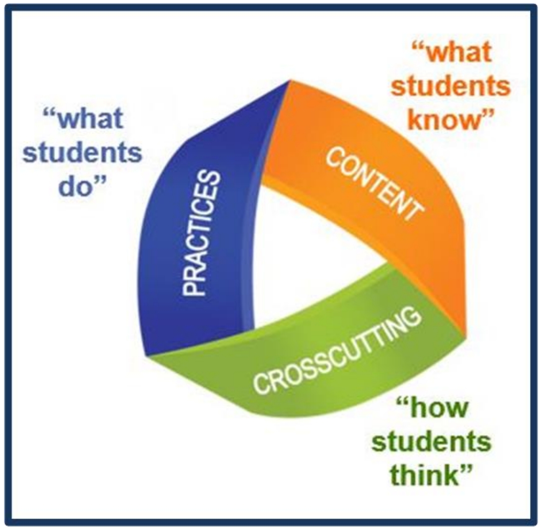
Ledyard Public Schools
Middle School NGSS Curriculum Course 3



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District Philosophy

Ledyard's vision for K-12 inquiry based science is to engage students in scientific and engineering practices as they apply crosscutting concepts to deepen their understanding of the core ideas in these fields.

A New Vision for Science Education

Implications of the Vision of the Framework for K-12 Science Education and the Next Generation Science Standards

SCIENCE EDUCATION WILL INVOLVE LESS:	SCIENCE EDUCATION WILL INVOLVE MORE:
Rote memorization of facts and terminology.	Facts and terminology learned as needed while developing explanations and designing solutions supported by evidence-based arguments and reasoning.
Learning of ideas disconnected from questions about phenomena.	Systems thinking and modeling to explain phenomena and to give a context for the ideas to be learned.
Teachers providing information to the whole class.	Students conducting investigations, solving problems, and engaging in discussions with teachers' guidance.
Teachers posing questions with only one right answer.	Students discussing open-ended questions that focus on the strength of the evidence used to generate claims.
Students reading textbooks and answering questions at the end of the chapter.	Students reading multiple sources, including science-related magazine and journal articles and web-based resources; students developing summaries of information.
Pre-planned outcome for "cookbook" laboratories or hands-on activities.	Multiple investigations driven by students' questions with a range of possible outcomes that collectively lead to a deep understanding of established core scientific ideas.
Worksheets.	Student writing of journals, reports, posters, and media presentations that explain and argue.
Oversimplification of activities for students who are perceived to be less able to do science and engineering	Provision of supports so that all students can engage in sophisticated science and engineering practices

Source: National Research Council. (2015). *Guide to Implementing the Next Generation Science Standards* (pp. 8-9). Washington, DC: National Academies Press. http://www.nap.edu/catalog/18802/guide-to-implementing-the-next-generation-science-standards.

Three Dimensions of the *Next Generation Science Standards*:

SEP (appendix F), DCI (appendix E), CCC (appendix G)

Scientific and Engineering Practices Matrix

Asking Questions and Defining Problems

A practice of science is to ask and refine questions that lead to descriptions and explanations of how the natural and designed world works and which can be empirically tested.

Engineering questions clarify problems to determine criteria for successful solutions and identify constraints to solve problems about the designed world. Both scientists and engineers also ask questions to clarify the ideas of others.

Planning and Carrying Out Investigations

Scientists and engineers plan and carry out investigations in the field or laboratory, working collaboratively as well as individually. Their investigations are systematic and require clarifying what counts as data and identifying variables or parameters. Engineering investigations identify the effectiveness, efficiency, and durability of designs under different conditions.

Analyzing and Interpreting Data

Scientific investigations produce data that must be analyzed in order to derive meaning. Because data patterns and trends are not always obvious, scientists use a range of tools—including tabulation, graphical interpretation, visualization, and statistical analysis—to identify the significant features and patterns in the data. Scientists identify sources of error in the investigations and calculate the degree of certainty in the results. Modern technology makes the collection of large data sets much easier, providing secondary sources for analysis.

Engineering investigations include analysis of data collected in the tests of designs. This allows comparison of different solutions and determines how well each meets specific design criteria—that is, which design best solves the problem within given constraints. Like scientists, engineers require a range of tools to identify patterns within data and interpret the results. Advances in science make analysis of proposed solutions more efficient and effective.

Developing and Using Models

A practice of both science and engineering is to use and construct models as helpful tools for representing ideas and explanations. These tools include diagrams, drawings, physical replicas, mathematical representations, analogies, and computer simulations. Modeling tools are used to develop questions, predictions and explanations; analyze and identify flaws in systems; and communicate ideas. Models are used to build and revise scientific explanations and proposed engineered systems. Measurements and observations are used to revise models and designs.

Constructing Explanations and Designing Solutions

The products of science are explanations and the products of engineering are solutions. The goal of science is the construction of theories that provide explanatory accounts of the world. A theory becomes accepted when it has multiple lines of empirical evidence and greater explanatory power of phenomena than previous theories. The goal of engineering design is to find a systematic solution to problems that is based on scientific knowledge and models of the material world. Each proposed solution results from a process of balancing competing criteria of desired functions, technical feasibility, cost, safety, aesthetics, and compliance with legal requirements. The optimal choice depends on how well the proposed solutions meet criteria and constraints.

Engaging in Argument from Evidence

Argumentation is the process by which explanations and solutions are reached. In science and engineering, reasoning and argument based on evidence are essential to identifying the best explanation for a natural phenomenon or the best solution to a design problem. Scientists and engineers use argumentation to listen to, compare, and evaluate competing ideas and methods based on merits. Scientists and engineers engage in argumentation when investigating a phenomenon, testing a design solution,

Using Mathematics and Computational Thinking

In both science and engineering, mathematics and computation are fundamental tools for representing physical variables and their relationships. They are used for a range of tasks such as constructing simulations; statistically analyzing data; and recognizing, expressing, and applying quantitative relationships. Mathematical and computational approaches enable scientists and engineers to predict the behavior of systems and test the validity of such predictions. Statistical methods are frequently used to identify significant patterns and establish correlational relationships.

Obtaining, Evaluating, and Communicating Information

Scientists and engineers must be able to communicate clearly and persuasively the ideas and methods they generate. Critiquing and communicating ideas individually and in groups is a critical professional activity. Communicating information and ideas can be done in multiple ways: using tables, diagrams, graphs, models, and equations as well as orally, in writing, and through extended discussions. Scientists and engineers employ multiple sources to acquire information that is used to evaluate the merit and validity of claims, methods, and designs.

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Disciplinary Core Ideas Matrix Course 2 Disciplinary Core Ideas are highlighted yellow			
Physical Science	**Life Science**	**Earth and Space Science**	**Engineering, Technology, and the Application of Science**
PS1: Matter and Its Interactions PS1.A: Structure and Properties of Matter PS1.B: Chemical Reactions PS1.C: Nuclear Processes **PS2: Motion and Stability: Forces and Interactions** PS2.A: Forces and Motion PS2.B: Types of Interactions **PS3: Energy** PS3.A: Definitions of Energy PS3.B: Conservation of Energy and Energy Transfer PS3.C: Relationship Between Energy and Forces PS3.D: Energy in Chemical Processes and Everyday Life **PS4: Waves and Their Applications in Technologies for Information Transfer** PS4.A: Wave Properties PS4.B: Electromagnetic Radiation PS4.C: Information Technologies and Instrumentation	**LS1: From Molecules to Organisms: Structures and Processes** LS1.A: Structure and Function LS1.B: Growth and Development of Organisms LS1.C: Organization for Matter and Energy Flow in Organisms LS1.D: Information Processing **LS2: Ecosystems: Interactions, Energy, and Dynamics** LS2.A: Interdependent Relationships in Ecosystems LS2.B: Cycles of Matter and Energy Transfer in Ecosystems LS2.C: Ecosystem Dynamics, Functioning, and Resilience LS2.D: Social Interactions and Group Behavior **LS3: Heredity: Inheritance and Variation of Traits** LS3.A: Inheritance of Traits LS3.B: Variation of Traits **LS4: Biological Evolution: Unity and Diversity** LS4.A: Evidence of Common Ancestry and Diversity LS4.B: Natural Selection LS4.C: Adaptation LS4.D: Biodiversity and Humans	**ESS1: Earth's Place in the Universe** ESS1.A: The Universe and Its Stars ESS1.B: Earth and the Solar System ESS1.C: The History of Planet Earth **ESS2: Earth's Systems** ESS2.A: Earth Materials and Systems ESS2.B: Plate Tectonics and Large-Scale Systems ESS2.C: The Role of Water in Earth's Surface Processes ESS2.D: Weather and Climate ESS2.E: Biogeology **ESS3: Earth and Human Activity** ESS3.A: Natural Resources ESS3.B: Natural Hazards ESS3.C: Human Impacts on Earth Systems ESS3.D: Global Climate Change	**ETS1: Engineering Design** ETS1.A: Defining and Delimiting an Engineering Problem ETS1.B: Developing Possible Solutions ETS1.C: Optimizing the Design Solution

Developed by NSTA based on content from the *Framework for K-12 Science Education* and supporting documents for the *May 2012 Public Draft of the NGSS*

Crosscutting Concepts Matrix

Patterns
Observed patterns of forms and events guide organization and classification, and they prompt questions about relationships and the factors that influence them.

Cause and Effect: Mechanism and Explanation Events have causes, sometimes simple, sometimes multifaceted. A major activity of science is investigating and explaining causal relationships and the mechanisms by which they are mediated. Such mechanisms can then be tested across given contexts and used to predict and explain events in new contexts.

Scale, Proportion, and Quantity
In considering phenomena, it is critical to recognize what is relevant at different measures of size, time, and energy and to recognize how changes in scale, proportion, or quantity affect a system's structure or performance.

Systems and System Models
Defining the system under study—specifying its boundaries and making explicit a model of that system—provides tools for understanding and testing ideas that are applicable throughout science and engineering.

Energy and Matter: Flows, Cycles, and Conservation
Tracking fluxes of energy and matter into, out of, and within systems helps one understand the systems' possibilities and limitations.

Structure and Function
The way in which an object or living thing is shaped and its substructure determine many of its properties and functions.

Stability and Change
For natural and built systems alike, conditions of stability and determinants of rates of change or evolution of a system are critical elements of study.

Developed by NSTA based on content from the *Framework for K-12 Science Education* and supporting documents for the *May 2012 Public Draft of the NGSS*

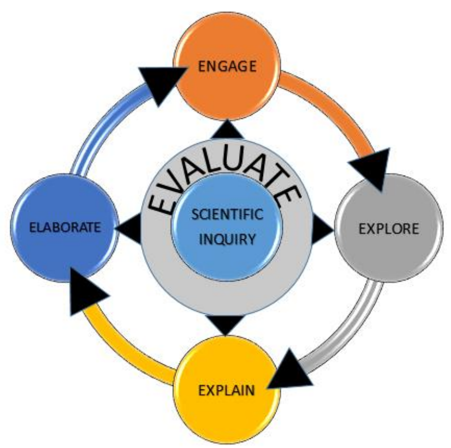
Connections to the Nature of Science

Nature of Science Practices	Nature of Science Crosscutting Concepts
These understandings about the nature of science are closely associated with the science and engineering practices, and are found in that section of the foundation box on a standards page. More information about the Connections to Engineering, Technology and Applications of Science can be found in Appendix H.	These understandings about the nature of science are closely associated with the crosscutting concepts, and are found in that section of the foundation box on a standards page. More information about the Connections to Engineering, Technology and Applications of Science can be found in Appendix H.
Scientific Investigations Use a Variety of Methods	Science is a Way of Knowing
Science Knowledge is Based on Empirical Evidence	Scientific Knowledge Assumes and Order and Consistency in Natural Systems
Scientific Knowledge is Open to Revision in Light of New Evidence	Science is a Human Endeavor
Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena.	Science Addresses Questions About the Natural and Material World

How does Ledyard Define Inquiry?

Inquiry is defined as a way of seeking information, knowledge, or truth through questioning. Inquiry is a way for a learner to acquire new information and data and turn it into useful knowledge. Inquiry involves asking good questions and developing robust investigations from them. Inquiry also involves considering possible solutions and consequences. A third component of inquiry is separating evidence based claims from common opinion, and communicating claims with others, and acting upon these claims when appropriate. Questions lead to gathering information through research, study, experimentation, observation, or interviews. During this time, the original question may be revised, a line of research refined, or an entirely new path may be pursued. As more information is gathered, it becomes possible to make connections and allows individuals to construct their own understanding to form new knowledge. Sharing this knowledge with others develops the relevance of the learning for both the student and a greater community. Sharing is followed by reflection and potentially more questions, bringing the inquiry process full circle.

Inquiry 5 Science Teaching Model



Engagement	Object, event or question used to engage students. Connections facilitated between what students know and can do.
Exploration	Objects and phenomena are explored. Hands-on activities, with guidance.
Explanation	Students explain their understanding of concepts and processes. New concepts and skills are introduced as conceptual clarity and cohesion are sought.
Elaboration	Activities allow students to apply concepts in contexts, and build on or extend understanding and skill.
Evaluation	Students assess their knowledge, skills and abilities. Activities permit evaluation of student development and lesson effectiveness.

Unit 1: The Study of Forces and Energy

Unit Duration: 41 classes (August-first week in November)

Anchoring Phenomenon	
New Phobia Roller Coaster at Lake Compounce	
Compelling Question(s)	**Supporting Questions**
What forces affect your daily life?	• *What happens when a driver in a car on the highway is inattentive and collides with a stationary tractor-trailer?* • *Why does the person making the tackle in football also get injured when he/she hits another player?* • *Why does a magnetic clip only hold so many papers on a refrigerator?* • *How does an electromagnet pick up a vehicle without even touching it?* • *How can a magnet on one side of your hand exert a force on the other side of your hand?* • *How does doubling your swing speed affect how far a baseball will travel?* • *Why does an air conditioner falling from a second story window cause more damage than the same air conditioner falling from the first story window?*
Unit 1 Storyline	**Unit 1 Possible Student Misconceptions:**
Students will investigate the forces around them in their daily lives.	• *Speed and velocity are the same.* • *Acceleration only means to speed up.* • ***Single** forces can exist*
Prior Learning:	
3.PS2.A Forces and Motion; **3.PS2.B Types of Interactions** **4.PS3.B Conservation of Energy and Energy Transfer** **5.PS2.B Types of Interactions**	

Unit 1: The Study of Forces and Energy
Standards and 3-D Learning Overview

Performance Expectations	Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
• **MS-PS2-2** • **MS-PS2-1** • **MS-PS2-4** • **MS-PS2-5** • **MS-PS2-3** • **MS-PS3-2** • **MS-PS3-1** • **MS-ETS1-1** *Teacher Note: All the Performance Expectations above will be covered this unit and can be worked on concurrently. All Science and Engineering Practices and Crosscutting Concepts in bold are written in the Performance Expectations above. The italicized practices and crosscutting concepts, although not mentioned specifically, may be incorporated additionally in any science lesson at any time.*	• **1: Asking Questions and Defining Problems** • **2: Developing and Using Models** • **3: Planning and Carrying Out Investigations** • **4: Analyzing and Interpreting Data** • *5: Using Mathematical Computational Thinking* • **6: Constructing Explanations and Designing Solutions** • **7: Engaging in Argument from Evidence** • *8: Obtaining, Evaluating, and Communicating Information*	**ENGINEERING, TECHNOLOGY AND THE APPLICATION OF SCIENCE** • **ETS1 Engineering Design** -ETS1.A: Defining and Delimiting Engineering Problems **PHYSICAL SCIENCE** • **PS2: Motion and Stability: Forces and Interactions** -PS2.A: Forces and Motion -PS2.B: Types of Interactions • **PS3: Energy** -PS3.A: Definitions of Energy -PS3.C: Relationship Between Energy and Forces	• *1: Patterns* • **2: Cause and Effect** • **3: Scale, Proportion and Quantity** • **4: Systems and System Models** • *5: Energy and Matter* • *6: Structure and Function* • *7: Stability and Change*
Formal Assessment Unit 1: TCI 1-1 **REQUIRED IAB: Forces Interaction and Energy**		**Additional Teacher Resources Unit 1:** **Google Drive:** Team Drive Grade 8 Science Resources Classroom	

Performance Expectation
MS-PS2-2 Motion and Stability: Forces and Interactions

Students who demonstrate understanding can:

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.

Clarification Statement: Emphasis is on balanced (Newton's First Law) and unbalanced forces in a system, qualitative comparisons of forces, mass and changes in motion (Newton's Second Law), frame of reference, and specification of units.

Assessment Boundary: *Assessment is limited to forces and changes in motion in one-dimension in an inertial reference frame and to change in one variable at a time. Assessment does not include the use of trigonometry.*

Lesson Level Phenomenon: **Sitting in a train alongside other trains, you might look out the window and be unsure about which train is moving. Examine how a wrench thrown in outer space moves and how the movement of the wrench affects the person who threw it; compare the movement of a football thrown on Earth and thrown on the International Space Station.**

note: all photo and video above links to suggested activities below

MS-PS2-2 Suggested Activities	MS-PS2-2 Recommended Formative Assessments
Describing Motion (*TCI Forces and Energy: Unit 1 Forces, Lesson 1)* Students will investigate reference points, perspectives (reference frame), speed, velocity and acceleration to describe movement. (3-4 class periods) **Effects of Forces** (*TCI Forces and Energy: Unit 1 Forces, Lesson 3)* Students will compare the outcome of throwing a wrench in space versus throwing a wrench on Earth. (4 class periods)	• Determine the winner of a short race based on starting time and rates of acceleration. • Lesson Level Assessment • Forced to Accelerate Lab Performance Assessment (also can use Performance Assessment TCI)

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations • 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. **Planning and carrying out investigations to answer questions or test solutions to problems in 6–8 builds on K–5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or design solutions.**	**PS2.A: Forces and Motion** • 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. • 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.	**Stability and Change** • Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales.

Performance Expectation
MS-PS2-2 Motion and Stability: Forces and Interactions

Connections to other DCIs in Middle School:
MS.PS3.A ; MS.PS3.B ; MS.ESS2.C

Articulation of DCIs across grade-levels:
3.PS2.A ; HS.PS2.A ; HS.PS3.B ; HS.ESS1.B

Common Core State Standards Connections*:*
ELA/Literacy

RST.6-8.3 Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks. *(MS-PS2-2)*

WHST.6-8.7 Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration. (MS-PS2-2)

Mathematics-

MP.2 Reason abstractly and quantitatively. (MS-PS2-2)

6.EE.A.2 Write, read, and evaluate expressions in which letters stand for numbers. *(MS-PS2-2)*

7.EE.B.3 Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form, using tools strategically. Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies. *(MS-PS2-2)*

7.EE.B.4 Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities. *(MS-PS2-2)*

Lesson Level Vocabulary: *rate, position, speed, reference point, velocity, balanced forces, unbalanced forces, Newton's Second Law of Motion, Newton's First Law of Motion, net force, friction*

DCI Domain Vocabulary:
Domains are bold:

- **Motion and Stability: Forces and Interactions→Forces and Motion (PS2)**
  Conservation, electric current, exert, interaction, transfer, mass, relative position, constant speed, control (variable), deceleration, dependent variable, direction of a force, direction of motion, economic, impact, independent variable, inertia, Isaac Newton, Newton's First Law of Motion, Newton's Second Law of Motion, Newton's Third Law of Motion, nonlinear, stationary, frame of reference, macroscopic, momentum, net force, optimal, systematic

Performance Expectation
MS-PS2-1 Motion and Stability: Forces and Interactions

Students who demonstrate understanding can:
Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects.
Clarification Statement: Emphasis is on balanced (Newton's First Law) and unbalanced forces in a system, qualitative comparisons of forces, mass and changes in motion (Newton's Second Law), frame of reference, and specification of units.]
Assessment Boundary: *Assessment is limited to forces and changes in motion in one-dimension in an inertial reference frame and to change in one variable at a time. Assessment does not include the use of trigonometry.*]

Lesson Level Phenomenon: Bottle rocket launch (on field of LMS); It takes an enormous amount of fuel to launch a rocket.
note: all photo and video above links to suggested activities below

MS-PS2-1 Suggested Activities	MS-PS2-1 Recommended Formative Assessments
Forces and Interactions (*TCI Forces and Energy: Unit 1 Forces Lesson 2*) Students will model a zip line using string, straw, paper clips, and balloons. (4 class periods)	• Complete a CER (Claim, Evidence, Reasoning) initial claim of how a rocket gets off the ground and a final reasoning of how a rocket gets off the ground using the zip-line activity as part of their reasoning.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions • Apply scientific ideas or principals to design an object, tool, process, or system. **Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.**	PS2.A: Forces and Motion • 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).	Systems and System Models • Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy and matter flows within systems. -- ***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.

Performance Expectation
MS-PS2-1 Motion and Stability: Forces and Interactions

Connections to other DCIs Middle School:
MS.PS3.C

Articulation of DCIs across grade-level bands:
3.PS2.A ; HS.PS2.A

Common Core State Standards Connections:
ELA/Literacy

RST.6-8.1	Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions. *(MS-PS2-1)*
RST.6-8.3	Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks. *(MS-PS2-1)*
WHST.6-8.7	Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration. *(MS-PS2-1)*

Mathematics

MP.2	Reason abstractly and quantitatively. (MS-PS2-1)
6.NS.C.5	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 real-world contexts, explaining the meaning of 0 in each situation. (MS-PS2-1)
6.EE.A.2	Write, read, and evaluate expressions in which letters stand for numbers. *(MS-PS2-1)*
7.EE.B.3	Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form, using tools strategically. Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies. *(MS-PS2-1)*
7.EE.B.4	Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities. *(MS-PS2-1)*

Lesson Level Vocabulary: *Newton's Third Law of Motion, newton, scientific law, force*

DCI Domain Vocabulary:
Domains are bold:

- **Motion and Stability: Forces and Interactions→Forces and Motion (PS2)**
  Conservation, electric current, exert, interaction, transfer, mass, relative position, constant speed, control (variable), deceleration, dependent variable, direction of a force, direction of motion, economic, impact, independent variable, inertia, Isaac Newton, Newton's First Law of Motion, Newton's Second Law of Motion, Newton's Third Law of Motion, nonlinear, stationary, frame of reference, macroscopic, momentum, net force, optimal, systematic

Performance Expectation
MS-PS2-3 Motion and Stability: Forces and Interactions

Students who demonstrate understanding can:

Ask questions about data to determine the factors that affect the strength of electric and magnetic forces.

Clarification Statement: Examples of devices that use electric and magnetic forces could include electromagnets, electric motors, or generators. Examples of data 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.

Assessment Boundary: Assessment about questions that require quantitative answers is limited to proportional reasoning and algebraic thinking.

Lesson Level Phenomenon: Sometimes you experience a shock or even a spark when you reach for a doorknob.
Headphones and speakers use magnets and wires to deliver sound to your ears.
note: all photo and video above links to suggested activities below

MS-PS2-3 Suggested Activities	MS-PS2-3 Recommended Formative Assessments
Electricity (*TCI Forces and Energy: Unit 2 Noncontact Forces, Lesson 5)* Students will investigate static electricity using balloons, a Phet simulation, and a static electricity demonstration using an electroscope. Students will also model and build a circuit. (4 class periods) **Magnetism and Electromagnetism** (*TCI Forces and Energy: Unit 2 Noncontact Forces, Lesson 6)* Students will model a magnetic field using bar magnets and iron filings and engineer an electromagnet to determine the factors that affect its strength, and build a simple electric motor. (4-5 class periods)	• Make a claim for what happens when you reach for a doorknob. • Keeping It Current Performance Assessment- analyze data to determine the most important controlling factor of the magnetic force. • Demonstrate techniques and ability to build a motor. (TCI investigation 3)

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Asking Questions and Defining Problems • Ask questions 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. **Asking questions and defining problems in grades 6–8 builds from grades K–5 experiences and progresses to specifying relationships between variables, and clarifying arguments and models.**	**PS2.B: Types of Interactions** • Electric and magnetic (electromagnetic) forces can be attractive or repulsive, and their sizes depend on the magnitudes of the charges, currents, or magnetic strengths involved and on the distances between the interacting objects.	**Cause and Effect** • Cause and effect relationships may be used to predict phenomena in natural or designed systems.

Performance Expectation
MS-PS2-3 Motion and Stability: Forces and Interactions

Connections to other DCIs Middle School:
N/A

Articulation of DCIs across grade-levels:
3.PS2.B ; HS.PS2.B

Common Core State Standards Connections:
ELA /Literacy –
RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions. *(MS-PS2-3*

Mathematics —
MP.2 Reason abstractly and quantitatively. (MS-PS2-3)

Lesson Level Vocabulary: *electric forces, electric field, resistance, electric current, electric charge, prototype, repulsive, magnetic poles, electromagnet, magnetic forces, magnetic field*

DCI Domain Vocabulary:
Domains are bold:

- **Motion and Stability: Forces and Interactions→Types of Interactions (PS2)**
  Current, electric current, electrical energy, exert, gravitational, interaction, magnetic force, magnetic repulsion, transfer, transmit, charged object, charged rod, attractive, charge repulsion, electric force, electric motor, electromagnet, facility, field, generator, insulator, electromagnetic, orientation, precision, repulsive

Performance Expectation
MS-PS2-4 Motion and Stability: Forces and Interactions

Students who demonstrate understanding can:

Construct and present arguments using evidence to support the claim that gravitation interactions are attractive and depend on the masses of interacting objects.

Clarification Statement: Examples of evidence for arguments 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

Assessment Boundary: *Assessment does not include Newton's Law of Gravitation or Kepler's Laws.*

Lesson Level Phenomenon: When a piece of paper is placed on top of a book, and both objects are dropped together, they fall straight to the ground; the paper does not flutter.

note: all photo and video above links to suggested activities below

MS-PS2-4 Suggested Activities	MS-PS2-4 Recommended Formative Assessments
Gravity (*TCI Forces and Energy: Unit 2, Lesson 4)* Students will learn the effects of air resistance and understand the relationship between air resistance and gravity (terminal velocity). Students investigate how mass and distance effect gravitational force. Students will also model gravitational fields. (4 class periods)	• Write a (CER) explaining how a book and a paper drop at the same time using reasoning from the activity investigations.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Engaging in Argument from Evidence • Construct and present oral and written arguments supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. **Engaging in argument from evidence in 6–8 builds from K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world.** -- ***Connections to Nature of Science*** **Scientific Knowledge is Based on Empirical Evidence** • Science knowledge is based upon logical and conceptual connections between evidence and explanations.	**PS2.B: Types of Interactions** • Gravitational forces are always attractive. 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—e.g., Earth and the sun.	**Systems and System Models** • Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy and matter flows within systems.

Performance Expectation
MS-PS2-4 Motion and Stability: Forces and Interactions

Connections to other DCIs Middle School:
MS.ESS1.A ; MS.ESS1.B ; MS.ESS2.C

Articulation of DCIs across grade-levels:
5.PS2.B ; HS.PS2.B ; HS.ESS1.B

Common Core State Standards Connections:
ELA /Literacy –
WHST.6-8.1 Write arguments focused on *discipline-specific content*. (MS-PS2-4)

Mathematics —*N/A*

Lesson Level Vocabulary: *attractive, mass, gravitational forces, gravitational field, weight, force field, orbit*

DCI Domain Vocabulary:
Domains are bold:
- **Motion and Stability: Forces and Interactions→Types of Interactions (PS2)**
Exert, gravitational, gravitational force, transfer, mass, orbital, attractive, direction of a force, direction of motion, field, Isaac Newton, linear, Newton's law of gravitation, nonlinear

Performance Expectation
MS-PS2-5 Motion and Stability: Forces and Interactions

Students who demonstrate understanding can:

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.

Clarification Statement: Examples of this phenomenon could include the interactions of magnets, electrically-charged strips of tape, and electrically-charged pith balls. Examples of investigations could include first-hand experiences or simulations.

Assessment Boundary: *Assessment is limited to electric and magnetic fields, and limited to qualitative evidence for the existence of fields.*

Lesson Level Phenomenon: Sometimes you experience a shock or even a spark when you reach for a doorknob.

note: all photo and video above links to suggested activities below

MS-PS2-5 Suggested Activities	MS-PS2-5 Recommended Formative Assessments
Electricity* (*TCI Forces and Energy: Unit 2 Noncontact Forces, Lesson 5)* Students will investigate static electricity using balloons, a Phet simulation, and a static electricity demonstration using an electroscope. Students will also model and build a circuit. ***students will also use this resource for Performance Expectation PS2-3 in those 4 class periods***	• Make a claim for what happens when you reach for a doorknob and experience a shock. • Keeping It Current Performance Assessment-students will manipulate the magnets to show force from different distances. • Demonstrate techniques and ability to build a motor. (TCI investigation 3) *addressed in PS2-3 • Demonstrate the difference between contact and non-contact forces by designing and building a levitating pencil.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations • Conduct an investigation and evaluate the experimental design to produce data to serve as the basis for evidence that can meet the goals of the investigation. **Planning and carrying out investigations to answer questions or test solutions to problems in 6–8 builds on K–5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or design solutions.**	**PS2.B: Types of Interactions** • 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** • Cause and effect relationships may be used to predict phenomena in natural or designed systems.

Performance Expectation
MS-PS2-5 Motion and Stability: Forces and Interactions

Connections to other DCIs in Middle School:
N/A

Articulation of DCIs across grade-levels:
3.PS2.B ; HS.PS2.B ; HS.PS3.A ; HS.PS3.B ; HS.PS3.C

Common Core State Standards Connections:
ELA /Literacy –

RST.6-8.3 Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks. *(MS-PS2-5)*

WHST.6-8.7 Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration. *(MS-PS2-5)*

Mathematics —N/A

Lesson Level Vocabulary: *electric shock, resistance, electric charge, prototype, electric forces, electric field, repulsive*

DCI Domain Vocabulary:
Domains are bold:

- **Motion and Stability: Forces and Interactions→Types of Interactions (PS2)**
  Current, electric current, electrical energy, exert, gravitational, interaction, magnetic force, magnetic repulsion, transfer, transmit, charged object, charged rod, attractive, charge repulsion, electric force, electric motor, electromagnet, facility, field, generator, insulator, electromagnetic, orientation, precision, repulsive

Performance Expectation
MS-PS3-1 Energy

Students who demonstrate understanding can:
Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object.
Clarification Statement: Emphasis is on descriptive relationships between kinetic energy and mass separately from kinetic energy and speed. Examples could include riding a bicycle at different speeds, rolling different sizes of rocks downhill, and getting hit by a wiffle ball versus a tennis ball.
Assessment Boundary: *N/A*

Lesson Level Phenomenon: Transfer of Energy A wrecking ball swing causes more damage when it's bigger or swung from further away.
note: all photo and video above links to suggested activities below

MS-PS3-1 Suggested Activities	MS-PS-1 Recommended Formative Assessments
Measuring Kinetic Energy (*TCI Forces and Energy: Unit 3 Kinetic and Potential Energy, Lesson 8*) Students will make predictions about how changes in mass or speed affect kinetic energy. Students will graph the relationships between kinetic energy, mass and speed to determine whether the relationships are proportional, linear, both, or neither. (4 to 5 class periods)	• Construct a graph displaying relationships between kinetic energy, mass and speed and explain whether the relationships are proportional, linear, both, or neither.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data • Construct and interpret graphical displays of data to identify linear and nonlinear relationships. **Analyzing data in 6–8 builds on K–5 and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.**	PS3.A: Definitions of Energy • Motion energy is properly called kinetic energy; it is proportional to the mass of the moving object and grows with the square of its speed.	Scale, Proportion, and Quantity • Proportional relationships (e.g. speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes.

Performance Expectation
MS-PS3-1 Energy

Connections to other DCIs in Middle School:
MS.PS2.A

Articulation of DCIs across grade-levels:
4.PS3.B ; HS.PS3.A ; HS.PS3.B

Common Core State Standards Connections:

ELA/Literacy –

RST.6-8.1	Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions. *(MS-PS3-1)*
RST.6-8.7	Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (MS-PS3-1)

Mathematics –

MP.2	Reason abstractly and quantitatively. (MS-PS3-1)
6.RP.A.2	Understand the concept of a unit rate a/b associated with a ratio a:b with b ≠ 0, and use rate language in the context of a ratio relationship. *(MS-PS3-1)*
7.RP.A.2	Recognize and represent proportional relationships between quantities. (MS-PS3-1)
8.EE.A.1	Know and apply the properties of integer exponents to generate equivalent numerical expressions. (MS-PS3-1)
8.EE.A.2	Use square root and cube root symbols to represent solutions to equations of the form x2 = p and x3 = p, where p is a positive rational number. Evaluate square roots of small perfect squares and cube roots of small perfect cubes. Know that √2 is irrational. *(MS-PS3-1)*
8.F.A.3	Interpret the equation y = mx + b as defining a linear function, whose graph is a straight line; give examples of functions that are not linear. (MS-PS3-1)

Lesson Level Vocabulary: *law of conservation of energy, potential energy, energy, kinetic energy, elastic potential energy, gravitational potential energy, magnetic potential energy, chemical potential energy*

DCI Domain Vocabulary:

Domains are bold:

- **Energy→Definitions of Energy (PS3)**
  conservation, conversion, convert, microscopic scale, particle, renewable energy, store, transfer, combination, conserve, limited, mass, relative, field, generator, kinetic energy, magnitude, motion energy, proportional, ratio, square root, thermal energy, chemical process, macroscopic scale, precision, wind turbine

Performance Expectation
MS-PS3-2 Energy

Students who demonstrate understanding can:

Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system.

Clarification Statement: *Emphasis is on relative amounts of potential energy, not on calculations of potential energy. Examples of objects within systems interacting at varying distances could include: the Earth and either a roller coaster cart at varying positions on a hill or objects at varying heights on shelves, changing the direction/orientation of a magnet, and a balloon with static electrical charge being brought closer to a classmate's hair. Examples of models could include representations, diagrams, pictures, and written descriptions of systems.*

Assessment Boundary: Assessment is limited to two objects and electric, magnetic, and gravitational interactions.

Lesson Level Phenomenon: *A pendulum boat ride cannot swing forever under the force of gravity. A firework transforms from a small cardboard-covered object to a large explosion of fire in the sky.*

****note: all photo and video above links to suggested activities below***

MS-PS3-2 Suggested Activities	*MS-PS3-2 Recommended Formative Assessments*
Forms of Energy *(TCI Forces and Energy: Unit 3, Lesson 7) Students will create a model of potential and kinetic energy and investigate the transformations between potential energy and kinetic energy to revise their model. (4 class periods)* **Potential Energy in Systems** *(TCI Forces and Energy: Unit 3, Lesson 9) Students will model gravitational potential energy changes using a skateboard simulation. Students will also investigate the transformation between potential and kinetic energy. (4 class periods)*	• *Optimizing a racing bike's design.* • *Create a Rube Goldberg machine. Number each transition and write an explanation (using the proper terminology) of energy transformations at that point.*

Science and Engineering Practices	*Disciplinary Core Ideas*	*Crosscutting Concepts*
Developing and Using Models • *Develop a model to describe unobservable mechanisms.* ***Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.***	*PS3.A: Definitions of Energy* • *A system of objects may also contain stored (potential) energy, depending on their relative positions.* *PS3.C: Relationship Between Energy and Forces* • *When two objects interact, each one exerts a force on the other that can cause energy to be transferred to or from the object.*	*Systems and System Models* • *Models can be used to represent systems and their interactions – such as inputs, processes, and outputs – and energy and matter flows within systems.*

Performance Expectation
MS-PS3-2 Energy

Connections to other DCIs in Middle School:
N/A

Articulation of DCIs across grade-levels:
HS.PS2.B ; **HS.PS3.B** ; **HS.PS3.C**

Common Core State Standards Connections:
ELA/Literacy –
SL.8.5 Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest. *(MS-PS3-2)*
Mathematics –N/A

Lesson Level Vocabulary: *law of conservation of energy, kinetic energy, potential energy, energy, electric potential energy, elastic potential energy, gravitational potential energy, magnetic potential energy, chemical potential energy,*

DCI Domain Vocabulary:
Domains are bold:

- **Energy→Definitions of Energy; Relationship Between Energy and Forces (PS3)**
  conservation, conversion, convert, microscopic scale, particle, renewable energy, store, transfer, combination, conserve, limited, mass, relative, field, generator, kinetic energy, magnitude, motion energy, proportional, ratio, square root, thermal energy, chemical process, macroscopic scale, precision, wind turbine, exert, store, transfer, relative, static, electrical charge, field, mechanical energy, potential energy, orientation

Performance Expectation
MS-ETS1-1 Engineering Design

Students who demonstrate understanding can:
Evaluate competing design solutions for maintaining biodiversity and ecosystem services.
Clarification Statement: *Examples of ecosystem services could include water purification, nutrient recycling, and prevention of soil erosion. Examples of design solution constraints could include scientific, economic, and social considerations.*
Assessment Boundary: *N/A*

Lesson Level Phenomenon: Bottle rocket launch (on field of LMS); It takes an enormous amount of fuel to launch a rocket. Examine how a wrench thrown in outers pace moves and how the movement of the wrench affects the person who threw it; compare the movement of a football thrown on Earth and thrown on the International Space Station.
note: all photo and video above links to suggested activities below

MS-ETS1-1 Suggested Activities	MS-ETS1-1 Recommended Formative Assessments
Forces and Interactions (*TCI Forces and Energy: Unit 1 Forces Lesson 2*) Students will model a zip line using string, straw, paper clips, and balloons. (4 class periods) **Effects of Forces** (*TCI Forces and Energy: Unit 1 Forces, Lesson 3)* Students will compare the outcome of throwing a wrench in space versus throwing a wrench on Earth. (4 class periods)	• Complete a CER (Claim, Evidence, Reasoning) initial claim of how a rocket gets off the ground and a final reasoning of how a rocket gets off the ground using the zip-line activity as part of their reasoning. • Forced to Accelerate Lab Performance Assessment (also can use Performance Assessment TCI)

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
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. **Asking questions and defining problems in grades 6–8 builds on grades K–5 experiences and progresses to specifying relationships between variables, and clarifying arguments and models.**	**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.	**Influence of Science, Engineering, and Technology on Society and the Natural World** • 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. • 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.

Performance Expectation
MS-ETS1-1 Engineering Design

Connections to other DCIs in Middle School:
MS-PS3-3

Articulation of DCIs across grade-levels:
3-5.ETS1.A ; 3-5.ETS1.C ; HS.ETS1.A ; HS.ETS1.B

Common Core State Standards Connections:

ELA/Literacy –

RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts. (MS-ETS1-1)

WHST.6-8.8 Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation. (MS-ETS1-1)

Mathematics –

MP.2 Reason abstractly and quantitatively. *(MS-ETS1-1)*

7.EE.3 Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form (whole numbers, fractions, and decimals), using tools strategically. Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies. *(MS-ETS1-1)*

Lesson Level Vocabulary: *net force, balanced forces, unbalanced forces, Newton's first law of motion, Newton's second law of motion, friction, scientific law, force, newton, Newton's third law of motion*

DCI Domain Vocabulary:

Domains are bold:

- **Engineering Design→Defining and Delimiting Engineering Problems (ETS1)**
  Consequence, consideration, criteria, design task, development, economic, humanity, impact, limitation, long-term, negative, positive, potential, precise, qualitative, quantitative, real-world, requirement, short-term, societal, specification, supply, testable

Unit 2: The Study of Waves

Unit Duration: 41 classes Second Week of November-January

Anchoring Phenomenon	
When you are driving the radio signal sometimes fades. Police officers use a radar gun to calculate your speed.	
Compelling Questions	**Supporting Questions**
What daily activities are made possible by waves? **How can we sense so many different sounds from a distance?**	• *How are wave amplitude and energy related?* • *What would be a perfect wave for a surfer?* • *Why does everything seem louder under water?* • *Why do dolphins and whales suffer health issues after submarine testing?* • *How does the rotation of wind turbines affect marine life?* • *Why does a digital television have a better picture than an analog television?* • *Why are some people unable to hear?* • *How do some animals hear and see differently than humans?*
Unit 2 Storyline	**Unit 2 Possible Student Misconceptions:**
Students will discover how waves are an integral part of our everyday existence.	*All matter can be seen with the naked eye.* *Sound waves do not need a medium.* *There is no noise in space.* *The water actually moves, not the energy moving.*
Prior Learning:	
4.PS3.A Definitions of Energy ; 4.PS3.B Conservation of Energy and Energy Transfer ; 4.PS4.A Wave Properties; 4.PS4.B Electromagnetic Radiation; 4.PS4.C Information Technologies and Instrumentation	

Unit 2 Overview: The Study of Waves

Performance Expectations	Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
• **MS-PS4-1** • **MS-PS4-2** • **MS-PS4-3** • **MS-ETS1-2** *Teacher Note: All the Performance Expectations above will be covered this unit and can be worked on concurrently. All Science and Engineering Practices and Crosscutting Concepts in bold are written in the Performance Expectations above. The italicized practices and crosscutting concepts, although not mentioned specifically, may be incorporated additionally in any science lesson at any time.*	• 1: Asking Questions and Defining Problems • **2: Developing and Using Models** • *3: Planning and Carrying Out Investigations* • ***4: Analyzing and Interpreting Data*** • *5: Using Mathematical Computational Thinking* • 6: Constructing Explanations and Designing Solutions • *7: Engaging in Argument from Evidence* • 8: Obtaining, Evaluating, and Communicating Information	**PHYSICAL SCIENCE** • **PS4 Waves and Their Applications** -PS1.A: Structure and Propertes of Matter -PS1.B: Chemical Reactions **ENGINEERING, TECHNOLOGY AND THE APPLICATION OF SCIENCE** • **ETS1 Engineering Design** -ETS1.B: Developing Possible Solutions	• **1: Patterns** • 2: Cause and Effect • ***3: Scale, Proportion and Quantity*** • *4: Systems and System Models* • *5: Energy and Matter* • *6: Structure and Function* • 7: Stability and Change

Formal Assessment Unit 2:	**Additional Teacher Resources Unit 2:**
Types of Waves **Possible IAB: Waves and Their Applications**	**Google Drive:** Grade 8 Team Drive Science Resources Classroom Jason Learning

Performance Expectation
MS-PS4-1 Waves and their Applications in Technologies for Information Transfer

Students who demonstrate understanding can:

Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave.

Clarification Statement: *Emphasis is on describing waves with both qualitative and quantitative thinking.*
Assessment Boundary: *Assessment does not include electromagnetic waves and is limited to standard repeating waves.*

Lesson Level Phenomenon: **At many sporting events, members of the crowd stand up and lift their hands in a pattern that people call 'doing the wave.'** **Huge waves form at Mavericks, and scientists, surfers, and weather forecasters can predict when they will occur up to 48 hours in advance.** **Wave energy converters produce more electricity in some locations than in other locations.**

note: all photo and video above links to suggested activities below

MS- PS4-1 Suggested Activities	MS- PS4-1 Recommended Formative Assessments
Types of Waves (*TCI Waves: Unit 1 Mechanical Waves, Lesson 1*) Students develop a scientific definition of waves as a beginning of a model they will develop. Students will apply their definition to a variety of given phenomenon to determine if they are waves. (4 class periods) **Properties of Waves** (*TCI Waves: Unit 1 Mechanical Waves, Lesson 2*) Students measure the amplitude, wavelength, frequency, and wave speed of a variety of waves. Students will graph these measurements to determine the relationship between the properties of different kinds of waves. (5 class periods) **Wave Energy** (*TCI Waves: Unit 1 Mechanical Waves, Lesson 3*) Students will determine how the energy in a wave is related to the amplitude and frequency of the waves, and examine this potential in terms of a power generator. (2 class periods)	• Define waves and describe how a mechanical wave can involve matter without transferring matter. • Use CER to classify phenomenon in TCI videos as waves. • Describe how dance moves could be models for representing transverse waves, longitudinal waves, or surface waves. • Compare and contrast waves made with our bodies are similar or different to water and sound waves. • Graph and analyze data collected to show whether different properties of waves are related to one another. • Graph and analyze data collected to determine patterns and the relationship between wave amplitude and wave energy.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Using Mathematics and Computational Thinking • Use mathematical representations to describe and/or support scientific conclusions and design solutions. **Mathematical and computational thinking at the 6–8 level builds on K–5 and progresses to identifying patterns in large data sets and using mathematical concepts to support explanations and arguments.** - - - - - - - - - - - - - - - - - ***Connections to Nature of Science*** **Scientific Knowledge is Based on Empirical Evidence** • Science knowledge is based upon logical and conceptual connections between evidence and explanations.	**PS4.A: Wave Properties** • A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude.	**Patterns** • Graphs and charts can be used to identify patterns in data.

Performance Expectation
MS-PS4-1 Waves and their Applications in Technologies for Information Transfer

Connections to other DCIs in Middle School:
N/A

Articulation of DCIs across grade-levels:
4.PS3.A ; 4.PS3.B ; 4.PS4.A ; HS.PS4.A ; HS.PS4.B

Common Core State Standards Connections*:*
ELA/Literacy-

SL.8.5	Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest. *(MS-PS4-1)*

Mathematics-

MP.2	Reason abstractly and quantitatively. (MS-PS4-1)
MP.4	Model with mathematics. (MS-PS4-1)
6.RP.A.1	Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities. (MS-PS4-1)
6.RP.A.3	Use ratio and rate reasoning to solve real-world and mathematical problems. (MS-PS4-1)
7.RP.A.2	Recognize and represent proportional relationships between quantities. (MS-PS4-1)
8.F.A.3	Interpret the equation y = mx + b as defining a linear function, whose graph is a straight line; give examples of functions that are not linear. *(MS-PS4-1)*

Lesson Level Vocabulary: *wave, mechanical wave, medium, model, wave pulse, wave cycle, transverse wave, longitudinal wave, surface wave, amplitude, wavelength, frequency, wave speed, the wave relationship, energy, ratio, proportional relationship, unit rate, criteria, constraint*

DCI Domain Vocabulary:
Domains are bold:
- **Waves and their Applications in Technologies for Information Transfer→Wave Properties (PS4)**
  Amplitude, dependent, light emission, light refraction, net motion, transmit, wave, wavelength, wave peaks, brightness, transparent, heat emission, light wave, linear, matter wave, mechanical wave, nonlinear, simple wave, electromagnetic, frequency

Performance Expectation
MS-PS4-2 Waves and their Applications in Technologies for Information Transfer

Students who demonstrate understanding can:

Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.

Clarification Statement: Emphasis is on both light and mechanical waves. Examples of models could include drawings, simulations, and written descriptions.

Assessment Boundary: *Assessment is limited to qualitative applications pertaining to light and mechanical waves.*

Lesson Level Phenomenon: **The sound of your finger tapping on a desktop seems much louder and lower pitched when you press your ear to the desk.** **An optical illusion can make you see more fish than there really are.** **A single object can appear to be many colors depending on the filter you see it through.**

***note: all photo and video above links to suggested activities below**

MS- PS4-2 Suggested Activities	MS- PS4-2 Recommended Formative Assessments
Waves in Different Media (*TCI Waves: Unit 1 Mechanical Waves, Lesson 4*) Students use models to investigate ways waves interact with the media they travel through. (2 class periods) **The Wave Model of Light** (*TCI Waves: Unit 2 Light Waves, Lesson 5*) Students will gather evidence of the wave-like properties of light by identifying the behaviors of light that are similar to mechanical waves. (4-5 class periods) **Properties of Light Waves** (*TCI Waves: Unit 2 Light Waves, Lesson 6*) Students will determine the relationship between colors that you see and the properties of light using a variety of instruments and methods. (4 class periods)	• Develop an Initial model to identify models of waves. Draw a model to identify the media and boundary between the media after the spring toy and string investigation. Revise your initial model. • Develop an Initial model to identify how we see light. Draw a model to identify how light travels after the light investigations. Revise your initial model. • Develop an Initial model to identify how we see color. Draw a model to identify how we see color(s) after the color investigations. Revise your initial model.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models • Develop and use a model to describe phenomena. **Modeling in 6–8 builds on K–5 and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.**	**PS4.A: Wave Properties** • A sound wave needs a medium through which it is transmitted. **PS4.B: Electromagnetic Radiation** • When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of the light. • The path that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and water, air and glass) where the light path bends. • A wave model of light is useful for explaining brightness, color, and the frequency-dependent bending of light at a surface between media. • However, because light can travel through space, it cannot be a matter wave, like sound or water waves.	**Structure and Function** • Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used.

Performance Expectation
MS-PS4-2 Waves and their Applications in Technologies for Information Transfer

Connections to other DCIs Middle School:
MS.LS1.D

Articulation of DCIs across grade-level bands:
4.PS4.B ; HS.PS4.A ; HS.PS4.B ; HS.ESS1.A ; HS.ESS2.A ; HS.ESS2.C ; HS.ESS2.D

Common Core State Standards Connections:
ELA/Literacy-

SL.8.5 Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest. *(MS-PS4-2)*

Mathematics- N/A

Lesson Level Vocabulary: *ray, reflection, transmission, refraction, absorption, scale model, light wave, light ray, lens, light intensity, visible light, electromagnetic spectrum*

DCI Domain Vocabulary:
Domains are bold:

- **Waves and their Applications in Technologies for Information Transfer→Wave Properties; Electromagnetic Radiation (PS4)**
  Amplitude, dependent, light emission, light refraction, net motion, transmit, wave, wavelength, wave peaks, brightness, transparent, heat emission, light wave, linear, matter wave, mechanical wave, nonlinear, simple wave, electromagnetic, frequency, convert, particle, wave, wavelength, atom, cell, phase, technical, transparent, color of light, field, illuminate, light scattering, light transmission, light wavelength, radio, thermal energy, visible light, frequency, opaque, peak, tissue, translucent, trough

Performance Expectation
MS-PS4-3 Waves and their Applications in Technologies for Information Transfer

Students who demonstrate understanding can:
Integrate qualitative scientific and technical information to support the claim that digitized signals are a more reliable way to encode and transmit information than analog signals.

Clarification Statement: Emphasis is on a basic understanding that waves can be used for communication purposes. Examples could include using fiber optic cable to transmit light pulses, radio wave pulses in wifi devices, and conversion of stored binary patterns to make sound or text on a computer screen.

Assessment Boundary: *Assessment does not include binary counting. Assessment does not include the specific mechanism of any given device.*

Lesson Level Phenomenon: When a message is whispered repeatedly during a game of telephone, it changes over time. A Digital Signal Sender is a more reliable way of communicating a phone number than an Analog Signal Sender.

note: all photo and video above links to suggested activities below

MS- PS4-3 Suggested Activities	MS- PS4-3 Recommended Formative Assessments
Sending Information Using Wave Pulses *(TCI Waves: Unit 3 Waves for Information Transfer, Lesson 7)* Students will participate in a great message race, sending messages using different technologies to determine the advantages and disadvantages of each. *(2 class periods)* **Analog and Digital Information** (*TCI Waves: Unit 3 Waves for Information Transfer, Lesson 8*) Students will compare the reliability of analog and digital technologies for measuring, storing, and transferring information. Students will also model the ways computers use digital encoding to store information including sound, images, and text. (4 class periods)	• Identify which process of sending a message works the best- through moving matter or using waves. Evaluate advantages and disadvantages of each. • Evaluate the differences between analog and digital devices using the Analog and Digital Device Information Sheets. • Compare and contrast the qualities of analog radio versus digital streaming. • Use the ASCII chart to translate binary signals to translate Morse Code. • Describe why digital signals are more reliable than analog signals.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Obtaining, Evaluating, and Communicating Information • Integrate qualitative scientific and technical information in written text with that contained in media and visual displays to clarify claims and findings. **Obtaining, evaluating, and communicating information in 6-8 builds on K-5 and progresses to evaluating the merit and validity of ideas and methods.**	**PS4.C: Information Technologies and Instrumentation** • Digitized signals (sent as wave pulses) are a more reliable way to encode and transmit information.	**Structure and Function** • Structures can be designed to serve particular functions. - ***Connections to Engineering, Technology, and Applications of Science*** **Influence of Science, Engineering, and Technology on Society and the Natural World** • Technologies extend the measurement, exploration, modeling, and computational capacity of scientific investigations. - ***Connections to Nature of Science*** **Science is a Human Endeavor** • Advances in technology influence the progress of science and science has influenced advances in technology.

Performance Expectation
MS-PS4-3 Waves and their Applications in Technologies for Information Transfer

Connections to other DCIs Middle School:
N/A

Articulation of DCIs across grade-level bands:
4.PS4.C ; HS.PS4.A ; HS.PS4.C

Common Core State Standards Connections:
ELA/Literacy

RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts. (MS-PS4-3)

RST.6-8.2 Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions. *(MS-PS4-3)*

RST.6-8.9 Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic. (MS-PS4-3)

WHST.6-8.9 Draw evidence from informational texts to support analysis, reflection, and research. (MS-PS4-3)

Mathematics – N/A

Lesson Level Vocabulary: Wi-Fi, transmitter, fiber-optic cable, receiver, analog encoding, digital encoding, signal, noise, binary code

DCI Domain Vocabulary:
Domains are bold:

- **Waves and their Applications in Technologies for Information Transfer→Information Technologies and Instrumentation (PS4)**
  Application, conversion, convert, digitize, memory, solar, store, transfer, transmit, wave, cell, criteria, performance, scanner, technical, advance, analog, encode, format, instrumentation, light pulse, progress, radio wave, transmission, visual, wave pulse, Wi-Fi device, binary, capacity, chemical process, civilization, frequency, interdependence

Performance Expectation
MS-ETS1-2 Engineering Design

Students who demonstrate understanding can:
Evaluate competing design solutions using a systematic process to determine how well they meet the criteria the constraints of the problem.
Clarification Statement: *N/A*
Assessment Boundary: *N/A*

Lesson Level Phenomenon: **Wave energy converters produce more electricity in some locations than in other locations. When a message is whispered repeatedly during a game of telephone, it changes over time.**

MS-ETS1-2 Suggested Activities	MS-ETS1-2 Recommended Formative Assessments
Wave Energy (*TCI Waves: Unit 1 Mechanical Waves, Lesson 3*) Students will determine how the energy in a wave is related to the amplitude and frequency of the waves, and examine this potential in terms of a power generator. (2 class periods) **Sending Information Using Wave Pulses** (*TCI Waves: Unit 3 Waves for Information Transfer, Lesson 7)* Students will participate in a great message race, sending messages using different technologies to determine the advantages and disadvantages of each. *(2 class periods)*	• Graph and analyze data collected to determine patterns and the relationship between wave amplitude and wave energy. • Identify which process of sending a message works the best- through moving matter or using waves. Evaluate advantages and disadvantages of each.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Engaging in Argument from Evidence • Evaluate competing design solutions based on jointly developed and agreed-upon design criteria. **Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world.**	**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.	**N/A**

Performance Expectation
MS-EST1-2 Engineering Design

Connections to other DCIs Middle School:
Physical Science: MS-PS1-6, MS-PS3-3, Life Science: MS-LS2-5
Connections to MS-ETS1.C: Optimizing the Design Solution include:
Physical Science: MS-PS1-6

Articulation of DCIs across grade-levels:
3-5.ETS1.A ; **3-5.ETS1.B** ; **3-5.ETS1.C** ; **HS.ETS1.B**

Common Core State Standards Connections:

RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts. *(MS-ETS1-2)*

RST.6-8.9 Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic. (MS-ETS1-2)

WHST.6-8.7 Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration. (MS-ETS1-2)

WHST.6-8.9 Draw evidence from informational texts to support analysis, reflection, and research. *(MS-ETS1-2)*

Mathematics —

MP.2 Reason abstractly and quantitatively. *(MS-ETS1-2)*

7.EE.3 Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form (whole numbers, fractions, and decimals), using tools strategically. Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies. *(MS-ETS1-2)*

Lesson Level Vocabulary: *energy, ratio, proportional relationship, unit rate, criteria, constraint, Wi-Fi, transmitter, fiber-optic cable, receiver*

DCI Domain Vocabulary:

Domains are bold:

- **Engineering Design→Developing Possible Solutions (ETS1)**
  abstract, agreed-upon, break down, concrete, consideration, convincing, criteria, jointly, mathematical model, physical replica, priority, real-world, representation, societal, systematic , theoretical model

Unit 3: The Study of Earth's Place in Space

Unit Duration: 36 classes February-March

Anchoring Phenomenon	
Video of future collision of Milky Way and Andromeda Galaxies (interactions of objects in space, scale…)	
Compelling Questions	**Supporting Questions**
How do other celestial bodies affect the Earth?	• *Why do we see different amounts of the moon every night?* • *Why are eclipses so rare?* • *If the sun is so much larger than the moon, why do they both appear the same size from Earth?* • *What causes tides?* • *Why do we have seasons?*
Unit 3 Storyline	**Unit 3 Possible Student Misconceptions:**
Students will study why the moon seems to change shape, what causes a solar eclipse, and why there are seasons.	*The moon and the sun are the same size.* *Space travel is easy as depicted in Hollywood movies.* *There are no complex mathematical calculations involved in satellite, rover, etc. launchings* *We have seasons because we are closer to the sun*
Prior Learning:	
3.PS2.A Forces and Motion **5.ESS1.B Earth and the Solar System ; 5.PS2.B Types of Interactions**	

Unit 3 Overview: The Study of Earth's Place in Space

Performance Expectations	Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
• **MS-ESS1-1** • **MS-ESS1-2** • **MS-ESS1-3** • **MS-ETS1-3** *Teacher Note: All the Performance Expectations above will be covered this unit and can be worked on concurrently. All Science and Engineering Practices and Crosscutting Concepts in bold are written in the Performance Expectations above. The italicized practices and crosscutting concepts, although not mentioned specifically, may be incorporated additionally in any science lesson at any time.*	• 1: Asking Questions and Defining Problems • **2: Developing and Using Models** • *3: Planning and Carrying Out Investigations* • ***4: Analyzing and Interpreting Data*** • *5: Using Mathematical Computational Thinking* • 6: Constructing Explanations and Designing Solutions • *7: Engaging in Argument from Evidence* • 8: Obtaining, Evaluating, and Communicating Information	**EARTH SCIENCE** • **ESS1 Earth's Place in the Universe** -ESS1.A: The Universe and Its Stars -ESS1.B: Earth and the Solar System **ENGINEERING, TECHNOLOGY AND THE APPLICATION OF SCIENCE** • **ETS1 Engineering Design** -ETS1.B: Developing Possible Solutions -ETS1.C: Optimizing the Design Solution	• **1: Patterns** • *2: Cause and Effect* • **3: Scale, Proportion and Quantity** • **4: Systems and System Models** • *5: Energy and Matter* • *6: Structure and Function* • *7: Stability and Change*
Formal Assessment Unit 3: TCI Space Assessment **Possible IAB: Earth and the Solar System**		**Additional Teacher Resources Unit 3:** **Google Drive: Team Drive Grade 8** Science Resources Classroom	

Performance Expectation
MS-ESS1-1 Earth's Place in the Universe

Students who demonstrate understanding can:

Develop and use a model of the Earth-sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons.

Clarification Statement: *Examples of models can be physical, graphical, or conceptual.*

Assessment Boundary: *N/A*

Lesson Level Phenomenon: The sun appears to move across the sky during the day, and stars appear to move across the sky during the night. Each year, trees sprout leaves, which grow, change color, die, and fall off. The appearance of the moon changes every night. Sometimes the sun appears to be blocked by the moon.

***note: all photo and video above links to suggested activities below**

MS-ESS1-1 Suggested Activities	MS-ESS1-1 Recommended Formative Assessments
Earth's Rotation and Revolution (*TCI Space: Unit 1 The Earth-Sun-Moon System, Lesson 1)* Students will model the patterns caused by Earth's rotation and revolution by building a Sun-Earth-Moon model. (3 class periods) **Earth's Tilted Axis** (*TCI Space: Unit 1 The Earth-Sun-Moon System, Lesson 2)* Students will model how Earth's tiled axis leads to seasonal patterns using their Sun-Earth-Moon model. (4 class periods) **Phases of the Moon** (*TCI Space: Unit 1 The Earth-Sun-Moon System, Lesson 3)* Students will model how the moon goes through phases using their Sun-Earth-Moon model. (3-4 class periods) **Eclipses** (*TCI Space: Unit 1 The Earth-Sun-Moon System, Lesson 4)* Students will model how the orientation of the Earth, sun and moon causes eclipses using their Sun-Earth-Moon model. (4 class periods)	• Draw and label the models of Earth's rotation and revolution, constellations, and Polaris. Include patterns. Analyze strengths and weaknesses of the models. • Write an explanation about seasonal patterns to share with a kindergarten student, and one explanation to share with an adult. • Draw and label the models of light reflected off the moon and moon phases. Include patterns. Analyze how the models helped you make predictions. • Draw and label the models of lunar and solar eclipses. Include patterns.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models • Develop a model to predict and/or describe phenomena. **Modeling in 6–8 builds on K–5 and progresses to developing, using and revising models to describe, test, and predict more abstract phenomena and design systems.**	**ESS1.A: The Universe and Its Stars** • Patterns of the apparent motion of the sun, the moon, and stars in the sky can be observed, described, predicted, and explained with models. **ESS1.B: Earth and the Solar System** • This model of the solar system can explain eclipses of the sun and the moon. Earth's spin axis is fixed in direction over the short-term but tilted relative to its orbit around the sun. The seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas of Earth across the year.	**Patterns** • Patterns can be used to identify cause-and-effect relationships. --- ***Connections to Nature of Science*** **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** • Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation.

Performance Expectation
MS-ESS1-1 Earth's Place in the Universe

Connections to other DCIs Middle School:
MS.PS2.A ; MS.PS2.B

Articulation of DCIs across grade-levels:
3.PS2.A ; 5.PS2.B ; 5.ESS1.B ; HS.PS2.A ; HS.PS2.B ; HS.ESS1.B

Common Core State Standards Connections:
ELA/Literacy -

SL.8.5 Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest. *(MS-ESS1-1)*

Mathematics -

MP.4 Model with mathematics. *(MS-ESS1-1)*

6.RP.A.1 Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities. *(MS-ESS1-1)*

7.RP.A.2 Recognize and represent proportional relationships between quantities. *(MS-ESS1-1)*

Lesson Level Vocabulary: *celestial object, rotation, axis, revolution, orbit, orbital plane, circumpolar star, criteria, constraint, system, solstice, tropic, equinox, model, lunar phase, new moon, first quarter moon, third quarter moon, full moon, umbra, penumbra, eclipse, lunar eclipse, solar eclipse*

DCI Domain Vocabulary:

Domains are bold:

- **Earth's Place in the Universe→The Universe and Its Stars; The Earth and the Solar System (ESS1)**
  Earth's orbit, gravitational, gravitational pull, Milky Way, development, orbit, orbital, phase, relative, spacecraft, tilted, lunar phase, asteroid, asteroid impact, asteroid movement patterns, disk, Earth-sun-moon system, eclipse, field, instrument, intensity, Isaac Newton, linear growth, meteor movement patterns, particle ring, physical change, planet composition, planet orbits, planet size, planet surface features, satellite, solar system formation, crust, cyclic, elliptical orbit, interdependence, orbital radius, Copernican revolution, dependent, astronomical, astronomical distance, astronomical object, astronomical size, astronomy, microscopic, transfer, atom, brightness, development, immensely, mass, relative, vast, celestial body, comet, comet impact, comet movement patterns, element, field, Galileo, helium, iron, light year, nucleus, atomic, chemical process, frequency, interdependence, massive

Performance Expectation
MS-ESS1-2 Earth's Place in the Universe

Students who demonstrate understanding can:

Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system.

Clarification Statement: *Emphasis for the model is on gravity as the force that holds together the solar system and Milky Way galaxy and controls orbital motions within them. Examples of models can be physical (such as the analogy of distance along a football field or computer visualizations of elliptical orbits) or conceptual (such as mathematical proportions relative to the size of familiar objects such as students' school or state).*

Assessment Boundary: *Assessment does not include Kepler's Laws of orbital motion or the apparent retrograde motion of the planets as viewed from Earth.*

Lesson Level Phenomenon: Planets revolve around stars while moons revolve around planets. Humans were not around to watch the solar system form, but we have observed patterns that may explain its formation. It would be extremely difficult to fit a scale model of our Milky Way Galaxy in a classroom.

note: all photo and video above links to suggested activities below

MS-ESS1-2 Suggested Activities	MS-ESS1-2 Recommended Formative Assessments
Gravity and the Solar System *(*TCI Space: Unit 2 The Solar System, Lesson 5*) Students will create a scale model of the solar system and investigate the scale of distances within the solar system. (3-4 class periods) ***ALSO USED IN MS-ESS1-3** Formation of the Solar System (*TCI Space: Unit 3 The Solar System and Beyond, Lesson 8)* Students will use models to discuss misconceptions about how the solar system was formed. (3 class periods) Beyond the Solar System (*TCI Space: Unit 3 The Solar System and Beyond, Lesson 9)* Students will describe and compare distances between objects within and beyond our solar system using models. (2-3 class periods)	• Draw and label a model that demonstrates how Earth's motion around the sun is caused by the gravitational force between the sun and the Earth. Include the sun, Earth, Earth's orbital path, and the direction of gravitational pull. • Identify how gravity was involved in the formation of the solar system. • Create a flip book representing how the formation of the moons and planets and how the solar system is held together.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models • Develop a model to describe unobservable mechanisms. **Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.**	**ESS1.A: The Universe and Its Stars** • Earth and its solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe. **ESS1.B: Earth and the Solar System** • The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them. • The solar system appears to have formed from a disk of dust and gas, drawn together by gravity.	**Systems and System Models** • Models can be used to represent systems and their interactions. --- ***Connections to Nature of Science*** **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** • Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation.

Performance Expectation
MS-ESS1-2 Earth's Place in the Universe

Connections to other DCIs in Middle School:
MS.PS2.A ; MS.PS2.B

Articulation of DCIs across grade-levels:
3.PS2.A ; 5.PS2.B ; 5.ESS1.A ; 5.ESS1.B ; HS.PS2.A ; HS.PS2.B ; HS.ESS1.A ; HS.ESS1.B

Common Core State Standards Connections:
ELA/Literacy -

SL.8.5	Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest.*(MS-ESS1-2)*

Mathematics -

MP.4	Model with mathematics. *(MS-ESS1-2)*
6.RP.A.1	Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities. *(MS-ESS1-2)*
7.RP.A.2	Recognize and represent proportional relationships between quantities. *(MS-ESS1-2)*
6.EE.B.6	Use variables to represent numbers and write expressions when solving a real-world or mathematical problem; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set. *(MS-ESS1-2)*
7.EE.B.6	Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities. *(MS-ESS1-2)*

Lesson Level Vocabulary: *gravitational force, planet, moon, comet, asteroid, dwarf planet, astronomical unit, scale model, scientific theory, nebula, supernova, evidence, light year, galaxy, black hole, universe*

DCI Domain Vocabulary:
Domains are bold:

- **Earth's Place in the Universe→The Universe and Its Stars; Earth and the Solar System (ESS1)**
  Earth's orbit, gravitational, gravitational pull, Milky Way, development, orbit, orbital, phase, relative, spacecraft, tilted, lunar phase, asteroid, asteroid impact, asteroid movement patterns, disk, Earth-sun-moon system, eclipse, field, instrument, intensity, Isaac Newton, linear growth, meteor movement patterns, particle ring, physical change, planet composition, planet orbits, planet size, planet surface features, satellite, solar system formation, crust, cyclic, elliptical orbit, interdependence, orbital radius, Copernican revolution, dependent, astronomical, astronomical distance, astronomical object, astronomical size, astronomy, microscopic, transfer, atom, brightness, development, immensely, mass, relative, vast, celestial body, comet, comet impact, comet movement patterns, element, field, Galileo, helium, iron, light year, nucleus, atomic, chemical process, frequency, interdependence, massive

Performance Expectation
MS-ESS1-3 Earth's Place in the Universe

Students who demonstrate understanding can:

Analyze and interpret data to determine scale properties of objects in the solar system.

Clarification Statement: *Emphasis is on the analysis of data from Earth-based instruments, space-based telescopes, and spacecraft to determine similarities and differences among solar system objects. Examples of scale properties include the sizes of an object's layers (such as crust and atmosphere), surface features (such as volcanoes), and orbital radius. Examples of data include statistical information, drawings and photographs, and models.*

Assessment Boundary: *Assessment does not include recalling facts about properties of the planets and other solar system bodies.*

Lesson Level Phenomenon: **Planets revolve around stars while moons revolve around planets.** **Astronomers believe that Mars would be an ideal place to build a colony.** **There are millions of objects in our solar system, but we only call a few of them 'planets.'**

note: all photo and video above links to suggested activities below

MS-ESS1-3 Suggested Activities	MS-ESS1-3 Recommended Formative Assessments
Gravity and the Solar System*(*TCI Space: Unit 2 The Solar System, Lesson 5)* Students will investigate the scale of distances in the solar system by creating a scale model of the solar system. (3-4 class periods) ***ALSO USED IN MS-ESS1-2** **The Inner Solar System** (*TCI Space: Unit 2 The Solar System, Lesson 6)* Students will collect given data gathered by various fictional space missions to planets of the solar system. Students will also design and optimize a Martian Lander Assembly. (4 class periods) **The Outer Solar System** (*TCI Space: Unit 3 The Solar System and Beyond, Lesson 7)* Students will collect given data gathered by various fictional space missions to planets of the solar system Students will also design spacecraft for the outer solar system. (2-3 class periods)	• Draw and label a picture that shows a scale model of the moon and Earth. • Calculate and record the scaled distances from the sun in a table. • Design a mission to study the planets of our solar system. • Create a CER that classifies Pluto. • Design a Martian Lander Assembly collaboratively. • Create a triple Venn diagram that compares similarities and differences between three of the planets. • Describe a planet classification system that is supported by at least three characteristics in your data. • Design spacecraft for the outer solar system.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data • Analyze and interpret data to determine similarities and differences in findings. **Analyzing data in 6–8 builds on K–5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.**	**ESS1.B: Earth and the Solar System** • The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them.	**Scale, Proportion, and Quantity** • Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. - ***Connections to Engineering, Technology, and Applications of Science*** **Interdependence of Science, Engineering, and Technology** • Engineering advances have led to important discoveries in virtually every field of science and scientific discoveries have led to the development of entire industries and engineered systems.

Performance Expectation
MS-ESS1-3 Earth's Place in the Universe

Connections to other DCIs Middle School:
MS.ESS2.A

Articulation of DCIs across grade-levels:
5.ESS1.B ; HS.ESS1.B ; HS.ESS2.A

Common Core State Standards Connections:

ELA/Literacy —

RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts. (MS-ESS1-3)

RST.6-8.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (MS-ESS1-3)

Mathematics —

MP.2 Reason abstractly and quantitatively. (MS-ESS1-3)

6.RP.A.1 Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities. (MS-ESS1-3)

7.RP.A.2 Recognize and represent proportional relationships between quantities. (MS-ESS1-3)

Lesson Level Vocabulary: *ground-based telescope, space telescope, data, terrestrial planet, orbital radius, planetary radius, gas planet, density, scale*

DCI Domain Vocabulary:

Domains are bold:

- **Earth's Place in the Universe→The Universe and Its Stars; Earth and the Solar System (ESS1)**
  Earth's orbit, gravitational, gravitational pull, Milky Way, development, orbit, orbital, phase, relative, spacecraft, tilted, lunar phase, asteroid, asteroid impact, asteroid movement patterns, disk, Earth-sun-moon system, eclipse, field, instrument, intensity, Isaac Newton, linear growth, meteor movement patterns, particle ring, physical change, planet composition, planet orbits, planet size, planet surface features, satellite, solar system formation, crust, cyclic, elliptical orbit, interdependence, orbital radius, Copernican revolution, dependent, astronomical, astronomical distance, astronomical object, astronomical size, astronomy, microscopic, transfer, atom, brightness, development, immensely, mass, relative, vast, celestial body, comet, comet impact, comet movement patterns, element, field, Galileo, helium, iron, light year, nucleus, atomic, chemical process, frequency, interdependence, massive

Performance Expectation
MS-ETS1-3 Engineering Design

Students who demonstrate understanding can:

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.

Clarification Statement: *N/A*

Assessment Boundary: *N/A*

Lesson Level Phenomenon: There are millions of objects in our solar system, but we only call a few of them 'planets.'

***note: all photo and video above links to suggested activities below**

MS-ETS1-3 Suggested Activities	MS-ETS1-3 Recommended Formative Assessments
The Outer Solar System (*TCI Space: Unit 3 The Solar System and Beyond, Lesson 7)* Students will collect given data gathered by various fictional space missions to planets of the solar system Students will also design spacecraft for the outer solar system. (2-3 class periods)	• Create a triple Venn diagram that compares similarities and differences between three of the planets. • Describe a planet classification system that is supported by at least three characteristics in your data. • Design spacecraft for the outer solar system.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data • Analyze and interpret data to determine similarities and differences in findings. **Analyzing data in 6–8 builds on K–5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.**	**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. • Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. **ETS1.C: Optimizing the Design Solution** • 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.	**N/A**

Performance Expectation
MS-EST1-3 Engineering Design

Connections to other DCIs Middle School:
Physical Science: MS-PS1-6, MS-PS3-3, **Life Science:** MS-LS2-5
Connections to MS-ETS1.C: Optimizing the Design Solution include:
Physical Science: MS-PS1-6

Articulation of DCIs across grade-levels:
3-5.ETS1.A ; 3-5.ETS1.B ; 3-5.ETS1.C ; HS.ETS1.B ; HS.ETS1.C

Common Core State Standards Connections:
ELA/Literacy —

RST.6-8.1	Cite specific textual evidence to support analysis of science and technical texts. *(MS-ETS1-3)*
RST.6-8.7	Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). *(MS-ETS1-3)*
RST.6-8.9	Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic. (MS-ETS1-3)

Mathematics —

MP.2	Reason abstractly and quantitatively. *(MS-ETS1-3)*
7.EE.3	Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form (whole numbers, fractions, and decimals), using tools strategically. Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies. *(MS-ETS1-3)*

Lesson Level Vocabulary: *gas planet, density, scale*

DCI Domain Vocabulary:
Domains are bold:

- **Biological Evolution: Engineering Design→Developing Possible Solutions, Optimizing the Design Solution (ETS1)**
  abstract, agreed-upon, collaboratively, computational, concrete, consideration, control of variables, controlled experiment, convincing, criteria, cultural, data analysis, data interpretation, data presentation, design system, element, impact, iterative process, jointly, linear, mathematical model, nonlinear, optimal, physical replica, priority, prototype, quantitative, real-world, redesign process, representation, societal, break down, statistical, systematic, systematic, test results, theoretical model, trial

Unit 4: The Study of Adaptation

Unit Duration: 36 classes April-June

Anchoring Phenomenon

CDC Says Antibiotic-Resistant Bacteria Found in 27 States
The world's best free divers seem to have evolved super-size spleens

Compelling Questions	Supporting Questions
How has the life on Earth changed over time? **What percentage of species that ever existed are currently in existence?**	• *How do fossils demonstrate how Earth has changed over time?* • *What are evidence for the existence dinosaurs?* • *Where are you most likely to find fossils, and how does this relate to how most fossils are formed?* • *Why do some locations yield fossils while others do not?* • *What do you think happened to organisms whose fossils never show up again in the fossil record?* • *What patterns can you find by looking at the whole fossil record of organisms over the history of Earth?* • *Why is it beneficial for a population to have variation?*

Unit 4 Storyline	Unit 4 Possible Student Misconceptions:
Students will study the history of life on Earth, examining how Earth's environment and life has changed over time.	• *Mass extinctions are sudden and instantaneous.* • *Evolution is the result of a goal.* • *Evolution only occurs slowly and cannot occur rapidly.* • *Natural selection is the only mechanism for natural evolution.* • *Humans cannot influence evolution.* • *Humans are not currently evolving and do not have adaptations.* • *Individuals can evolve*

Prior Learning:

5.ESS3.C Human Impacts on Earth Systems
4.ESS1.C The History of Planet Earth
3.LS2.C Ecosystem Dynamics, Functioning, and Resilience ; 3.LS3.B Variation of Traits; 3.LS4.AEvidence of Common Ancestry and Diversity; 3.LS4.B Natural Selection ; 3.LS4.C Adaptation; 3.LS4.D Biodiversity and Humans

Unit 4 Overview: The Study of Adaptation

Performance Expectations	Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
• **MS-ESS1-4** • **MS-LS4-1** • **MS-LS4-4** • **MS-LS3-1** • **MS-LS4-6** • **MS-LS4-2** • **MS-LS4-3** • **MS-LS4-5** • **MS-ESS3-4** • **MS-ETS1-4** *Teacher Note: All the Performance Expectations above will be covered this unit and can be worked on concurrently. All Science and Engineering Practices and Crosscutting Concepts in bold are written in the Performance Expectations above. The italicized practices and crosscutting concepts, although not mentioned specifically, may be incorporated additionally in any science lesson at any time.*	• *1: Asking Questions and Defining Problems* • **2: Developing and Using Models** • *3: Planning and Carrying Out Investigations* • **4: Analyzing and Interpreting Data** • **5: Using Mathematical Computational Thinking** • **6: Constructing Explanations and Designing Solutions** • **7: Engaging in Argument from Evidence** • **8: Obtaining, Evaluating, and Communicating Information**	**EARTH AND SPACE SCIENCE** • **ESS1 The History of Planet Earth** -ESS1.C: The History of Planet Earth • **ESS3 Earth and Human Activity** -ESS3.C: Human Impacts on Earth Systems **ENGINEERING, TECHNOLOGY AND THE APPLICATION OF SCIENCE** • **ETS1 Engineering Design** -ETS1.B: Developing Possible Solutions **LIFE SCIENCE** • **LS3 Heredity: Inheritance and Variation of Traits** -LS3.A: Inheritance of Traits -LS3.B: Variation of Traits • **LS4 Biological Evolution: Unity and Diversity** -LS4.A: Evidence of Common Ancestry and Diversity -LS4.B: Natural Selection -LS4.C: Adaptation	• **1: Patterns** • **2: Cause and Effect** • **3: Scale, Proportion and Quantity** • *4: Systems and System Models* • *5: Energy and Matter* • **6: Structure and Function** • *7: Stability and Change*
Formal Assessment Unit 4: Evolution Assessment **Possible IAB: Inheritance and Variation of Traits** **Biological Evolution Through Natural Selection**		**Additional Teacher Resources Unit 4:** **Google Drive:** Team Drive Grade 8 Science Resources Classroom Population Connection	

Performance Expectation
MS-ESS1-4 Earth's Place in the Universe

Students who demonstrate understanding can:

Construct a scientific explanation based on evidence from rock strata for how the geologic time scale is used to organize Earth's 4.6 billion-year-old history.

Clarification Statement: *Emphasis is on how analyses of rock formations and the fossils they contain are used to establish relative ages of major events in Earth's history. Examples of Earth's major events could range from being very recent (such as the last Ice Age or the earliest fossils of homo sapiens) to very old (such as the formation of Earth or the earliest evidence of life). Examples can include the formation of mountain chains and ocean basins, the evolution or extinction of particular living organisms, or significant volcanic eruptions.*

Assessment Boundary: *Assessment does not include recalling the names of specific periods or epochs and events within them.*

Lesson Level Phenomenon: You would usually find shells by the ocean, but fossilized shells can be found in the middle of the desert. How is this possible?

note: all photo and video above links to suggested activities below

MS- ESS1-4 Suggested Activities	MS- ESS1-4 Recommended Formative Assessments
Earth's History (*TCI Adaptations: Unit 1 The History of Life on Earth, Lesson 1*) Students will analyze data and construct explanations for patterns found in the fossil record after learning about rock strata and fossil formation within rock strata. Students will understand how fossils in certain locations form a timeline of Earth's history. (6 class periods)	• Explain the law of superposition; which rock layers and fossils were formed first using sand models. • Identify fossils, recording the name, a short description and a drawing. • Explain how index fossils helps us identify the age of fossils. • Identify patterns in the fossil record over Earth's 4.6 billion-year history. • Explain the age of rock strata or a fossil sample using relative dating and radiometric dating.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions • 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. **Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.**	ESS1.C: The History of Planet Earth • 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.	Scale, Proportion, and Quantity • Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.

Performance Expectation
MS- ESS1-4 Earth's Place in the Universe

Connections to other DCIs in Middle School:
MS.LS4.A ; MS.LS4.C

Articulation of DCIs across grade-levels:
3.LS4.A ; 3.LS4.C ; 3.LS4.D ; 4.ESS1.C ; HS.PS1.C ; HS.LS4.A ; HS.LS4.C ; HS.ESS1.C ; HS.ESS2.A

Common Core State Standards Connections:

ELA/Literacy -

RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts. (MS-ESS1-4)

WHST.6-8.2 Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content. (MS-ESS1-4)

Mathematics-

6.EE.B.6 Use variables to represent numbers and write expressions when solving a real-world or mathematical problem; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set. *(MS-ESS1-4)*

7.EE.B.6 Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities. *(MS-ESS1-4)*

Lesson Level Vocabulary: *scientific evidence, geologic time scale, relative dating, model, absolute dating, scientific law, scientific theory*

DCI Domain Vocabulary:

Domains are bold:

- **Earth's Place in the Universe→The History of Planet Earth (ESS1)**
  Earth force, plate tectonics, rock formation, ancient, development, mineral, relative, account, asteroid, crater, Earth's age, evidence from sedimentary rock, fossil record, geologic, geologic evidence, Homo sapiens, meteorite, ocean basin, rock layer movement, spontaneous, decay, formation, radioactive, rock strata, time scale

Performance Expectation
MS-LS4-1 Biological Evolution: Unity and Diversity

Students who demonstrate understanding can:

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.

Clarification Statement: *Emphasis is on finding patterns of changes in the level of complexity of anatomical structures in organisms and the chronological order of fossil appearance in the rock layers.*

Assessment Boundary: *Assessment does not include the names of individual species or geological eras in the fossil record.*

Lesson Level Phenomenon: Dinosaurs once roamed the earth, but now we do not find them alive anywhere.

note: all photo and video above links to suggested activities below

MS-LS4-1 Suggested Activities	MS-LS4-1 Recommended Formative Assessments
Fossils and the History of Life (*TCI Adaptations: Unit 1 The History of Life on Earth, Lesson 1*) Students will explore the skeletons of modern organisms along with fossils found in different strata to identify similarities and differences across organisms and make arguments about what you can and cannot tell about an organism based on fossil evidence. (4 class periods)	• Analyze modern day animal skeletons. Draw conclusions about modern day organisms and their environment based on their skeletons. • Analyze fossilized animal skeletons. Draw conclusions about fossilized organisms and their environment based on their skeletons. • Analyze what happened to the dinosaurs. Explain what happened to the dinosaurs based on the data. • Analyze the data of five mass extinctions. Label where the mass extinction events took place. • Analyze comparison graphics of fossils to modern organisms. Compare and contrast fossils to modern organisms.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data • Analyze and interpret data to determine similarities and differences in findings. **Analyzing data in 6–8 builds on K–5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.** - ***Connections to Nature of Science*** **Scientific Knowledge is Based on Empirical Evidence** • Science knowledge is based upon logical and conceptual connections between evidence and explanations.	LS4.A: Evidence of Common Ancestry and Diversity • 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.	Patterns • Graphs, charts, and images can be used to identify patterns in data. - ***Connections to Nature of Science*** **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** • Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation.

Performance Expectation
LS4-1 Biological Evolution: Unity and Diversity

Connections to other DCIs Middle School:
MS.ESS1.C ; MS.ESS2.B

Articulation of DCIs across grade-levels:
3.LS4.A ; HS.LS4.A ; HS.ESS1.C

Common Core State Standards Connections:
ELA /Literacy -

RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions. *(MS-LS4-1)*

RST.6-8.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (MS-LS4-1)

Mathematics -

6.EE.B.6 Use variables to represent numbers and write expressions when solving a real-world or mathematical problem; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set. *(MS-LS4-1)*

Lesson Level Vocabulary:
extinct, fossil record, constraints, biodiversity, mass extinction, criteria, fossil

DCI Domain Vocabulary:
Domains are bold:

- **Biological Evolution: Unity and Diversity→Evidence of Common Ancestry and Diversity (LS4)**
  Development, anatomy, descent, embryo, fossil record, unity of life, anatomical, ancestry, biological, biological evolution, branch, embryological, evolution, evolutionary, genetic, macroscopic, modern, reconstruction

Performance Expectation
MS-LS4-4 Biological Evolution: Unity and Diversity

Students who demonstrate understanding can:
Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment.
Clarification Statement*: Emphasis is on using simple probability statements and proportional reasoning to construct explanations.*
Assessment Boundary: *N/A*

Lesson Level Phenomenon: The Galápagos Islands are smaller than the state of Connecticut. But, even in such a small area, Darwin noticed a huge variety in the finches. The finch birds on the different islands looked alike, but their beaks varied in size and shape.
note: all photo and video above links to suggested activities below

MS- LS4-4 Suggested Activities	MS- LS4-4 Recommended Formative Assessments
Darwin's Theory of Evolution Through Natural Selection (*TCI Adaptations: Unit 2 The Evolution of Life, Lesson 3*) Students will use a model to explain how different finches compete for food in different environments. Students will also analyze and model population variance and discuss what would happen to traits in that population and in the next generation. (4 class periods) Dragon Lab- Students will participate in s simulation where they randomly select genotypes of dragon parents. The genotypes are used to produce a dragon baby. Students will determine the phenotypes and how they will affect individual survival. (3-4 class periods) ALSO MS-LS3-1, MS-LS4-6	• Analyze finches. Construct an explanation for why Darwin hypothesized one ancestor population of finches came from South America and took over the different Galapagos Islands. • Explain why finch beaks are different shapes and how those shapes help the finches survive. Give evidence to support your explanation using the common ancestor theory, the narrow-down hypothesis, or the forever-the-same hypothesis. • Compare and contrast the variations in the "model mouthpieces". Explain which "model mouthpiece" was the most successful food capturing capabilities and how that capability would impact species survival. • Use evidence collected from the Dragon Lab to support claims and findings about inheritance and natural selection.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions • Construct an explanation that includes qualitative or quantitative relationships between variables that describe phenomena. **Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.**	**LS4.B: Natural Selection** • Natural selection leads to the predominance of certain traits in a population, and the suppression of others.	**Cause and Effect** • **Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.**

Performance Expectation
MS-LS4-4 Biological Evolution: Unity and Diversity

Connections to other DCIs Middle School:
MS.LS2.A ; MS.LS3.A ; MS.LS3.B

Articulation of DCIs across grade-level bands:
3.LS3.B ; 3.LS4.B ; HS.LS2.A ; HS.LS3.B ; HS.LS4.B ; HS.LS4.C

Common Core State Standards Connections:
ELA/Literacy-

RST.6-8.1	Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions. *(MS-LS4-4)*
RST.6-8.9	Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic. *(MS-LS4-4)*
WHST.6-8.2	Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content. (MS-LS4-4)
WHST.6-8.9	Draw evidence from informational texts to support analysis, reflection, and research. (MS-LS4-4)
SL.8.1	Engage effectively in a range of collaborative discussions (one-on-one, in groups, teacher-led) with diverse partners on grade 6 topics, texts, and issues, building on others' ideas and expressing their own clearly. *(MS-LS4-4)*
SL.8.4	Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation. *(MS-LS4-4)*

Mathematics -

6.RP.A.1	Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities. *(MS-LS4-4)*
6.SP.B.5	Summarize numerical data sets in relation to their context. *(MS-LS4-4)*
7.RP.A.2	Recognize and represent proportional relationships between quantities. *(MS-LS4-4)*

Lesson Level Vocabulary: *adaptation, population, evolution, natural selection, genetic variation, trait*

DCI Domain Vocabulary:
Domains are bold:

- **Biological Evolution: Unity and Diversity→Natural Selection (LS4)**
  Shift, variation, consequence, development, adaptation, animal husbandry, artificial selection, continuation of species, decrease, impact, potential, probability, proportional, selective breeding, suppression, taxonomy, anatomical, behavioral, capacity, distribution, evolution, gene, gene therapy, generation, genetic, genetic modification, genetic variation, interdependence, natural selection, predominance, sexual reproduction

Performance Expectation
MS-LS3-1 Heredity: Inheritance and Variation of Traits

Students who demonstrate understanding can:
Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of the past plate motions.

Clarification Statement: *Examples of data include similarities of rock and fossil types on different continents, the shapes of the continents (including continental shelves), and the locations of ocean structures (such as ridges, fracture zones, and trenches).*
Assessment Boundary: *Paleomagnetic anomalies in oceanic and continental crust are not assessed.*

Lesson Level Phenomenon: Lovebirds in captivity have unique colorations not found in the wild population.
note: all photo and video above links to suggested activities below

MS-ESS2-3 Suggested Activities	MS-ESS2-3 Recommended Formative Assessments
Genes and Natural Selection *(*TCI Adaptations: Unit 2 The Evolution of Life, Lesson 5*) Students will model how genetic mutations can change an organism's traits and function using paper airplanes, analyze bacterial resistance, and model genetic divergence using sentence structure. (6 class periods) ***ALSO USED IN MS-LS4-4**	• Develop a model to explain how an organism's mutation can affect its traits. • Identify organism mutations as harmful, beneficial, or neutral and explain how this mutation is or is not beneficial for the organism to attract a mate. • Describe how antibiotic resistance is a result of natural selection. • Explain how antibiotic mutations are beneficial, neutral or harmful mutations.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models • Develop and use a model to describe phenomena. **Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.**	**LS3.A: Inheritance of Traits** • Genes are located in the chromosomes of cells, with each chromosome pair containing two variants of each of many distinct genes. Each distinct gene chiefly controls the production of specific proteins, which in turn affects the traits of the individual. Changes (mutations) to genes can result in changes to proteins, which can affect the structures and functions of the organism and thereby change traits. **LS3.B: Variation of Traits** • In addition to variations that arise from sexual reproduction, genetic information can be altered because of mutations. Though rare, mutations may result in changes to the structure and function of proteins. Some changes are beneficial, others harmful, and some neutral to the organism.	**Structure and Function** • Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the shapes, composition, and relationships among its parts, therefore complex natural structures/systems can be analyzed to determine how they function.

Performance Expectation
MS-LS3-1 Heredity: Inheritance and Variation of Traits

Connections to other DCIs Middle School:
MS.LS1.A ; MS.LS4.A

Articulation of DCIs across grade-levels:
3.LS3.A ; 3.LS3.B ; HS.LS1.A ; HS.LS1.B ; HS.LS3.A ; HS.LS3.B

Common Core State Standards Connections:
ELA/Literacy –

RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts. *(MS-LS3-1)*

RST.6-8.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6-8 texts and topics. *(MS-LS3-1)*

RST.6-8.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (MS-LS3-1)

SL.8.5 Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest. *(MS-LS3-1)*

Mathematics –*N/A*

Lesson Level Vocabulary: *mutation, allele, chromosome, protein, gene, DNA, iterative testing*

DCI Domain Vocabulary:
Domains are bold:

- **Heredity: Inheritance and Variation of Traits→Inheritance of Traits; Variation of Traits (LS3)**
  breed, transfer, variation, cell, development, instruction, recognizable, version, allele, contribute, hereditary information, identical, Punnett square, random, transmission, asexual reproduction, chromosome, formation, gene, genetic, genetic variation, human genetics, molecule, protein, sexual reproduction, structural, subset, microscopic, variation, cell, combination, beneficial, neutral, probability, production, progress, species diversity, chromosome, distinct, distribution, gene, genetic, genetic variation, protein, sexual reproduction, structural, variant

Performance Expectation
MS-LS4-6 Biological Evolution: Unity and Diversity

Students who demonstrate understanding can:

Use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time.

Clarification Statement: *Emphasis is on using mathematical models, probability statements, and proportional reasoning to support explanations of trends in changes to populations over time.*

Assessment Boundary: *Assessment does not include Hardy Weinberg calculations.*

Lesson Level Phenomenon: In only two years, the average beak size of finches on Daphne Major got almost 1 mm larger.

note: all photo and video above links to suggested activities below

MS-LS4-6 Suggested Activities	MS-LS4-6 Recommended Formative Assessments
Observing Natural Selection in Action (*TCI Adaptations: Unit 2 The Evolution of Life, Lesson 4*) Students will test new environmental factors that may influence survival in a wolf and deer game simulation and graph changes of a population's traits over time as the environment changes. (6 class periods) ***ALSO USED IN MS-LS4-3**	• Collect data during the wolf and deer simulation game. Graph and analyze the wolf and deer data from the investigation collaboratively. • Analyze and explain adaptations using given guppy data over time in tanks with and without predators. • Use a model of the cichlid population at the top or the bottom of Lake Victoria to analyze and explain how an organism's traits can pertain to sexual selection.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Using Mathematics and Computational Thinking • Use mathematical representations to support scientific conclusions and design solutions. **Mathematical and computational thinking in 6–8 builds on K–5 experiences and progresses to identifying patterns in large data sets and using mathematical concepts to support explanations and arguments.**	LS4.C: Adaptation • Adaptation by natural selection acting over generations is one important process by which species change over time in response to changes in environmental conditions. Traits that support successful survival and reproduction in the new environment become more common; those that do not become less common. Thus, the distribution of traits in a population changes.	Cause and Effect • Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.

Performance Expectation
MS-LS4-6 Biological Evolution: Unity and Diversity

Connections to other DCIs in Middle School:
MS.LS2.A ; MS.LS2.C ; MS.LS3.B ; MS.ESS1.C

Articulation of DCIs across grade-levels:
3.LS4.C ; HS.LS2.A ; HS.LS2.C ; HS.LS3.B ; HS.LS4.B ; HS.LS4.C

Common Core State Standards Connections:
ELA /Literacy – N/A

Mathematics —

MP.4 Model with mathematics. (MS-LS4-6)

6.RP.A.1 Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities. *(MS-LS4-6)*

6.SP.B.5 Summarize numerical data sets in relation to their context. *(MS-LS4-6)*

7.RP.A.2 Recognize and represent proportional relationships between quantities. *(MS-LS4-6)*

Lesson Level Vocabulary: *probability, coevolution, proportion, adapt*

DCI Domain Vocabulary:

Domains are bold:

- **Biological Evolution: Unity and Diversity→Adaptation (LS4)**
  Geographic, trend, adaptation, beneficial change, detrimental change, acquired trait, decrease, increase, life form change, proportional, adaptive characteristics, anatomical, behavioral, behavioral change in organisms, climate change, distinct, distribution, emergence, emergence of life forms, evolution, fertilizer, frequency, gene, generation, natural selection

Performance Expectation

MS-LS4-2 Biological Evolution: Unity and Diversity

Students who demonstrate understanding can:

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.

Clarification Statement: *Emphasis is on explanations of the evolutionary relationships among organisms in terms of similarity or differences of the gross appearance of anatomical structures.*

Assessment Boundary: *N/A*

Lesson Level Phenomenon: Crayfish, spiders, and dragonflies seem very different at first glance, but they have many similarities.

note: all photo and video above links to suggested activities below

MS-LS4-2 Suggested Activities	MS-LS4-2 Recommended Formative Assessments
Evolutionary Relationships (*TCI Adaptations: Unit 2 The Evolution of Life, Lesson 6*) Students will match fossil data with modern day organisms, and then sort imaginary organisms using the tree-branch diagram. (6 class periods) **Evolutionary Tree Web Lab**- Students will use the tree of life to understand how different species are related to each other. (1 class period)	• Describe one way to categorize organisms. • Explain why the tree-branching diagram is a helpful model to show the similarities and differences of organisms.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions • Apply scientific ideas to construct an explanation for real-world phenomena, examples, or events. **Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.**	**LS4.A: Evidence of Common Ancestry and Diversity** • 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.	**Patterns** • Patterns can be used to identify cause and effect relationships. --- ***Connections to Nature of Science*** **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** • Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation.

Performance Expectation
MS-LS4-2 Biological Evolution: Unity and Diversity

Connections to other DCIs in Middle School:
MS.LS3.A ; MS.LS3.B ; MS.ESS1.C

Articulation of DCIs across grade-levels:
3.LS4.A ; HS.LS4.A ; HS.ESS1.C

Common Core State Standards Connections:

ELA /Literacy –

RST.6-8.1	Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions. (MS-LS4-2)
WHST.6-8.2	Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content. (MS-LS4-2)
WHST.6-8.9	Draw evidence from informational texts to support analysis, reflection, and research. (MS-LS4-2)
SL.8.1	Engage effectively in a range of collaborative discussions (one-on-one, in groups, teacher-led) with diverse partners on grade 6 topics, texts, and issues, building on others' ideas and expressing their own clearly. *(MS-LS4-2)*
SL.8.4	Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation. *(MS-LS4-2)*

Mathematics —

6.EE.B.6	Use variables to represent numbers and write expressions when solving a real-world or mathematical problem; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set. *(MS-LS4-2)*

Lesson Level Vocabulary: *species, evolutionary tree, common ancestor, anatomy, embryo, convergent evolution*

DCI Domain Vocabulary:

Domains are bold:

- **Biological Evolution: Unity and Diversity→Adaptation (LS4)**
  Geographic, trend, adaptation, beneficial change, detrimental change, acquired trait, decrease, increase, life form change, proportional, adaptive characteristics, anatomical, behavioral, behavioral change in organisms, climate change, distinct, distribution, emergence, emergence of life forms, evolution, fertilizer, frequency, gene, generation, natural selection

Performance Expectation
MS-LS4-3 Biological Evolution: Unity and Diversity

Students who demonstrate understanding can:
Analyze displays of pictorial data to compare patterns of similarities in the embryological development across multiple species to identify relationships not evident in the fully formed anatomy.
Clarification Statement: *Emphasis is on inferring general patterns of relatedness among embryos of different organisms by comparing the macroscopic appearance of diagrams or pictures.*
***Assessment* Boundary:** *Assessment of comparisons is limited to gross appearance of anatomical structures in embryological development.*

Lesson Level Phenomenon: **In only two years, the average beak size of finches on Daphne Major got almost 1 mm larger.**
note: all photo and video above links to suggested activities below

MS-LS4-3 Suggested Activities	MS-LS4-3 Recommended Formative Assessments
Observing Natural Selection in Action * (*TCI Adaptations: Unit 2 The Evolution of Life, Lesson 4*) Students will test new environmental factors influence survival in a game simulation and graph changes of a population's traits over time as the environment changes. (6 class periods) ***ALSO USED IN MS-LS4-6**	• Collect data during the wolf and deer simulation game. Graph and analyze the wolf and deer data from the investigation collaboratively. • Analyze and explain adaptations using given guppy data over time in tanks with and without predators. • Use a model of the cichlid population at the top or the bottom of Lake Victoria to analyze and explain how an organism's traits can pertain to sexual selection.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data • Analyze displays of data to identify linear and nonlinear relationships. **Analyzing data in 6–8 builds on K–5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.**	**LS4.A: Evidence of Common Ancestry and Diversity** • Comparison of the embryological development of different species also reveals similarities that show relationships not evident in the fully-formed anatomy.	**Patterns** • Graphs, charts, and images can be used to identify patterns in data.

Performance Expectation
MS-LS4-3 Biological Evolution: Unity and Diversity

Connections to other DCIs Middle School:
N/A

Articulation of DCIs across grade-levels:
HS.LS4.A

Common Core State Standards Connections:

ELA/Literacy —

RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions. *(MS-LS4-3)*

RST.6-8.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (MS-LS4-3)

RST.6-8.9 Compare and contrast the information gained from experiments, simulations, video or multimedia sources with that gained from reading a text on the same topic. *(MS-LS4-3)*

Mathematics —
N/A

Lesson Level Vocabulary: *probability, coevolution, proportion, adapt*

DCI Domain Vocabulary:

Domains are bold:

- **Biological Evolution: Unity and Diversity→Evidence of Common Ancestry and Diversity (LS4)**
  Diversity, development, anatomy, descent, embryo, fossil record, unity of life, anatomical, ancestry, biological, biological evolution, branch, embryological, evolution, evolutionary, genetic, macroscopic, modern, reconstruction

Performance Expectation
MS-LS4-5 Biological Evolution: Unity and Diversity

Students who demonstrate understanding can:

Gather and synthesize information about technologies that have changed the way humans influence the inheritance of desired traits in organisms.

Clarification Statement: *Emphasis is on synthesizing information from reliable sources about the influence of humans on genetic outcomes in artificial selection (such as genetic modification, animal husbandry, gene therapy); and, on the impacts these technologies have on society as well as the technologies leading to these scientific discoveries.*

***Assessment* Boundary:** *N/A*

Lesson Level Phenomenon: **Bulldog skulls have dramatically changed in shape over the past 150 years.**

note: all photo and video above links to suggested activities below

MS-LS4-5 Suggested Activities	MS-LS4-5 Recommended Formative Assessments
Artificial Selection (*TCI Adaptations: Unit 3 Human Impacts on Evolution, Lesson 7*) Students will play an ox simulation game to simulate artificial and natural selection, and then research and develop a presentation about one species that has been selectively bred by humans. (6 class periods)	• Collect data during the ox simulation game. Construct a table using the data for breeding (artificial selection) and hunting (natural selection). Explain which genetic factor was important for artificial selection to work with the ox. • Research plant or animal domestication as a result of artificial selection using the Reliable Sources in Science . Use the notebook to answer the questions about your organism and present the detailed research to the class.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Obtaining, Evaluating, and Communicating Information • Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence. **Obtaining, evaluating, and communicating information in 6–8 builds on K–5 experiences and progresses to evaluating the merit and validity of ideas and methods**	**LS4.B: Natural Selection** • In *artificial* selection, humans have the capacity to influence certain characteristics of organisms by selective breeding. One can choose desired parental traits determined by genes, which are then passed on to offspring.	**Cause and Effect** • Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability. - ***Connections to Engineering, Technology, and Applications of Science*** **Interdependence of Science, Engineering, and Technology** • Engineering advances have led to important discoveries in virtually every field of science, and scientific discoveries have led to the development of entire industries and engineered systems. - ***Connections to Nature of Science*** **Science Addresses Questions About the Natural and Material World** • Scientific knowledge can describe the consequences of actions but does not necessarily prescribe the decisions that society takes.

Performance Expectation
MS-LS4-5 Biological Evolution: Unity and Diversity

Connections to other DCIs Middle School:
N/A

Articulation of DCIs across grade-levels:
HS.LS3.B ; *HS.LS4.C*

Common Core State Standards Connections:
ELA/Literacy —

RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions. *(MS-LS4-5)*

WHST.6-8.8 Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation.*(MS-LS4-5)*

Mathematics —
N/A

Lesson Level Vocabulary: *artificial selection, domesticated, artificial pollination, animal husbandry, artificial insemination*

DCI Domain Vocabulary:
Domains are bold:

- **Biological Evolution: Unity and Diversity→Natural Selection (LS4)**
  Shift, variation, consequence, development, adaptation, animal husbandry, artificial selection, continuation of species, decrease, impact, potential, probability, proportional, selective breeding, suppression, taxonomy, anatomical, behavioral, capacity, distribution, evolution, gene, gene therapy, generation, genetic, genetic modification, genetic variation, interdependence, natural selection, predominance, sexual reproduction

Performance Expectation
MS-ESS3-4 Earth and Human Activity

Students who demonstrate understanding can:
Construct an argument supported by evidence for how increased in human population and per-capita consumption of natural resources impact Earth's systems.
Clarification Statement: *Examples of evidence include grade-appropriate databases on human populations and the rates of consumption of food and natural resources (such as freshwater, mineral, and energy). Examples of impacts can include changes to the appearance, composition, and structure of Earth's systems as well as the rates at which they change. The consequences of increases in human populations and consumption of natural resources are described by science, but science does not make the decisions for the actions society takes.*
***Assessment* Boundary:** *N/A*

Lesson Level Phenomenon: The Aral Sea shrunk to a quarter of its size in only 50 years.
note: all photo and video above links to suggested activities below

MS-ESS3-4 Suggested Activities	MS-ESS3-4 Recommended Formative Assessments
Human Population and Global Change (*TCI Adaptations: Unit 3 Human Impacts on Evolution, Lesson 9*) Students will play a game to simulate the effect of human population growth on other species and use evidence from given case studies to make a claim an argue the most important factor in an organism's ability to adapt to an environmental change. (4 class periods)	• Collect data during the human population growth resource game. Graph and analyze the environmental changes caused by humans and environmental changes not caused by humans from the investigation collaboratively. Evaluate what humans can do to minimize their effect on the environment. • Argue from evidence in the given case studies for what the most important factor is in an organism's ability to adapt to its environment.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Engaging in Argument from Evidence • 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. **Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s).**	ESS3.C: Human Impacts on Earth Systems • 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 • Cause and effect relationships may be used to predict phenomena in natural or designed systems. - ***Connections to Engineering, Technology, and Applications of Science*** Influence of Science, Engineering, and Technology on Society and the Natural World • 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. - ***Connections to Nature of Science*** **Science Addresses Questions About the Natural and Material World** • Scientific knowledge can describe the consequences of actions but does not necessarily prescribe the decisions that society takes.

Performance Expectation
MS-ESS3-4 Earth and Human Activity

Connections to other DCIs Middle School:
MS.LS2.A ; MS.LS4.D

Articulation of DCIs across grade-levels:
3.LS2.C ; 3.LS4.D ; 5.ESS3.C ; HS.LS2.A ; HS.LS2.C ; HS.LS4.C ; HS.LS4.D ; HS.ESS2.E ; HS.ESS3.A ; HS.ESS3.C

Common Core State Standards Connections:

ELA/Literacy —

RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts. (MS-ESS3-4)

WHST.6-8.1 Write arguments focused on discipline content. (MS-ESS3-4)

WHST.6-8.9 Draw evidence from informational texts to support analysis, reflection, and research. (MS-ESS3-4)

Mathematics —

6.RP.A.1 Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities. *(MS-ESS3-4)*

7.RP.A.2 Recognize and represent proportional relationships between quantities. *(MS-ESS3-4)*

6.EE.B.6 Use variables to represent numbers and write expressions when solving a real-world or mathematical problem; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set. *(MS-ESS3-4)*

7.EE.B.4 Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities. *(MS-ESS3-4)*

Lesson Level Vocabulary: *total consumption, per capita consumption, biosphere, endangered species, geosphere, hydrosphere, atmosphere, global warming, climate change*

DCI Domain Vocabulary:

Domains are bold:

- **Earth and Human Activity→Human Impacts on Earth Systems (ESS3)**
  Diversity, societal, wetland, agriculture, biosphere, development, fertile, groundwater, industry, material world, mineral, river delta, aquifer, Earth system, economic, geologic, human activity, human impact, impact, land usage, levee, negative, positive, water usage, civilization, consumption, cultural, interior, mass wasting, modern, per-capita, urban development

Performance Expectation
MS-ETS1-4 Engineering Design

Students who demonstrate understanding can:
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.
Clarification Statement: *N/A*
Assessment Boundary: *N/A*

Lesson Level Phenomenon: **Lovebirds in captivity have unique colorations not found in the wild population.**

MS-ETS1-4 Suggested Activities	MS-ETS1-4 Recommended Formative Assessments
Genes and Natural Selection *(*TCI Adaptations: Unit 2 The Evolution of Life, Lesson 5*) Students will model how genetic mutations can change an organism's traits and function using paper airplanes, analyze bacterial resistance, and model genetic divergence using sentence structure. (6 class periods) ***ALSO USED IN MS-LS4-4**	• Develop a model to explain how an organism's mutation can affect its traits. • Identify organism mutations as harmful, beneficial, or neutral and explain how this mutation is or is not beneficial for the organism to attract a mate. • Describe how antibiotic resistance is a result of natural selection. • Explain how antibiotic mutations are beneficial, neutral or harmful mutations.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models • Develop a model to generate data to test ideas about designed systems, including those representing inputs and outputs. **Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.**	**ETS1.B: Developing Possible Solutions** • A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. • Models of all kinds are important for testing solutions. **ETS1.C: Optimizing the Design Solution** • 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.	**N/A**

Performance Expectation
MS-EST1-4 Engineering Design

Connections to other DCIs Middle School:
Physical Science: MS-PS1-6, MS-PS3-3, Life Science: MS-LS2-5
Connections to MS-ETS1.C: Optimizing the Design Solution include:
Physical Science: MS-PS1-6

Articulation of DCIs across grade-levels:
3-5.ETS1.A ; **3-5.ETS1.B** ; **3-5.ETS1.C** ; **HS.ETS1.B** ; **HS.ETS1.C**

Common Core State Standards Connections:
ELA/Literacy -

SL.8.5 Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest. *(MS-ETS1-4)*

Mathematics —

MP.2 Reason abstractly and quantitatively. *(MS-ETS1-4)*

7.SP Develop a probability model and use it to find probabilities of events. Compare probabilities from a model to observed frequencies; if the agreement is not good, explain possible sources of the discrepancy. *(MS-ETS1-4)*

Lesson Level Vocabulary: *DNA, gene, protein, chromosome, allele, mutation, iterative testing*

DCI Domain Vocabulary:

Domains are bold:

- **Engineering Design→Developing Possible Solutions (ETS1)**
  abstract, agreed-upon, break down, concrete, consideration, convincing, criteria, jointly, mathematical model, physical replica, priority, real-world, representation, societal, systematic , theoretical model