and constraints and combine these parts into a design solution that is better than any of its predecessors.

Performance Expectations

Science and Engineering Practices	DCI	Crosscutting Concepts
<p><u>Constructing Explanations and Designing Solutions</u></p> <ul style="list-style-type: none"> Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the 	<p><u>ESS3.C: Human Impacts on Earth Systems</u></p> <ul style="list-style-type: none"> Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats 	<p><u>Cause and Effect</u></p> <ul style="list-style-type: none"> Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation. (MS-ESS3-3) <p>-----</p>

<p>assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (MS-ESS3-1)</p> <ul style="list-style-type: none"> Apply scientific principles to design an object, tool, process or system. (MS-ESS3-3) <p><u>Asking Questions and Defining Problems</u></p> <ul style="list-style-type: none"> Define a design problem that can be solved through the development of an object, tool, process or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions. (MS-ETS1-1) <p><u>Engaging in Argument from Evidence</u></p> <ul style="list-style-type: none"> Evaluate competing design solutions based on jointly developed and agreed-upon design criteria. (MS-ETS1-2) <p><u>Analyzing and Interpreting Data</u></p> <ul style="list-style-type: none"> Analyze and interpret data to determine similarities and differences in findings. (MS-ETS1-3) 	<p>and causing the extinction of other species. But changes to Earth’s environments can have different impacts (negative and positive) for different living things. (MS-ESS3-3)</p> <ul style="list-style-type: none"> Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise. (MS-ESS3-3),(MS-ESS3-4) <p><u>ETS1.A: Defining and Delimiting Engineering Problems</u></p> <ul style="list-style-type: none"> 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 are likely to limit possible solutions. (MS-ETS1-1) <p><u>ETS1.B: Developing Possible Solutions</u></p> <ul style="list-style-type: none"> A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (MS-ETS1-4) There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (MS-ETS1-2), (MS-ETS1-3) Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. (MS-ETS1-3) Models of all kinds are important for testing solutions. (MS-ETS1-4) 	<p><i>Connections to Engineering, Technology, and Applications of Science</i></p> <p><u>Influence of Science, Engineering, and Technology on Society and the Natural World</u></p> <ul style="list-style-type: none"> The uses of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time. (MS-ESS3-3) <p><u>Influence of Science, Engineering, and Technology on Society and the Natural World</u></p> <ul style="list-style-type: none"> All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment. (MS-ETS1-1) The uses of technologies and limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. (MS-ETS1-1)
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Cross-Curricular Connections

English/Language Arts Standards	Mathematics Standards
<ul style="list-style-type: none"> Conduct short research projects to determine a method for monitoring and minimizing a human impact on the environment, drawing on several sources and generating additional, related, focused questions that 	<ul style="list-style-type: none"> Use abstract and quantitative reasoning to analyze and interpret data in order to determine similarities and differences in findings of how well designed methods meet the criteria and constraints of

<p>allow multiple avenues of exploration.</p> <ul style="list-style-type: none"> ● Gather relevant information from multiple print and digital sources about a method for monitoring and minimizing a human impact on the environment, assess the credibility of each source, and quote or paraphrase the data and conclusions of others while avoiding plagiarism and providing basic bibliographic information for sources. ● Draw evidence from informational texts about minimizing a human impact on the environment to support analysis, reflection, and research. ● Cite specific textual evidence about a method for monitoring and minimizing a human impact on the environment to support analysis of science and technical texts. ● Compare and contrast the information gained from experiments, simulations, videos, or multimedia sources with that gained from reading a text on a method for monitoring and minimizing a human impact on the environment. ● Integrate quantitative or technical information about a method for monitoring and minimizing a human impact on the environment expressed in words with a version of that information expressed visually. 	<p>solutions that could reduce a human impact on the environment.</p> <ul style="list-style-type: none"> ● Understand the concept of a ratio and use ratio language to describe a ratio relationship between <i>human impacts on environments and the impact of methods to minimize these impacts</i>. ● Use variables to represent quantities when analyzing and interpreting data to determine how well designed methods meet the criteria and constraints of solutions that could reduce a human impact on the environment and construct simple equations and inequalities to solve problems by reasoning about the quantities. ● While analyzing data to determine how well designed methods meet the criteria and constraints of solutions that could reduce a human impact on the environment, solve multi step 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.
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21st Century Career Ready Practices

- **CRP1.** Act as a responsible and contributing citizen and employee.
- **CRP4.** Communicate clearly and effectively and with reason.
- **CRP5.** Consider the environmental, social and economic impacts of decisions.
- **CRP6.** Demonstrate creativity and innovation.
- **CRP7.** Employ valid and reliable research strategies.
- **CRP8.** Utilize critical thinking to make sense of problems and persevere in solving them.
- **CRP9.** Model integrity, ethical leadership and effective management.
- **CRP11.** Use technology to enhance productivity.
- **CRP12.** Work productively in teams while using cultural global competence.

Grade 8 - Science

Unit 6: Chapter 5 & Chapter 6

Instructional Time: 20 – 25 days

How can we trace synthetic materials back to natural ingredients?

Students build understandings of what occurs at the atomic and molecular scale. Students apply their understanding that pure substances have characteristic properties and are made from a single type of atom or molecule. They also provide a molecular level accounts to explain states of matter and changes between states. The crosscutting concepts of *cause and effect, scale, proportion and quantity, structure and function, interdependence of science, engineering, and technology, and the influence of science, engineering and technology on society and the natural world* provide a framework for understanding the disciplinary core ideas. Students demonstrate grade appropriate proficiency in *developing and using models, and obtaining, evaluating, and communicating information*. Students are also expected to use the scientific and engineering practices to demonstrate understanding of the core ideas.

Student Learning Objectives

New Jersey Student Learning Standards/ NGSS

MS-PS1-3

Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.

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.

Enduring Understandings

- Solids, liquids, and gases have different particle motion, which created differences in their molecules.
- The total thermal energy (sometimes called the total internal energy) of a system depends jointly on the temperature, the total number of atoms in the system, and the state of the material.
- Cause-and-effect relationships may be used to predict and describe changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed in natural systems.

Essential Questions

- How can you tell what the molecules are doing in a substance?
- How can we trace synthetic materials back to natural ingredients?
- How are solids, liquids, and gases similar and different on a molecular level.

Concepts

- Part A:** *How can you tell what the molecules are doing in a substance?*
- Changes in particle motion, temperature, and state of a pure substance occur when thermal energy is added or removed.
 - Qualitative molecular-level models of solids, liquids, and gases can be used to show that adding or removing thermal energy increases or decreases the kinetic energy of the particles until a change of state occurs.
 - Gases 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, the molecules 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 models of matter.

Formative Assessment

- Part A:** *How can you tell what the molecules are doing in a substance?*
- Students who understand the concepts are able to:*
- Develop a model that predicts and describes changes in particle motion that could include molecules or inert atoms or pure substances.
 - Use cause-and-effect relationships to predict changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed in natural or designed systems.
- Part B:** *How can we trace synthetic materials back to natural ingredients? Students who understand the concepts are able to:*
- Obtain, evaluate, and communicate information to show that synthetic materials come from natural resources and affect society.
 - Gather, read, and synthesize information about how synthetic materials formed from natural resources affect society.
 - Assess the credibility, accuracy, and possible bias of

- The term heat as used in everyday language refers both to thermal energy and the transfer of that thermal energy from one object to another.
- Thermal energy is the motion of atoms or molecules within a substance.
- In science, heat is used to refer to the energy transferred due to the temperature difference between two objects.
- The temperature of a system is proportional to the average internal kinetic energy and potential energy per atom or molecule (whichever is the appropriate building block for the system's material).
- The details of the relationship between the average internal kinetic energy and the potential energy per atom or molecule depend on the type of atom or molecule and the interactions among the atoms in the material.
- Temperature is not a direct measure of a system's total thermal energy.
- The total thermal energy (sometimes called the total internal energy) of a system depends jointly on the temperature, the total number of atoms in the system, and the state of the material.
- Cause-and-effect relationships may be used to predict and describe changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed in natural systems.

Part B: *How can we trace synthetic materials back to natural ingredients?*

- Each pure substance has characteristic physical and chemical properties that can be used to identify it.
- Substances react chemically in characteristic ways.
- In a chemical process, the atoms that make up the original substances are regrouped into different molecules.
- New substances that result from chemical processes have different properties from those of the reactants.
- Natural resources can undergo a chemical process to form synthetic material.
- Structures can be designed to serve particular functions by taking into account properties of different materials and how materials can be shaped and used.
- Engineering advances have led to discoveries of important synthetic materials, and scientific discoveries have led to the development of entire industries and engineered systems using these materials.
- Technology use varies from region to region and over time.
- The uses of technologies (engineered/synthetic materials) and any limitations on their use are driven

each publication and methods used within the publication.

- Describe how information about how synthetic materials formed from natural resources affect society is supported or not supported by evidence.

<p>by individual or societal needs, desires, and values.</p> <ul style="list-style-type: none"> The uses of technologies (engineered/synthetic materials) and any limitations on their use are driven by the findings of scientific research and by differences in such factors as climate, natural resources, and economic conditions. 	
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Suggested Learning Activities

Students will locate information that describes changes in particle motion, changes in temperature, or changes in state as thermal energy is added to or removed from a pure substance. Students will then use models to predict and describe the changes in particle motion, temperature, and state of a pure substance. An example could include the change of state of water from its solid (ice) to liquid and vapor with the addition of thermal energy. Students will come to understand that this process is reversible through the removal of thermal energy, where the pure substance can return from a vapor to a liquid and back to a solid state.

Students who accurately demonstrate understanding will be able to develop qualitative molecular-level models of solids, liquids, and gases to show the cause-and-effect relationships of adding or removing thermal energy, which increases or decreases the kinetic energy of the particles until a change of state occurs. Models could include drawings and diagrams.

Students will also need to use mathematics to demonstrate their understanding of the particle motion that is taking place during these changes in state. They will use positive and negative numbers to represent the changes in particle motion and temperature as thermal energy is added or removed. They will then integrate an expression of that same quantitative information in a visual format.

It is important to note that students will need to be responsible for developing the models that they use. It is possible that the teacher could model the process with one type of model and provide opportunities for students to use different types of model to illustrate the same process. After students have a firm understanding of the motion of particles during a phase change, they will be able to move to the next section of this unit. In this portion of the unit of study, students will apply their understanding of particle and chemical change from Unit 1 to make sense of how natural resources react chemically to produce new substances. Students will explain that as a result of the rearrangement of atoms during a chemical process, the synthetic substance has different characteristic properties than the original pure substance. For example, pure substances like methane, carbon monoxide, and carbon dioxide can be combined chemically to form synthetic fuel. The synthetic fuel would have different characteristic properties than the original pure substances.

Within this unit, students will gather, read, and synthesize qualitative information from multiple sources about the use of natural resources to form synthetic materials and how these new materials affect society. Examples of new materials could include new medicine, foods, and alternative fuels. Some sources could include journals, articles, brochures, or digital media from government publications and/or private industries. Students will cite some of these sources to support the analysis of evidence that these synthetic materials were formed from natural resources and have an impact on society. They will pay special attention to the precise details of explanations or descriptions of how these new substances affect society. Students will also include relevant information from multiple print and digital sources about these impacts. While gathering this information, they will use 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.

Performance Expectations

Science and Engineering Practices	DCI	Crosscutting Concepts
<p><u>Obtaining, Evaluating, and Communicating Information</u></p> <ul style="list-style-type: none"> Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe 	<p><u>PS1.A: Structure and Properties of Matter</u></p> <ul style="list-style-type: none"> Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it. (MS-PS1-3) 	<p><u>Structure and Function</u></p> <ul style="list-style-type: none"> Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used. (MS-PS1-3) <p><u>Cause and Effect</u></p> <ul style="list-style-type: none"> Cause and effect relationships may

<p>how they are supported or not supported by evidence. (MS-PS1-3)</p> <p>Developing and Using Models Develop a model to predict and/or describe phenomena. (MS-PS1-4)</p>	<ul style="list-style-type: none"> • Gases and liquids are made of molecules or inert atoms that are moving about relative to each other. (MS-PS1-4) • 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. (MS-PS1-4) <p>PS1.B: Chemical Reactions</p> <ul style="list-style-type: none"> • Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. (MS-PS1-2),(MS-PS1-3) <p>PS3.A: Definitions of Energy</p> <ul style="list-style-type: none"> • 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. (<i>secondary to MS-PS1-4</i>) • The temperature of a system is proportional to the average internal kinetic energy and potential energy per atom or molecule (whichever is the appropriate building block for the system’s material). The details of that relationship depend on the type of atom or molecule and the interactions among the atoms in the material. Temperature is not a direct measure of a system's total thermal energy. The total thermal energy (sometimes called the total internal energy) of a system depends jointly on the temperature, the total number of 	<p>be used to predict phenomena in natural or designed systems. (MS-PS1-4)</p> <p>-----</p> <p>Connections to Engineering, Technology, and Applications of Science</p> <p>Interdependence of Science, Engineering, and Technology</p> <ul style="list-style-type: none"> • 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-PS1-3) <p>Influence of Science, Engineering and Technology on Society and the Natural World</p> <ul style="list-style-type: none"> • The uses of technologies and any limitation on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time. (MS-PS1-3)
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	atoms in the system, and the state of the material. (<i>secondary to MS-PS1-4</i>)	
Cross-Curricular Connections		
English/Language Arts Standards	Mathematics Standards	
<ul style="list-style-type: none"> ● Cite specific text to support the analysis of evidence that synthetic materials formed from natural resources affect society. Attend to the precise details of explanations or descriptions. ● Gather relevant information from multiple print and digital sources about the impact on society of synthetic materials that are formed from natural resources. Use 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. 	<ul style="list-style-type: none"> ● Integrate quantitative information about changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed that is expressed in words with a version of that information that is expressed visually. ● Understand that positive and negative numbers are used together to describe quantities having opposite directions or values. Use positive and negative numbers to represent changes in particle motion and temperature when thermal energy is added or removed, explaining the meaning of zero in each situation. 	
21 st Century Career Ready Practices		
<ul style="list-style-type: none"> ● CRP2. Apply appropriate academic and technical skills. ● CRP4. Communicate clearly and effectively and with reason. ● CRP6. Demonstrate creativity and innovation. ● CRP7. Employ valid and reliable research strategies. ● CRP8. Utilize critical thinking to make sense of problems and persevere in solving them. ● CRP11. Use technology to enhance productivity. 		

Grade 8 - Science

Unit 7: Chapter 7 & Chapter 8

Instructional Time: 15 - 20 days

How is it that everything is made of stardust?

Students build understandings of what occurs at the atomic and molecular scale. Students apply their understanding that pure substances have characteristic properties and are made from a single type of atom or molecule. They also provide a molecular level accounts to explain states of matter and changes between states. The crosscutting concepts of *cause and effect, scale, proportion and quantity, structure and function, interdependence of science, engineering, and technology, and the influence of science, engineering and technology on society and the natural world* provide a framework for understanding the disciplinary core ideas. Students demonstrate grade appropriate proficiency in *developing and using models, and obtaining, evaluating, and communicating information*. Students are also expected to use the scientific and engineering practices to demonstrate understanding of the core ideas.

Student Learning Objectives

New Jersey Student Learning Standards/ NGSS

MS-PS1-1	Develop models to describe the atomic composition of simple molecules and extended structures.
MS-PS1-2	Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.

Enduring Understandings

- All matter is made up of atoms.
- Atoms combine to make elements, which combine to make compounds.
- Molecules have specific behaviors and structure.
- All atoms have chemical and physical properties that help to identify the atom.
- Density, melting point, boiling point, solubility, flammability, and odor are characteristic properties that can be used to identify a pure substance.

Essential Questions (3 or 4)

- If the universe is not made of Legos®, then what is it made of?
- Is it possible to tell if two substances mixed or if they reacted with each other?

Concepts

Part A: *If the universe is not made of Legos®, then what is it made of?*

- Substances are made from different types of atoms.
- Atoms are the basic units of matter.
- Substances combine with one another in various ways.
- Molecules are two or more atoms joined together.
- Atoms form molecules that range in size from two to thousands of atoms.
- Molecules can be simple or very complex.
- Solids may be formed from molecules, or they may be extended structures with repeating subunits (e.g., crystals).

Part B: *Is it possible to tell if two substances mixed or if they reacted with each other?*

- Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it.
- Substances react chemically in characteristic ways.
- In a chemical process, the atoms that make up the original substances are regrouped into different molecules; these new substances have different properties from those of the reactants.
- The analysis of data on the properties of products and reactants can be used to determine whether a

Formative Assessment

Part A: *If the universe is not made of Legos®, then what is it made of?*

Students who understand the concepts are able to:

- Develop a model of a simple molecule.
- Use the model of the simple molecule to describe its atomic composition.
- Develop a model of an extended structure.
- Use the model of the extended structure to describe its repeating subunits.

Part B: *Is it possible to tell if two substances mixed or if they reacted with each other?*

Students who understand the concepts are able to:

- Analyze and interpret data to determine similarities and differences from results of chemical reactions between substances before and after they undergo a chemical process.
- Analyze and interpret data on the properties of substances before and after they undergo a chemical process.
- Identify and describe possible correlation and causation relationships evidenced in chemical reactions.
- Make logical and conceptual connections between evidence that chemical reactions have occurred and

<p>chemical process has occurred.</p> <ul style="list-style-type: none"> Density, melting point, boiling point, solubility, flammability, and odor are characteristic properties that can be used to identify a pure substance. Macroscopic patterns are related to the nature of the atomic-level structure of a substance. 	<p>explanations of the properties of substances before and after they undergo a chemical process.</p>
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Suggested Learning Activities

Within this unit, students will use informational text and models (which can include student-generated drawings, 3-D ball-and-stick structures, or computer representations) to understand that matter is composed of atoms and molecules. These models should reflect that substances are made from different types of atoms. Student models can be manipulated to show that molecules can be disassembled into their various atoms and reassembled into new substances according to chemical reactions. This scientific knowledge can be used to explain the properties of substances. Students will examine and differentiate between physical and chemical properties of matter. They are limited to the analysis of the following characteristic properties: density, melting point, boiling point, solubility, flammability, and odor. This analysis of properties serves as evidence to support that chemical reactions of substances cause a rearrangement of atoms to form different molecules.

Students will also recognize that they are using models to observe phenomena too small to be seen. Students who demonstrate this understanding can develop or modify a model of simple molecules to describe the molecules' atomic composition. Examples of molecules that can be modeled include water, oxygen, carbon dioxide, ammonia, and methanol. Additionally, students will develop and modify a model that describes the atomic composition of an extended structure showing a pattern of repeating subunits. Examples may include sodium chloride and diamonds. Due to the repeating subunit patterns, models can include student-generated drawings, 3-D ball-and-stick structures, and computer representations.

Building upon these experiences, students will analyze and interpret data on the properties of substances in order to provide evidence that a chemical reaction has occurred. They will also analyze and interpret data to determine similarities and differences in findings. Students will recognize that macroscopic patterns are related to the nature of microscopic and atomic-level structure. They will use patterns to identify cause-and-effect relationships and graphs and charts to identify patterns in data.

Science and Engineering Practices	DCI	Crosscutting Concepts
<p>Developing and Using Models</p> <ul style="list-style-type: none"> Develop a model to predict and/or describe phenomena. (MS-PS1-1) <p>Analyzing and Interpreting Data</p> <ul style="list-style-type: none"> Analyze and interpret data to determine similarities and differences in findings. (MS-PS1-2) 	<p>PS1.A: Structure and Properties of Matter</p> <ul style="list-style-type: none"> Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms. (MS-PS1-1) Solids may be formed from molecules, or they may be extended structures with repeating subunits (e.g., crystals). (MS-PS1-1) Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it. (MS-PS1-2) <p>PS1.B: Chemical Reactions</p> <ul style="list-style-type: none"> Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new 	<p>Scale, Proportion, and Quantity</p> <ul style="list-style-type: none"> Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. (MS-PS1-1) <p>Patterns</p> <ul style="list-style-type: none"> Macroscopic patterns are related to the nature of microscopic and atomic-level structure. (MS-PS1-2) <p>-----</p> <p>Connections to Nature of Science</p> <p>Scientific Knowledge is Based on Empirical Evidence</p> <ul style="list-style-type: none"> Science knowledge is based upon logical and conceptual connections between evidence and explanations. (MS-PS1-2)

	substances have different properties from those of the reactants. (MS-PS1-2)	
Cross-Curricular Connections		
English/Language Arts Standards	Mathematics Standards	
<ul style="list-style-type: none"> ● Cite specific textual evidence to support analysis of science and technical texts on the characteristic properties of pure substances. Attend to precise details of explanations or descriptions about the properties of substances before and after they undergo a chemical process. ● Integrate qualitative information (flowcharts, diagrams, models, graphs, or tables) about the characteristic properties of substances before and after a chemical process has occurred with a version of that information expressed visually, <i>or</i> integrate technical information about the characteristic properties of substances before and after a chemical process has occurred with a version of that information expressed visually. 	<ul style="list-style-type: none"> ● Integrate quantitative or technical information about the composition of simple molecules and extended structures that is expressed in words in a text with a version of that information expressed in a model. ● Reason quantitatively (with amounts, numbers, sizes) and abstractly (with variables). ● Develop a mathematical model to describe the atomic composition of simple molecules and extended structures. ● Use ratio and rate reasoning to describe the atomic composition of simple molecules and extended structures. ● Reason quantitatively with amounts, numbers, and sizes for properties like density, melting point, boiling point, solubility, flammability, and odor, and reason abstractly by assigning labels or symbols. ● Use ratio and rate reasoning to determine whether a chemical reaction has occurred. ● Display numerical data for properties such as density, melting point, solubility, flammability, and order in plots on a number line, including dot plots, histograms, and box plots. ● Summarize numerical data sets on the properties of substances before and after the substances interact to determine whether a chemical reaction has occurred. The summary of the numerical data sets must be in relation to their context. 	
21 st Century Career Ready Practices		
<ul style="list-style-type: none"> ● CRP2. Apply appropriate academic and technical skills. ● CRP4. Communicate clearly and effectively and with reason. ● CRP6. Demonstrate creativity and innovation. ● CRP7. Employ valid and reliable research strategies. ● CRP8. Utilize critical thinking to make sense of problems and persevere in solving them. 		

Grade 8 - Science

Unit 8: Chapter 9

Instructional Time: 15 - 20 days

How do substances combine or change (react) to make new substances?

Students provide molecular-level accounts of states of matters and changes between states, of how chemical reactions involve regrouping of atoms to form new substances, and of how atoms rearrange during chemical reactions. Students also apply their understanding of optimization design and process in engineering to chemical reaction systems. The crosscutting concept of *energy and matter* provides a framework for understanding the disciplinary core ideas. Students are expected to demonstrate proficiency in *developing and using models, analyzing and interpreting data, designing solutions, and obtaining, evaluating, and communicating information*. Students are also expected to use these science and engineering practices to demonstrate understanding of the disciplinary core ideas.

Student Learning Objectives

New Jersey Student Learning Standards/ NGSS

MS-PS1-5	Develop and use a model to describe how the total number of atoms does not change in a chemical reaction and thus mass is conserved.
MS-PS1-6	Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes.
MS-ETS1-3	Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

Enduring Understandings

- In a chemical process, the atoms that make up the original substances are regrouped into different molecules.
- New substances created in a chemical process have different properties from those of the reactants.
- The total number of each type of atom in a chemical process is conserved, and thus the mass does not change (the law of conservation of matter).
- Matter is conserved because atoms are conserved in physical and chemical processes.
- The law of conservation of mass is a mathematical description of natural phenomena.

Essential Questions (3 or 4)

- What happens to the atoms when I bake a cake?
- How does the law of conservation of matter affect chemical processes?
- How can a device be designed, constructed, tested, and modified that either releases or absorbs thermal energy by chemical processes?

Concepts

Part A: What happens to the atoms when I bake a cake?

- Substances react chemically in characteristic ways.
- In a chemical process, the atoms that make up the original substances are regrouped into different molecules.
- New substances created in a chemical process have different properties from those of the reactants.
- The total number of each type of atom in a chemical process is conserved, and thus the mass does not change (the law of conservation of matter).
- Matter is conserved because atoms are conserved in physical and chemical processes.
- The law of conservation of mass is a mathematical description of natural phenomena.

Part B: How can a device be designed, constructed, tested, and modified that either releases or absorbs thermal energy by chemical processes?

- Some chemical reactions release energy, while others

Formative Assessment

Part A: What happens to the atoms when I bake a cake?

Students who understand the concepts are able to:

- Use physical models or drawings, including digital forms, to represent atoms in a chemical process.
- Use mathematical descriptions to show that the number of atoms before and after a chemical process is the same.

Part B: How can a device be designed, constructed, tested, and modified that either releases or absorbs thermal energy by chemical processes?

Students who understand the concepts are able to:

- Undertake a design project, engaging in the design cycle, to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes.
- Specific criteria are limited to amount, time, and temperature of a substance.

<p>store energy.</p> <ul style="list-style-type: none"> ● The transfer of thermal energy can be tracked as energy flows through a designed or natural system. ● Models of all kinds are important for testing solutions. ● There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. ● The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. ● A solution needs to be tested and then modified on the basis of the test results in order to for it to be improved. ● Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process. ● Some of the characteristics identified as having the best performance may be incorporated into the new design. 	<ul style="list-style-type: none"> ● Analyze and interpret data for the amount, time, and temperature of a substance in testing a device that either releases or absorbs thermal energy by chemical processes to determine similarities and differences in findings. ● Develop a model to generate data for testing a device that either releases or absorbs thermal energy by chemical processes, including those representing inputs and outputs of thermal energy. ● Track the transfer of thermal energy as energy flows through a designed system that either releases or absorbs thermal energy by chemical processes.
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Suggested Learning Activities

Students begin by gaining understanding that substances react chemically in very characteristic ways. To develop this understanding, students will follow precisely a multistep procedure when carrying out experiments that involve chemical reactions that release energy and chemical reactions that absorb energy. As part of their data analysis, students will integrate quantitative information about atoms before and after the chemical reaction. The analysis will include translating written information into information that is expressed in a physical model or drawing or in digital forms. Reasoning both quantitatively and abstractly to communicate their understanding of these reactions, students will model the law of conservation of matter.

They will use ratio and rate to demonstrate that the total number of atoms involved in the chemical reactions does not change and therefore mass is conserved. Within this unit, students will develop a model of the reactions they observe to describe how the total number of atoms does not change in a chemical reaction. Examples of models could include physical models, drawings, or digital forms that represent atoms. Student models ideally should have the ability to be manipulated to represent the rearrangement of reactants to products as a way to demonstrate that matter is conserved during chemical processes. Students will show how their model provides evidence that the law of conservation of matter is a mathematical description of what happens in nature.

In prior units of study, students have learned about the behavior of particles of matter during a change of state and about characteristic chemical and physical properties of matter. This unit will leverage that prior learning by having students undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes. For example, students could design a device that releases heat in a way similar to how heat is released when powdered laundry detergent is mixed with water to form a paste. Students will need to be able to track energy transfer as heat energy is either released to the environment or absorbed from the environment. Students could also design a device that absorbs and stores heat from the environment.

The design problem has already been identified; therefore, the emphasis is on designing the device, controlling the transfer of energy to the environment, and modifying the device according to factors such as type and concentration of substance. The criteria for a successful design have not been determined; therefore, teachers will need to work with students to determine criteria for a successful design. Before attempting to determine criteria, students will conduct a short research project to familiarize themselves with scientific information they can use when designing the device. Students must draw on several sources and generate additional focused questions that allow for further avenues of exploration.

After completing their research, students will compare and contrast the information gained from experiments,

simulations, videos, or multimedia sources with that gained from their reading about the design of the device. Students, with the support of the teacher, will then write design criteria.

Students are now at a point where they can begin the design process. Prior to construction, students should develop a probability model and use it as part of the process for testing their device. They will use the probability model to determine which designs have the greatest probability of success.

It is important that students use mathematics appropriately when analyzing their test results. They must apply properties of operations to calculate numerical data with numbers in any form, convert between forms as appropriate, and assess the reasonableness of answers using mental computations and estimation strategies.

Students will collect and analyze these numerical data to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

Performance Expectations		
Science and Engineering Practices	DCI	Crosscutting Concepts
<p><u>Developing and Using Models</u></p> <ul style="list-style-type: none"> Develop a model to describe unobservable mechanisms. (MS-PS1-5) <p><u>Constructing Explanations and Designing Solutions</u></p> <ul style="list-style-type: none"> Undertake a design project, engaging in the design cycle, to construct and/or implement a solution that meets specific design criteria and constraints. (MS-PS1-6) <p><u>Analyzing and Interpreting Data</u></p> <ul style="list-style-type: none"> Analyze and interpret data to determine similarities and differences in findings. (MS-ETS1-3) 	<p><u>PS1.B: Chemical Reactions</u></p> <ul style="list-style-type: none"> Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. (MS-PS1-5) The total number of each type of atom is conserved, and thus the mass does not change. (MS-PS1-5) Some chemical reactions release energy, others store energy. (MS-PS1-6) <p><u>ETS1.B: Developing Possible Solutions</u></p> <ul style="list-style-type: none"> A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (secondary to MS-PS1-6) There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (MS-ETS1-3) Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. (MS-ETS1-3) <p><u>ETS1.C: Optimizing the Design Solution</u></p> <ul style="list-style-type: none"> Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process - that is, some of the characteristics may be 	<p><u>Energy and Matter</u></p> <ul style="list-style-type: none"> Matter is conserved because atoms are conserved in physical and chemical processes. (MS-PS1-5) The transfer of energy can be tracked as energy flows through a designed or natural system. (MS-PS1-6) <p>-----</p> <p><u>Connections to Nature of Science</u></p> <p><u>Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena</u></p> <ul style="list-style-type: none"> Laws are regularities or mathematical descriptions of natural phenomena. (MS-PS1-5)

	<p>incorporated into the new design. (<i>secondary to MS-PS1-6</i>)</p> <ul style="list-style-type: none"> • The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. (<i>secondary to MS-PS1-6</i>) • Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design. (MS-ETS1-3) 	
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Cross-Curricular Connections

English/Language Arts Standards	Mathematics Standards
<ul style="list-style-type: none"> • Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks <i>related to chemical reactions that release energy and some that store energy</i>. • Cite specific textual evidence to support analysis of science and technical texts on the design and modification of a device that controls the transfer of energy to the environment using factors such as type and concentration of a substance. • Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text <i>on the design and modification of a device that controls the transfer of energy to the environment using factors such as type and concentration of a substance</i>. • <i>Conduct</i> research on the design and modification of a device that controls the transfer of energy to the environment using factors such as type and concentration of a substance 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. • Draw evidence from informational texts to support analysis, reflection, and research on the design and modification of a device that controls the transfer of energy to the environment using factors such as type and concentration of a substance. • Include multimedia components and visual displays in presentations to clarify claims and findings and emphasize salient points <i>on the design and modification of a device that controls the transfer of</i> 	<ul style="list-style-type: none"> • Integrate quantitative information expressed in words about atoms before and after a chemical process with a version of that information expressed in a physical model or drawing, including digital forms. • Reason quantitatively and abstractly during communication about melting or boiling points. • Use mathematics to model the law of conservation of matter. • Use ratio and rate reasoning to describe how the total number of atoms does not change in a chemical reaction, and thus mass is conserved. • Reason quantitatively and abstractly: Reason quantitatively using numbers to represent the criteria (amount, time, and temperature of substance) when testing a device that either releases or absorbs thermal energy by chemical processes; reason abstractly by assigning labels or symbols. • Collect and analyze numerical data from tests of a device that either releases or absorbs thermal energy by chemical processes. Determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success. Pose problems with positive and negative rational numbers in any form, using tools strategically. Apply properties of operations to calculate the numerical data with numbers in any form, convert between forms as appropriate, and assess the reasonableness of answers using mental computations and estimation strategies. • Develop a probability model and use it as part of an iterative process for testing to find the probability that

energy to the environment.

a promising design solution will lead to an optimal solution. Compare probabilities from a model to observed frequencies; if the agreement is not good, explain possible sources of the discrepancy in order to ultimately develop an optimal design.

21st Century Career Ready Practices

- **CRP2.** Apply appropriate academic and technical skills.
- **CRP4.** Communicate clearly and effectively and with reason.
- **CRP6.** Demonstrate creativity and innovation.
- **CRP7.** Employ valid and reliable research strategies.
- **CRP8.** Utilize critical thinking to make sense of problems and persevere in solving them.
- **CRP11.** Use technology to enhance productivity.
- **CRP12.** Work productively in teams while using cultural global competence.

Grade 8 - Science

Unit 9: Chapter 1 & Chapter 2

Instructional Time: 15- 20

Is it possible to exert on an object without touching it?

Students use *cause and effect*; *system and system models*; and *stability and change* to understand ideas that explain why some materials are attracted to each other while others are not. Students apply ideas about gravitational, electrical, and magnetic forces to explain a variety of phenomena including beginning ideas about why some materials attract each other while others repel. In particular, students develop understandings that gravitational interactions are always attractive but that electrical and magnetic forces can be both attractive and negative. Students also develop ideas that objects can exert forces on each other even though the objects are not in contact, through fields. Students are expected to consider the influence of science, engineering, and technology on society and the natural world. Students are expected to demonstrate proficiency in *asking questions*, *planning and carrying out investigations*, *designing solutions*, and *engaging in argument*. Students are also expected to use these practices to demonstrate understanding of the core ideas.

Student Learning Objectives

New Jersey Student Learning Standards/ NGSS

MS-PS2-5	Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact
MS-PS2-3	Ask questions about data to determine the factors that affect the strength of electric and magnetic forces.
MS-PS2-4	Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects.

Enduring Understandings

- Fields exist between objects that exert forces on each other even though the objects are not in contact.
- Forces that act at a distance (electric, magnetic, and gravitational) can be explained by fields that extend through space and can be mapped by their effect on a test object (a charged object or a ball, respectively).
- The size of an electric or magnetic (electromagnetic) force depends on the magnitudes of the charges, currents, or magnetic strengths involved and on the distances between the interacting objects.
- There is a gravitational force between any two masses, but it is very small except when one or both of the objects have large mass

Essential Questions

- Can you apply a force on something without touching it?
- Why are there different types of forces?
- How does a Maglev train work?
- If I were able to eliminate air resistance and dropped a feather and a hammer at the same time, which would land first?

Concepts

- Part A:** *Can you apply a force on something without touching it?*
- Fields exist between objects that exert forces on each other even though the objects are not in contact.
 - The interactions of magnets, electrically charged strips of tape, and electrically charged pith balls are examples of fields that exist between objects exerting forces on each other, even though the objects are not in contact.
 - Forces that act at a distance (electric, magnetic, and gravitational) can be explained by fields that extend through space and can be mapped by their effect on a test object (a charged object or a ball, respectively).
 - Cause-and-effect relationships may be used to predict phenomena in natural or designed systems.

Part B: *How does a Maglev train work?*

Formative Assessment

- Part A:** *Can you apply a force on something without touching it?*
- Students who understand the concepts are able to:*
- Students will conduct an investigation and evaluate an experimental design to produce data that can serve as the basis for evidence that fields exist between objects exerting forces on each other even though the objects are not in contact.
 - Students will identify the cause-and-effect relationships between fields that exist between objects and the behavior of the objects.
- Part B:** *How does a Maglev train work? Students who understand the concepts are able to:*
- Students will ask questions about data to determine the effect of the strength of electric and magnetic forces

<ul style="list-style-type: none"> • Factors affect the strength of electric and magnetic forces. • Devices that use electric and magnetic forces could include electromagnets, electric motors, and generators. • Electric and magnetic (electromagnetic) forces can be attractive or repulsive. • The size of an electric or magnetic (electromagnetic) force depends on the magnitudes of the charges, currents, or magnetic strengths involved and on the distances between the interacting objects. • Cause-and-effect relationships may be used to predict the factors that affect the strength of electrical and magnetic forces in natural or designed systems <p>Part C: <i>If I were able to eliminate air resistance and dropped a feather and a hammer at the same time, which would land first?</i></p> <ul style="list-style-type: none"> • Gravitational interactions are always attractive and depend on the masses of interacting objects. • There is a gravitational force between any two masses, but it is very small except when one or both of the objects have large mass. • Evidence supporting the claim that gravitational interactions are attractive and depend on the masses of interacting objects could include data generated from simulations or digital tools and charts displaying mass, strength of interaction, distance from the sun, and orbital periods of objects within the solar system. 	<p>that can be investigated within the scope of the classroom, outdoor environment, and museums and other public facilities with available resources and, when appropriate, frame a hypothesis based on observations and scientific principles.</p> <ul style="list-style-type: none"> • Students will perform investigations using devices that use electromagnetic forces. • Students will collect and analyze data that could include the effect of the number of turns of wire on the strength of an electromagnet or the effect of increasing the number or strength of magnets on the speed of an electric motor. <p>Part C: <i>If I were able to eliminate air resistance and dropped a feather and a hammer at the same time, which would land first?</i></p> <p><i>Students who understand the concepts are able to:</i></p> <ul style="list-style-type: none"> • Students construct and present oral and written arguments supported by empirical evidence and scientific reasoning to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects. • Students use models to represent the gravitational interactions between two masses.
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Suggested Learning Activities

Students will conduct investigations of fields that exist between objects exerting forces on each other, even though the objects are not in contact. Through first-hand experiences or simulations, students will observe and evaluate the behavior of objects and record evidence of fields that exist and are responsible for the observed behavior of the objects. Students can investigate the interactions between magnets, electrically charged strips of tape, and/or electrically charged pith balls. Through hands-on investigations or simulations, students will be able to observe how the motion or the behavior of objects changes when they are exposed to electric or magnetic fields. For example, a pith ball could be suspended from a lightweight string and students can apply a charge to a balloon, comb, or plastic rod and make observations about the motion of the pith ball when these objects are placed in close proximity to the ball. The same type of investigation could be conducted with magnets or strips of electric tape. If instruction starts with students making these observations, students could then generate questions that they could use to ask questions about the cause-and-effect relationships that could explain their observations. A short research project could be conducted to provide data that students would use to help them answer their self-generated questions.

Students will investigate magnetic and electric forces to determine the nature of the force (repulsive, attractive, or both), and factors that affect the strength of the forces. Before beginning the investigations, students will generate questions that will be used to guide their investigations. Depending on the nature of their questions, students may need to cite specific textual evidence to support the generation of a hypothesis. During the investigation, students will identify cause-and-effect relationships and use their understanding of these relationships to make predictions about what would happen if a variable in the investigation were changed. They will also determine the impact of distance on the strength of a force. Investigations may include the use of electromagnets, electric motors, or generators. During these investigations, students will collect data that they will use to answer their self-generated questions. Students will investigate magnetic and electric forces to determine the nature of the force (repulsive, attractive, or both), and factors that affect the strength of the forces. Before beginning the investigations, students will generate questions that will be used to guide their investigations. Depending on the nature of their questions, students may need to cite specific textual evidence to

support the generation of a hypothesis. During the investigation, students will identify cause-and-effect relationships and use their understanding of these relationships to make predictions about what would happen if a variable in the investigation were changed. They will also determine the impact of distance on the strength of a force. Investigations may include the use of electromagnets, electric motors, or generators. During these investigations, students will collect data that they will use to answer their self-generated questions. Investigations can take place in the classroom, outdoor environment, or museums and other public facilities with available resources and when appropriate.

Students will frame a hypothesis based on observations and scientific principles about the behavior of electromagnetic forces and carry out investigations to collect data about the factors that affect the strength of electric and magnetic forces. Examples of investigations could include the effect of the number of turns of wire on the strength of an electromagnet or the effect of increasing the number or strength of magnets on the speed of an electric motor. Students will analyze both numerical and symbolic data and use these data to determine the factors that affect the strength of electric and magnetic fields. Students will conclude this portion of the unit by citing specific textual evidence to support the analysis of information they access while reading science and technical texts or online sources about electric and magnetic forces, attending to the precise details of explanations or descriptions.

The next portion of this unit will focus on gravitational forces. Students will construct and present oral and written arguments using evidence to support the claim that gravitational interactions are always attractive and depend on the masses of interacting objects. Students will also understand that there is gravitational force between any two masses, but it is very small except when one or both of the objects have large mass. Because of this, gravitational fields will only be observed through the observation of simulations, the use of models, or the analysis of data. These could include simulations or digital tools and charts displaying mass, strength of interactions, distance from the sun, and orbital periods of objects within the solar system. Models used need to represent gravitational interactions between two masses within and between systems.

Performance Expectations

Science and Engineering Practices	DCI	Crosscutting Concepts
<p>Using Mathematics and Computational Thinking</p> <ul style="list-style-type: none"> Use mathematical representations of phenomena to describe explanations. (HS-PS2-4) <p>Constructing Explanations and Designing Solutions</p> <ul style="list-style-type: none"> Apply scientific ideas to solve a design problem, taking into account possible unanticipated effects. (HS-PS2-3) <p>Planning and Carrying Out Investigations</p> <ul style="list-style-type: none"> Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-PS2-5) 	<p>PS2.B: Types of Interactions</p> <ul style="list-style-type: none"> Newton’s law of universal gravitation and Coulomb’s law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects. (HS-PS2-4) Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields. (HS-PS2-4) <p>PS2.A: Forces and Motion</p> <ul style="list-style-type: none"> If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system. (HS-PS2-3) <p>ETS1.A: Defining and Delimiting an Engineering Problem</p> <ul style="list-style-type: none"> Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk 	<p>Patterns</p> <ul style="list-style-type: none"> Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS2-4) <p>Cause and Effect</p> <ul style="list-style-type: none"> Systems can be designed to cause a desired effect. (HS-PS2-3) Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-PS2-5) <p>-----</p> <p>Connections to Nature of Science</p> <p>Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena</p> <ul style="list-style-type: none"> Theories and laws provide explanations in science. (HS-PS2-4) Laws are statements or descriptions of the relationships

	<p>mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (secondary) (HS-PS2-3)</p> <p>ETS1.C: Optimizing the Design Solution</p> <ul style="list-style-type: none"> Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed. (secondary HS-PS2-3) <p>PS2.B: Types of Interactions</p> <ul style="list-style-type: none"> Newton’s law of universal gravitation and Coulomb’s law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects. (HS-PS2-5) Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields. (HS-PS2-5) <p>PS3.A: Definitions of Energy</p> <ul style="list-style-type: none"> “Electrical energy” may mean energy stored in a battery or energy transmitted by electric currents. (secondary HS-PS2-5) 	<p>among observable phenomena. (HS-PS2-4)</p>
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Cross-Curricular Connections

English/Language Arts Standards	Mathematics Standards
<ul style="list-style-type: none"> Cite specific textual evidence to support analysis of information about science and technical texts regarding <i>the factors that affect the strength of electric and magnetic forces</i>, attending to the precise details of explanations or descriptions. Write arguments focused on evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects. 	<ul style="list-style-type: none"> Reason abstractly and quantitatively while using data to determine the factors that affect the strength of electric and magnetic forces.

21st Century Career Ready Practices

<ul style="list-style-type: none"> CRP2. Apply appropriate academic and technical skills. CRP4. Communicate clearly and effectively and with reason. CRP5. Consider the environmental, social and economic impacts of decisions. CRP6. Demonstrate creativity and innovation. CRP7. Employ valid and reliable research strategies. CRP8. Utilize critical thinking to make sense of problems and persevere in solving them. CRP11. Use technology to enhance productivity.
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Grade 8 - Science

Unit 10: Chapter 2

Instructional Time: 10 -15 days

How can we predict the motion of an object?

Students use *system and system models* and *stability and change* to understanding ideas related to why some objects will keep moving and why objects fall to the ground. Students apply Newton’s third law of motion to related forces to explain the motion of objects. Students also apply an engineering practice and concept to solve a problem caused when objects collide. The crosscutting concepts of *system and system models* and *stability and change* provide a framework for understanding the disciplinary core ideas. Students demonstrate proficiency in *asking questions, planning and carrying out investigations, designing solutions, engaging in argument from evidence, developing and using models, and constructing explanations and designing solutions*. Students are also expected to use these practices to demonstrate understanding of the core ideas.

Student Learning Objectives

New Jersey Student Learning Standards/ NGSS

MS-PS2-1	Apply Newton’s Third Law to design a solution to a problem involving the motion of two colliding objects.
MS-PS2-2	Plan an investigation to provide evidence that the change in an object’s motion depends on the sum of the forces on the object and the mass of the object.
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.
MS-ETS1-3	Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
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.

Enduring Understandings

- For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first, but in the opposite direction (Newton’s third law).
- Specification of constraints includes consideration of scientific principles and other relevant knowledge, which are likely to limit possible solutions.
- The change in an object’s motion depends on balanced (Newton’s first law) and unbalanced forces in a system Evidence that the change in an object’s motion depends on the sum of the forces on the object and the mass of the object includes qualitative comparisons of forces, mass, and changes in motion (Newton’s second law); frame of reference; and specification of units.
- Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales.

Essential Questions

- How are objects affected by the 3rd law of motion?
- How do scientific designs limit possible solution?
- How can mathematical equations explain and express how objects are affected by Newton’s 3rd law?
- How does a sailboat work?
- Who can build the fastest sailboat?

Concepts

Part A: How does a sailboat work?

- For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on

Formative Assessment

Part A: How does a sailboat work?

Students who understand the concepts are able to:

- Apply Newton’s third law to design a solution to a problem involving the motion of two colliding objects.

the first, but in the opposite direction (Newton's third law).

- Models can be used to represent the motion of objects in colliding systems and their interactions, such as inputs, processes, and outputs, as well as energy and matter flows within systems.
- The uses of technologies and any limitations on their use are driven by individual or societal needs, desires, and values, by the findings of scientific research and by differences in such factors as climate, natural resources, and economic conditions.
- 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, which are likely to limit possible solutions.

Part B: Who can build the fastest sailboat?

- The change in an object's motion depends on balanced (Newton's first law) and unbalanced forces in a system. Evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object includes qualitative comparisons of forces, mass, and changes in motion (Newton's second law); frame of reference; and specification of units.
- The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change.
- The greater the mass of the object, the greater the force needed to achieve the same change in motion.
- For any given object, a larger force causes a larger change in motion.
- Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales.

- Define a design problem involving the motion of two colliding objects that can be solved through the development of an object, tool, process, or system and that includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions.
- Evaluate competing design solutions involving the motion of two colliding objects based on jointly developed and agreed-upon design criteria.
- Develop a model to generate data to test ideas about designed systems, including those representing inputs and outputs.
- Analyze and interpret data to determine similarities and differences in findings.

Part B: Who can build the fastest sailboat?

Students who understand the concepts are able to:

- Plan an investigation individually and collaboratively to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.
- Design an investigation and identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim.
- Make logical and conceptual connections between evidence and explanations.
- Examine the changes over time and forces at different scales to explain the stability and change in designed systems.

Suggested Learning Activities

Throughout this unit of study, students will be examining and interacting with objects in motion. They will begin this unit by investigating Newton's third law of motion by observing the action/reaction forces involved during a collision. Students will expand their idea of collisions beyond the narrow view of collisions as being an accident in which two or more objects crash into each other. They will learn that scientists' use of the word collision does not refer to the size of the force; instead it describes any interaction between two objects. We want students to understand that a collision can be as small as an ant walking on a blade of grass—that is, that a collision is any touch between two objects, no matter how small or how large the force.

Some possible observations may include the action/reaction forces involved in roller skating, skateboarding, moving boxes of different masses, etc. Students will then apply Newton's third law to possible problems and solutions. Some possible investigations could include designing and launching rockets or protecting eggs in a collision.

Students then investigate Newton's first and second laws of motion through hands-on activities in which they observe the result of balanced and unbalanced forces on an object's motion. Some examples may include using a seesaw or kicking a ball. In addition, students will observe how an object's motion will change depending upon the mass of the object and the amount of force applied. Activities could include pushing objects of different masses and comparing the forces needed to accelerate the objects.

Students will continue their investigation of Newton’s third law by participating in an engineering and design problem that will require them to design a solution to a problem involving the motion of two colliding objects.

Students could begin by observing collisions. An example of a collision could be an egg in a cart rolling down an incline and colliding with a barrier. Based on their observations of collisions, students will jointly develop and agree upon the design problem that they will focus on. Students will begin by making a clear statement of the problem they are going to attempt to solve. Once students have a clearly stated problem, the teacher will need to provide them with time and opportunity to participate in a short research project where they will gather background information that will help them come up with possible design solutions. Students will need to document their findings, making sure that they cite the resources they use.

After students have collected evidence, they can then begin to brainstorm possible solutions. To begin this process, students will need to identify the constraints and criteria for a successful design solution. This would involve them identifying the limits of the design. For example, time, materials, and resources could be some constraints. Students will next identify the criteria for a successful design. For example, one criterion could be that the egg in the collision does not break at all, or that it may crack as long as the contents do not spill out.

After the constraints and criteria have been identified, students can then generate possible solutions. Multiple solutions could be generated. Using the evidence collected during their research, as well as information they have learned as a part of their classroom experience, students can eliminate the solutions that seem least likely to be successful and focus on those that are more likely to be successful.

After students have identified the solutions that are most likely to be successful, they will evaluate their competing design solutions using a rubric, checklist, or decision tree to assist them in selecting the design solution they will take into the next phase of the process.

Students have reached the stage where they will need to create a model that can be tested. The model could be physical, graphical, mathematical, or it could be a scale model. Students will use the model to collect evidence that will help them determine which of the possible design solutions will be taken into the prototype phase. During the prototype phase, students will create their actual model. Once students have constructed their devices, they should gather necessary data from tests performed on their design solutions. They will analyze and interpret these data to determine which design best minimizes the force acting upon the egg. For example, the materials of a particular design may be superior and/or the structure of another design may be more successful. Once students have evaluated competing solutions and analyzed and interpreted data, they may then begin to modify their original designs. It is important that students consider the benefits of each design solution. This is when they are deciding whether different parts of their solutions can be combined to maximize efficiency. The final goal is for students to identify the parts of each design solution that best fit their criteria and combine these parts into a design solution that is better than any of its predecessors. Students will then translate this activity to a real world-example in which they see the influence of science, engineering, and technology on society and the natural world.

Performance Expectations

Science and Engineering Practices	DCI	Crosscutting Concepts
<p><u>Planning and Carrying Out Investigations</u></p> <ul style="list-style-type: none"> Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim. (MS-PS2-2) <p><u>Constructing Explanations and Designing Solutions</u></p> <ul style="list-style-type: none"> Apply scientific ideas or principles 	<p><u>PS2.A: Forces and Motion</u></p> <ul style="list-style-type: none"> For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first, but in the opposite direction (Newton’s third law). (MS-PS2-1) The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater 	<p><u>Systems and System Models</u></p> <ul style="list-style-type: none"> Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy and matter flows within systems. (MS-PS2-1) <p><u>Stability and Change</u></p> <ul style="list-style-type: none"> Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales. (MS-PS2-2) <p>-----</p>

to design an object, tool, process or system. (MS-PS2-1)

Asking Questions and Defining Problems

- Define a design problem that can be solved through the development of an object, tool, process or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions. (MS-ETS1-1)

Engaging in Argument from Evidence

- Evaluate competing design solutions based on jointly developed and agreed-upon design criteria. (MS-ETS1-2)

the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion. (MS-PS2-2)

- All positions of objects and the directions of forces and motions must be described in an arbitrarily chosen reference frame and arbitrarily chosen units of size. In order to share information with other people, these choices must also be shared. (MS-PS2-2)

ETS1.A: Defining and Delimiting Engineering Problems

- 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 are likely to limit possible solutions. (MS-ETS1-1)

ETS1.B: Developing Possible Solutions

- There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (MS-ETS1-2)
- A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (MS-ETS1-4)
- There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (MS-ETS1-2), (MS-ETS1-3)
- Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. (MS-ETS1-3)
- Models of all kinds are important for testing solutions. (MS-ETS1-4)

ETS1.C: Optimizing the Design Solution

- Although one design may not perform the best across all tests, identifying the characteristics of

Connections to Engineering, Technology, and Applications of Science

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

- The uses of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. (MS-PS2-1)
- All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment. (MS-ETS1-1)
- The uses of technologies and limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. (MS-ETS1-1)

	<p>the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design. (MS-ETS1-3)</p> <ul style="list-style-type: none"> • The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. (MS-ETS1-4) 	
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Cross-Curricular Connections

English/Language Arts Standards	Mathematics Standards
<ul style="list-style-type: none"> • Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions of the application of Newton’s third law involving the motion of two colliding objects. • Follow precisely a multistep procedure when carrying out experiments to apply Newton’s third law when designing a solution to a problem involving the motion of two colliding objects, taking measurements, or performing technical tasks. • Follow precisely a multistep procedure when performing an investigation that provides evidence that the change in an object’s motion depends on the sum of the forces on the object and the mass of the object, taking measurements or performing technical tasks. • Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading texts about the application of Newton's third law to the motion of two colliding objects Conduct a short research project to answer a question about the application of Newton’s third law when designing a solution to a problem involving the motion of two colliding objects, drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration. • Conduct a short research project to answer a question about how the sum of the forces on the object and the mass of the object change an object’s motion, drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration. • Gather relevant information from multiple print and digital sources that provide information about the application of Newton's third law when designing a solution to a problem involving the motion of two colliding objects; assess the credibility of each source 	<ul style="list-style-type: none"> • Reason abstractly and quantitatively when collecting and analyzing data about the application of Newton’s third law in the course of designing a solution to a problem involving the motion of two colliding objects. • Analyze data in the form of numbers and symbols to draw conclusions about how the sum of the forces on an object and the mass of an object change the object’s motion. • Understand that positive and negative numbers are used together to describe quantities having opposite directions or values; use positive and negative numbers to represent quantities in a design that applies Newton’s third law to a problem involving the motion of two colliding objects. • When collecting and analyzing data from investigations about how the sum of the forces on an object and the mass of the object changes the object’s motion, write, read, and evaluate expressions in which letters stand for numbers.

and quote or paraphrase the data and conclusions of others while avoiding plagiarism and providing basic bibliographic information for sources.

- Draw evidence from informational texts to support analysis, reflection, and research about the application of Newton's third law when designing a solution to a problem involving the motion of two colliding objects.

21st Century Career Ready Practices

- **CRP2.** Apply appropriate academic and technical skills.
- **CRP3.** Attend to personal health and financial well-being.
- **CRP4.** Communicate clearly and effectively and with reason.
- **CRP6.** Demonstrate creativity and innovation.
- **CRP7.** Employ valid and reliable research strategies.
- **CRP8.** Utilize critical thinking to make sense of problems and persevere in solving them.
- **CRP11.** Use technology to enhance productivity.