NEPTUNE CITY SCHOOL DISTRICT

Science

Curriculum

Grade 8

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

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

April 1, 2025 Document C1#1

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SCHOOL DISTRICT MISSION STATEMENT

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

NEPTUNE CITY SCHOOL DISTRICT

SCIENCE
GRADE 8
CURRICULUM

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Unit Title

NEPTUNE CITY SCHOOL DISTRICT

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Acknowledgements

The Science Grade 8 curriculum was developed through the dedicated efforts of Allison Ringer, Christina Tuozzolo, and Amy Corbet-Elsbree, middle school science teachers, with the guidance of the district's curriculum steering committee members including Dolores Dalelio, Department Chairperson , Stacie Ferrara, Ed.D., STEM Supervisor, and Sally A. Millaway, Ed.D., Director for Curriculum, Instruction and Assessment.

Mrs. Corbet-Elsbree, Mrs. Ringer, and Ms. Tuozzolo are commended for their dedication in creating this curriculum utilizing the UbD format and Open Sci Ed framework. The curriculum guide was written in alignment with the 2020 New Jersey Student Learning Standards for Science and highlights the 3-dimensional nature that these standards bring to the teaching and learning of science.

This curriculum guide also includes alignment to the 2016 New Jersey Student Learning Standards for Mathematics and English language Arts and the 2020 New Jersey Student Learning Standards in Computer Science and Design Thinking and Career Readiness, Life Literacies, and Key Skills. Included are also instructional strategies and resources that focus on developing scientifically literate students and providing opportunities for students to make sense of science. It is our hope that this guide will serve as a valuable resource for the staff members who teach this course and that they will feel free to make recommendations for its continued improvement.

NEPTUNE CITY SCHOOL DISTRICT

DISTRICT MISSION STATEMENT

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

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

NEPTUNE CITY School District

Educational Outcome Goals

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

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

GRADE 8 SCIENCE

COURSE DESCRIPTION

The Grade 8 Science curriculum takes an integrated approach to teaching science, and includes the following topics: forces; sound waves; Earth in space; genetics and natural selection. In each unit, students will observe and make sense of a phenomenon or problem. Investigations are driven by students' questions that arise from their interactions with the phenomena. Students learn how to construct scientific explanations and how to design evidence-based solutions. This course will provide students with strategies and tools to think critically about personal and societal issues and needs. Students can then contribute meaningfully to decision-making processes, such as discussions about climate change and innovative solutions to local and global problems.

INTEGRATED SOCIAL AND EMOTIONAL LEARNING COMPETENCIES

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

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

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

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

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

Interdisciplinary Connections
New Jersey Student Learning Standards for English Language Arts (2016) ● NJSLSA.R1. Read closely to determine what the text says explicitly and to make logical inferences and relevant connections from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text. ● NJSLSA.R10. Read and comprehend complex literary and informational texts independently and proficiently with scaffolding as needed. **Standards for Mathematical Practices (2016)** 1. Make sense of problems and persevere in solving them. 2. Reason abstractly and quantitatively. 5. Use appropriate tools strategically. **NJSLS Career Readiness,Life Literacies, and Key Skills (2020)** https://www.nj.gov/education/cccs/2020/2020%20NJSLS-CLKS.pdf ● 9.4.2.CI.1: Demonstrate openness to new ideas and perspectives (e.g., 1.1.2.CR1a, 2.1.2.EH.1, 6.1.2.CivicsCM.2). ● 9.4.2.CT.2: Identify possible approaches and resources to execute a plan (e.g., 1.2.2.CR1b, 8.2.2.ED.3). ● 9.4.2.CT.3: Use a variety of types of thinking to solve problems (e.g., inductive, deductive). **NJSLS Computer Science and Design Thinking (2020)** https://www.nj.gov/education/cccs/2020/2020%20NJSLS-CSDT.pdf ● 8.2.8.NT.1: Examine a malfunctioning tool, product, or system and propose solutions to the problem.

Student Resources
HS Safety Contract (Flinn) https://www.flinnsci.com/high-school-student-safety-contract---english/dc10494/ MS Safety Contract (Flinn) https://www.flinnsci.com/middle-school-science-safety-contract/dc10642/ Spanish version Safety Contract https://www.flinnsci.com/high-school-student-safety-contract---spanish/dc10495/
Teacher Resources
Flinn Safety Course for teachers online (free with registration) https://labsafety.flinnsci.com/ NSTA Safety Resources https://www.nsta.org/topics/safety NSTA Duty of Care https://static.nsta.org/pdfs/DutyOfCare.pdf

Safety and the NGSS https://static.nsta.org/pdfs/Safety%20and%20the%20Next%20Generation%20Science%20Standards_29Oct2020_FINAL.pdf Safety Practices with Demonstrations https://static.nsta.org/pdfs/MinimumSafetyPracticesAndRegulations.pdf Labeling of Chemicals https://static.nsta.org/pdfs/GloballyHarmonizedSystemOfClassificationAndLabelingOfChemicals.pdf Eye Protection **https://www.nsta.org/eye-protection-and-safer-practices-faq** **K-12 Universal Legislation** **Amistad Law N.J.S.A. 18A 52:16A-88** Every board of education shall incorporate the information regarding the contributions of African Americans to our country in an appropriate place in the curriculum of elementary and secondary school students. **Diversity and Inclusion Law (N.J.S.A. 18A:35-4.36a)** Beginning in the 2021-2022 school year, each school district shall incorporate instruction on diversity and inclusion in an appropriate place in the curriculum of students in grades kindergarten through 12 as part of the district's implementation of the New Jersey Student Learning Standards. **Holocaust Law (N.J.S.A. 18A:35-28)** Every board of education shall include instruction on the Holocaust and genocides in an appropriate place in the curriculum of all elementary and secondary school pupils. The instruction shall further emphasize the personal responsibility that each citizen bears to fight racism and hatred whenever and wherever it happens. **LGBT and Disabilities Law (N.J.S.A. 18A:35-4.35)** A board of education shall include instruction on the political, economic, and social contributions of persons with disabilities and lesbian, gay, bisexual, and transgender people, in an appropriate place in the curriculum of middle school and high school students as part of the district's implementation of the New Jersey Student Learning Standards. N.J.S.A.18A:35-4.36 A board of education shall have policies and procedures in place pertaining to the selection of instructional materials to implement the requirements of N.J.S.A. 18A:35-4.35.

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

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

Summative Assessments:
Safety Test

Performance Task(s):
Safety Practical

Stage 3 – Learning Plan

- Explain and demonstrate lab expectations and safety and disposal procedures.
- Safety tour of classroom- hood, eyewash, safety gas valve, eye goggle cabinet.
- Practice fire drill
- Review safety and lab equipment - name, location, use
- Review scenarios and how to call for help
- Model how to handle lab equipment

Unit Plan Title	8.1 Contact Forces
Suggested Time Frame	33 Days

Overview / Rationale
This unit on contact forces begins as students consider situations in which they have seen their phones break. They contrast these situations with others where something else collided with another object and either did break or, surprisingly, did not. Attempting to identify the factors that contribute to damage occurring in some collisions and not others, as well as trying to explain what is happening during the collision that causes one type of result versus another, sparks a series of questions and ideas for investigations around the question why do things sometimes get damaged when they hit each other? identify trade-offs, analyze and critique design solutions, and optimize designs solutions using evidence from these investigations to solve different design problems for different stakeholders and different contexts. Students will complete a design problem to figure out what kinds of solutions we can design to protect fragile things from breaking.

Stage 1 – Desired Results

Established Goals:

New Jersey Student Learning Standards in Science (2020)

- **MS-PS2-1:** Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects.* *[Clarification Statement: Examples of practical problems could include the impact of collisions between two cars, between a car and stationary objects, and between a meteor and a space vehicle.]* [*Assessment Boundary: Assessment is limited to vertical or horizontal interactions in one dimension.*]

- **MS-PS2-1:** 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.*]

- **MS-PS3-1:** 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.*]

Essential Questions:	Enduring Understandings:
- Why do things sometimes get damaged when they hit each other? - How does Newton's Third Law describe the collision between two objects? - How can we design a mitigating solution between the collision of two objects? - How do force and mass affect the motion of an object? - How do we change the acceleration of an object? - How can the mass of an object change the amount of kinetic energy in a system? - How does kinetic energy affect the speed of an object?	*Students will understand:* - The force and speed of a collision can cause damage to the colliding objects. - Newton's Third Law is that for every action there is an equal and opposite reaction, so when two objects collide they exert equal and opposite forces on each other. - The damage of collision could be mitigated through use of protection to lessen the force of impact. - The more force placed on the object, the greater the acceleration. - The more mass an object has, the more force it has upon impact and the greater the acceleration. - The acceleration of an object depends upon the force and mass of the object, so the greater those two characteristics the more acceleration an object has. - The more mass an object has, the more kinetic energy the object will have. - The more kinetic energy in the system, the greater the speed potential of an object.
Knowledge: *Students will know…* **Key Vocab Terms:** Collision, Force, Potential Energy, Kinetic Energy, Contact Force, Friction, Newton's First Law, Newton's Second Law, Newton's Third Law, mass, acceleration, speed - How to describe a collision between two objects using Newton's Third Law of Motion. - How to design a solution mitigating the collision between two objects. - How force and mass affect the motion of an object. - That changing certain factors will change the acceleration of an object - Changing the mass of an object will change the kinetic energy of an object. - How kinetic energy affects the speed of an object.	**Skills:** *Students will be able to…* - Develop a model to describe interactions between two objects as they collide and show the changes that occur in the structure of both objects when one object is damaged as a result and also when neither object is damaged as a result. - Ask questions that arise from observations of collisions between two objects in order to seek additional information about factors (causes) that might affect the outcome of such collisions. - Collect data on changes in the motion and shape of colliding objects that serve as the basis for evidence that energy transfer occurs during the collision and that there are forces between colliding objects. - Construct an argument supported by empirical evidence and scientific

	reasoning to support a model showing that changes in motion of colliding objects (connected to subsystems) results from energy transfer between them (cause) and changes in the shape of those objects results from force(s) between them (cause). ● Construct and revise a written argument using evidence from various sources of data (slow-motion videos, photos, and first hand investigations) to support or refute the claim that all objects do bend or change shape when pushed in a collision. ● Plan an investigation, identifying controls to keep constant, and carry out the investigation to produce data to serve as the basis for evidence to develop a mathematical model for the relationship (pattern) between the amount of force applied to an object and the amount it deforms. ● Analyze and interpret graphical data (patterns) from tests of compression force vs. amount and type of deformation (temporary vs. permanent) to provide evidence that supports an argument that all objects behave elastically up to a specific limit beyond which permanent damage occurs (stability and change). ● Plan and carry out an investigation and identify patterns in the data collected from the investigation to provide evidence that when peak contact forces on each object during the collision are equal in strength, the strength of those forces increases when the mass or the speed of the object that was moving before the collision increases. ● Develop and use subsystem models (free body diagrams) to represent how the peak contact forces on two different objects compare in a collision and how these are related to corresponding changes in the kinetic energy of a moving object before it collides due to a change in its mass or the speed.

	• Apply science ideas and use evidence to construct an explanation for how the amounts of peak force and energy transfer (cause) in soccer collisions result in instability in the brain (concussions, effect) due to sudden changes at the cellular level. • Construct, analyze, and interpret graphical displays of data collected from a computer simulation to identify patterns in the data, including a linear relationship between the mass of a moving object and its kinetic energy and its kinetic energy and a nonlinear relationship between the speed of a moving object and its kinetic energy. • Construct an explanation based on quantitative relationships (scale) for whether decreasing the mass of a moving object or decreasing its speed would have a bigger effect on the peak forces produced in a collision between it and a stationary object and use these ideas to further explain why this would cause damage in some collisions but not others (effect). • Develop and use a model to identify other parts of the system the cart and box are making contact with or colliding into that could be producing contact forces on these subsystems, causing energy to be transferred to or from them as the box and cart travel down the track. • Apply scientific ideas and evidence to construct an explanation for the causes of motion and kinetic energy changes that happen before and after collisions and how these affect the outcome of a collision. • Respectfully provide and receive critiques about claims to identify relevant evidence to support an explanation for how energy transfers through the cart-launcher system before and right after a collision. • Develop and revise a model to identify other parts of the system the cart and box

	are making contact with or colliding into that are producing contact forces on these subsystems, causing energy to be transferred to or from them as the box and cart travel down the track. ● Apply scientific ideas to explain why some collision-related phenomena resulted in damage while others did not and to explain how the contributing factors (energy, matter, peak forces) could change to result in different collision outcomes. ● Apply scientific ideas to explain multiple baseball phenomena, including the effects of air density and wind on ball speed (changes to the stability of the system and its effect on kinetic energy changes due to air resistance), bat mass vs. bat speed (interpreting patterns in graphical and tabular data to determine the linear and nonlinear effects on increases of kinetic energy within the system), and bat type (the effect deformation has on peak forces in the system and kinetic energy) on how the game is played. ● Define a problem that can be solved with the development of a protective device to reduce damage (peak force) during a collision by identifying and considering multiple criteria and constraints along with specific materials, shapes, and designs of devices that reflect our science ideas of how certain material properties function in a collision. ● Design a solution to a problem to reduce the damage to an object in a collision (by reducing peak forces) by considering the properties of different, individual materials and shapes being used to serve particular functions. ● Analyze data to determine which materials reduce peak force in a collision and analyze the similarities (visual patterns across materials) in the properties of those materials (macroscopic deformability).

	• Develop a model to explain how the changes in the structures of cushioning materials contribute to their function (a reduction in peak forces) at a microscopic level during a collision. • Construct an explanation for how (and why) the structure of a cushioning material affects the peak forces produced (function) in a collision, relating the amount of space available for deformation, the total contact time during a collision, and the peak forces produced from the addition of such structures. • Develop and use subsystem models (free body diagrams) to represent how the peak contact forces on different objects in a collision compare when they have different cushioning structures between them. • Critically read a scientific text adapted for classroom use to determine how concussions can result in breaks in the axons of neurons (structure) and why this can lead to memory loss (function), how a snug fit (structure) for a helmet would affect its performance (function), and how other changes in the structure of cushioning material (in a helmet) would affect its performance (function). • Optimize the performance of a design by prioritizing the particular functions and properties of materials based upon stakeholder feedback to assess the relative effectiveness of the materials. • Engage in a quantitative analysis using prioritized scores and consider the trade-offs of prioritizing particular uses and functions of materials to assess their relative effectiveness for the optimization of the design. • Develop and use a series of models to represent (a) the relative strength of the forces (change and stability) being applied to three different objects and subsystems in contact in a collision, (b) in each case

	what interaction (cause) is producing this force (effect) on the object, and (c) the direction of these forces in three different free body diagrams and use the ideas from these models to support or refute an argument for the effect on peak forces on heads during a collision. ● Construct an explanation for why a design solution will optimize performance, including the prioritized criteria, constraints brought from stakeholders, and trade-offs made when revising the design to meet criteria. ● Design a solution to a problem to reduce the damage to an object in a collision (by reducing peak forces) by considering the properties of different materials and shapes being used to serve particular functions.

Interdisciplinary Connections
New Jersey Student Learning Standards-English Language Arts (2016) **RST.6-8.1** Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions. (MS-PS2-1) **RST.6-8.3** Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks. (MS-PS2-1),(MS-PS2-2) **RST.6-8.7** Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (MS-PS3-1) **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),(MS-PS2-2) **New Jersey Student Learning Standards-Mathematics (2016)** **MP.2** Reason abstractly and quantitatively. (MS-PS2-1),(MS-PS2-2) **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),(MS-PS2-2) **6.RP.A.1** Understand the concept of ratio and use ratio language to describe a ratio relationship between two quantities. (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.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),(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-PS2-1),(MS-PS2-2)
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)

New Jersey Student Learning Standards- Computer Science & Design Thinking (2020)
8.2.8.ED.1 Evaluate the function, value, and aesthetics of a technological product or system, from the perspective of the user and the producer.
8.2.8.ED.2 Identify the steps in the design process that could be used to solve a problem.
8.2.8.ED.3 Develop a proposal for a solution to a real-world problem that includes a model (e.g., physical prototype, graphical/technical sketch).
8.2.8.ED.4 Investigate a malfunctioning system, identify its impact, and explain the step-by-step process used to troubleshoot, evaluate, and test options to repair the product in a collaborative team.

Student Resources
Primary Source Readings ● Student Edition of 8.1 Unit **Secondary Source Readings** ● How Does Touch Work ● How Do We Sense Different Textures ● Anatomy Of A Bike Helmet **Supporting Text pages** ● Handouts - All student handouts are within the lesson folders for each unit in the teacher resource section ● Lesson 4 Investigation Procedures ● Lesson 7 Investigation Procedures ● Lesson 9 Lab Station Instructions ● Lesson 9 Microscope Pictures

- Lesson 9 Data Cards
- Lesson 12 Investigation Procedures
- Lesson 12 Microscope Close Up Images

Technology
- Collision Simulation
- Friction Simulation

Video:
- Colliding Carts Videos
    - Cart & Bricks Collision - 2 Rings
    - Cart & Bricks Collision - 2 Rings on Brick
    - Cart & Brick Collision - 1 Ring on Cart
    - Cart & Brick Collision - 1 Ring on Brick
    - Cart & Brick Collision - No Rings
    - Condition A Regular Speed & Mass
    - Condition B Regular Speed & Double Mass
    - Condition C Double Speed & Regular Mass
- Strength Testing of a Concrete Bridge
- Baseball & Bat Collision
- Carts Colliding With Brick
- Carts With Different Masses Colliding
- Slow Motion Golf Club Hitting Golf Ball
- Collision Showing Bumpers
- Carts With Metals Rings Colliding
- Carts With Rubber Stoppers Colliding
- Golf Ball Colliding With CD Case
- 2019 University of Kentucky Cheerleaders
- America's Got Talent Cheerleaders
- America's Got Talent Cheerleaders

Teacher Resources

Texts:
- Overview of Unit
- Lesson 1 Folder
- Lesson 2 Folder
- Lesson 3 Folder
- Lesson 4 Folder
- Lesson 5 Folder
- Lesson 6 Folder
- Lesson 7 Folder
- Lesson 8 Folder
- Lesson 9 Folder
- Lesson 10 Folder
- Lesson 11 Folder

- Lesson 12 Folder
- Lesson 13 Folder
- Lesson 14 Folder
- Lesson 15 Folder
- Lesson 16 (Optional) Folder
- Elements of NGSS Dimensions
- OpenEdSci Teacher Handbook

Technology:
- Collision Simulation
- Friction Simulation

Videos:
- Overview of Unit
- Lesson 2 Preparing Sugar Glass
- Lesson 3 Setting Up Laser
- Lesson 12 Investigation Ramp

Materials
- Materials List from OpenEdSci

NJSLA Science Practice Assessments
https://nj.mypearsonsupport.com/practice-tests/science/

Stage 2 – Assessment Evidence
Pre-Assessments: **NJSLA Science Practice Assessments** https://nj.mypearsonsupport.com/practice-tests/science/ Lesson 1 (Initial Model: Objects During Collisions), Lesson 11 (Protection Device Design Thinking) Pre-Assessment Lesson 1 is an opportunity to uncover students' initial ideas and questions about how damage sometimes happens to objects in collisions. Analyzing student work will allow you to see if students have skills from prior grade bands (what a force is, balanced and unbalanced forces, energy is transferred in collisions, energy can be transferred through forces, and so forth) and if they have some current grade-band understandings (mass and speed as factors related to kinetic energy; net force ideas; and so forth). Lesson 11 provides an opportunity to find out what students may already understand about the relationship between material properties and their abilities to reduce peak forces in a collision. Students will draw a diagram of their own protective device designs for an object of their choice and will try to describe these protective materials from a microscopic and macroscopic level,

giving an idea of student understanding of scale, system models, and structure and function of the materials. Students will develop their understanding of how material properties reduce peak forces on the objects they are protecting in Lessons 12-14.

Formative Assessments: Lesson 4 (Independent, Dependent, and Controlled Variables), Lesson 5 (Slide K and related science notebook entry), Lesson 6 (Soccer Assessment)

At the start of Lesson 4, students express their initial ideas about important variables in an investigation. The handout Independent, Dependent, and Controlled Variables can be used as a reference for students throughout the unit and throughout 8th grade as they continue to design and carry out investigations.

Lesson 5 is a good opportunity to determine if students can plan investigations in small groups without a lot of scaffolding. Slide K cues students to start planning their investigation with their group. You can assess much of this plan before groups go to carry out the investigation and collect the data from it.

Lesson 6 is a putting-the-pieces-together lesson. It includes an assessment that provides students an opportunity to apply their understanding of peak forces, damage, and kinetic energy on different parts of a system in a collision. Students also draw free body diagrams of the parts of a system during a collision. It’s critical that students first understand that the forces during a collision are always equal and opposite and that the peak forces experienced by each object are the same before they attempt to make a free-body diagram describing that relationship. However, once students become adept at using the free-body diagram to describe forces and energy transfer as objects interact, they will better be able to use free-body diagrams to predict the changes in motion to objects and changes in kinetic energy in a collision.

Summative Assessments: Lesson 14 (Lesson 14 Device Redesign), Lesson 15 (End of Unit Assessment)

Lesson 14 is a putting-the-pieces-together lesson. It includes a summative assessment that gives students the opportunity to explore various types of padding and explain how padding helps ensure that objects in collisions change motion using small forces over long distances (rather than large forces over short distances). Then students apply their understanding from the entire unit to their own design idea. These material properties are used to refine designs, and trade-offs of different material choices are examined. Students have to apply the ideas of structure and function while considering stakeholder feedback and trade-offs to optimize their designs (ETS1).

Lesson 15 provides an end-of-unit assessment to assess student understanding of peak forces, material structure, net force, and equal and opposite forces relationships. Students apply this knowledge to evaluate cheerleading helmets for safety, support or refute claims about the protective qualities of the device, explain the structural properties of protective materials and how they can contribute to a reduction of peak forces on the object they are protecting, and design a new device while considering the needs of stakeholders.

This end-of-unit assessment provides evidence of student understanding in the concepts above and an additional opportunity to assess key ideas from Lesson Sets 1 and 2. See the alignment guide for further details about the alignment of questions to the science and engineering practices. crosscutting concepts, and disciplinary core ideas for the unit.

Formative-Summative Assessments: Lesson 10 (Lesson 10 Assessment)
Lesson 10 is a putting-the-pieces-together lesson. It includes a summative midpoint assessment that can provide formative information for moving forward in the unit. The goal of the assessment is to determine if students can apply their evidence from lab activities and key science ideas to explain how objects sometimes break when they hit each other.

This lesson is also an excellent opportunity to revisit the Driving Question Board to identify questions that can be answered so far. The lesson includes guidance for supporting students in selecting their own questions they feel they can now answer and sharing those answers with the class.

Stage 3 – Learning Plan
Lesson 1 (3 days): What happens when two things hit each other? We model what we think might happen at the moment of impact and a split second after a collision where something breaks and a collision where something doesn't break. We consider some of the factors that could have made a difference in the outcomes of these collisions. This motivates us to create a Driving Question Board (DQB) and brainstorm possible investigations we could do in order to answer our questions. **Lesson 2 (2 days): What causes changes in the motion and shape of colliding objects?** We explore colliding objects and record observations about changes in their motion and shape. We analyze slow-motion videos of some of these collisions. We develop a model to represent what we know about energy transfer and forces occurring in collisions when we see changes in motion of objects, shape of objects, or damage to objects. **Lesson 3 (1 day): Do all objects change shape or bend when they are pushed in a collision?** We make a claim about whether all solid objects bend or not when pushed during a collision. We analyze slow-motion videos, carry out an investigation with a laser and a mirror, and analyze

images from a timelapse concrete joint load testing video. We argue for whether our original claims are supported or refuted by the evidence.

Lesson 4 (2 days): How much do you have to push on any object to get it to deform (temporarily vs. permanently)? We plan and carry out an investigation to look at the relationship between contact force applied and the amount of deformation that occurs in different materials. We construct graphs of our data and compare them to those from other materials tests. We develop a model to represent the elastic and non-elastic behavior of all solid objects in response to varying amounts of force applied to them.

Lesson 5 (2 days): How does changing the mass or speed of a moving object before it collides with another object affect the forces on those objects during the collision? We carry out investigations to explore the strength of forces between two objects when they collide. We plan and carry out an investigation about how different speeds and masses of objects affect the amount of peak force on each object. We develop and use a model to represent the relationship between the energy of a moving object and the strength of the peak forces from a collision.

Lesson 6 (1 day): What have we figured out about objects interacting in collisions? How can we apply our new learning to answer questions about objects interacting in collisions? We look back at questions from our Driving Question Board and answer questions we have made progress on during Lesson Set 1. We take an assessment to apply our science ideas to a new context and determine we need to figure out what causes more damage and energy transfer during a collision-- increases in mass or increases in speed.

Lesson 7 (2 days): How much does doubling the speed or doubling the mass affect the kinetic energy of an object and the resulting damage that it can do in a collision? We carry out an investigation to determine how doubling the speed of an object vs. doubling its mass affects the amount of damage it does in a collision. We analyze data to determine how to quantify the relative change in the kinetic energy of an object. We use a computer simulation to collect additional data on changes in the mass and the speed of a moving object and the amount of kinetic energy. We develop mathematical models of these relationships and use them to predict and explain how this could affect the amount of damage in a collision.

Lesson 8 (1 day): Where did the energy in our launcher system come from, and after the collisions where did it go to?We develop a model to show where energy is transferred between the spring, cart, and box and how contact forces cause this energy transfer. We use this to start brainstorming other places where contact forces may be causing energy transfer in the system.

Lesson 9 (2 days): How do other contact forces from interactions with the air and the track cause energy transfers in the launcher system? We conduct investigations to gather evidence to explain what other forces affect the kinetic energy of an object before a collision. We develop claims using our evidence and provide and receive feedback with peers to synthesize our ideas. We revise our model to show additional places in the launcher system where energy is transferred and how contact forces cause this energy transfer.

Lesson 10 (2 days): Why do some objects break or not break in a collision?We revisit our collision types from Lesson 1 and explain why some objects were damaged and others weren't in different collisions. We use these ideas to answer questions on the Driving Question Board and take an assessment to apply our new ideas to a new set of collision-related phenomena in the context of baseball.

Lesson 11 (2 days): What can we design to better protect objects in a collision? We look back at our anchor and discover that some phones were in protective cases when they were damaged. We develop new phone case criteria and constraints and design our own protection device for something we want to protect. We receive feedback on our designs and consider what criteria and constraints all designs need to protect objects. We develop questions about our designs and ideas for investigation. We determine that we need to figure out the best damage-reducing materials.

Lesson 12 (2 days): What materials best reduce the peak forces in a collision? We conduct an investigation to determine what easily accessible materials reduce peak force in a collision. We compare the structure of the materials and find similarities in their compositions that might affect their function. We also determine that the peak force is reduced equally on both objects, regardless of size. We try to develop a model to explain how the structures of the materials function in a collision that helps to reduce peak forces on the objects we want to protect.

Lesson 13 (3 days): How (and why) does the structure of a cushioning material affect the peak forces produced in a collision? We develop a model to represent how the structures of materials compare in the top four performers for peak force reduction. We use scaled-up versions of these structures to generate data using slow-motion video about the unobservable mechanisms at work in the system. We carry out an investigation to determine how the amount of force applied to different points of a cushioning structure is affected by the shape of that structure.

Lesson 14 (2 days): How can we use our science ideas and other societal wants and needs to refine our designs? We redesign our protective devices and receive stakeholder feedback. We use the feedback and considerations to inform decisions on primary, secondary and tertiary criteria for materials in a decision matrix. We evaluate the overall scores of the materials and consider the consequences of each change made to the protective devices.

Lesson 15 (2 days): How can we use what we figured out to evaluate another engineer's design? We evaluate other engineers' design solutions to protect cheerleaders from concussions in collisions using the science and engineering ideas we have figured out over the course of the unit. We design our own solution and argue how it takes into consideration the criteria, constraints, and trade-offs considered in the proposed solution. We revisit the DQB to take stock of the questions we have answered.

Lesson 16 (4 days): OPTIONAL How can we market our designs to our potential investors? In this optional lesson we develop a presentation to share our design with potential investors. We have the option to create a scale prototype and test our design and/or add visual aids to our presentation. We also present our design ideas to investors.

Unit Plan Title	8. 2 Sound Waves
Suggested Time Frame	24 Days

Overview / Rationale
Students consider an interesting phenomenon: a truck is playing loud music in a parking lot and the windows of a building across the parking lot visibly shake in response to the music. Students generate questions about three aspects of sound phenomena : 1) What makes sound? 2) How does sound get from the truck to the window? 3) Why does the window shake like it does? Students engage in model-based reasoning, argumentation, and computational and mathematical reasoning to develop models to explain these three aspects of the mystery. Students investigate factors including loudness and pitch, students develop a model of vibration that captures important ideas about how changes in the frequency and amplitude of the vibrations can explain these different characteristics of sounds. Students create a model of vibration to answer their initial questions about what causes different sounds. With the models they have developed, students also figure out how sounds can be absorbed and transmitted. What students figure out helps them answer their initial questions about how objects that are not touching a sound source can shake in response to sound.

<table>
<tr><th colspan="2">Stage 1 – Desired Results</th></tr>
<tr><td colspan="2">Established Goals:
New Jersey Student Learning Standards in Science (2020)
● MS-PS4-1: 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.]

● MS-PS4-2: Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials. [Clarification Statement: Emphasis is on both light and mechanical waves. Examples of models could include drawings, simulations, and written descriptions.] [Assessment Boundary: Assessment is limited to qualitative applications pertaining to light and mechanical waves.]</td></tr>
<tr><td>Essential Questions:
● How can sound make things move?
● How is the amplitude of a wave related to the energy of a wave?</td><td>Enduring Understandings:
Students will understand:
● Sound is created due to vibrations and can change depending on amplitude.
● The energy of a wave and the amplitude of a wave have a direct relationship, where</td></tr>
</table>

• In a standard repeating wave, how is amplitude measured and how can that change mathematically? • How can waves be reflected, absorbed, or transmitted through various materials? • How can one model the reflection, absorption, and transmittance of waves in various materials?	when one changes, so does the other in the same way. • Amplitude is measured as the height of a wave from the resting position (line of equilibrium). • Waves are reflected, absorbed, and transmitted through various materials depending on the type of wave and the material composition.
Knowledge: *Students will know…* • **Key Vocab Terms:** Waves, Mechanical Waves, Transverse Waves, Longitudinal Waves, Electromagnetic Waves, Crest, Trough, Amplitude, Frequency, Line of Equilibrium, Compressions, Rarefactions, Medium, Reflection, Absorption, Transmittance • How to model transverse and longitudinal waves. • That amplitude is the height of a wave and how it is measured. • The mathematical relationship between amplitude and energy. • How waves can be reflected, absorbed, or transmitted through various materials. • How to differentiate between materials that can reflect, absorb, or transmit.	**Skills:** *Students will be able to…* • Develop a model to explain how a sound source (cause) can make another object move (effect). • Ask questions about patterns in observations that can be investigated to figure out how sound travels and causes movement in other objects. • Analyze and interpret data to identify patterns in the data that provide evidence of the relationship between a force (cause) on an instrument and the motion/vibration (effect) of the instrument. • Develop a model to describe how a force applied to an instrument causes its shape to change, leading it to repeatedly deform above and below its initial position (effect) as it vibrates and use that model to predict what a force will do to another instrument. • Engage in argument from evidence to support or refute our predictions about whether all solid objects vibrate (cause) when they make sounds (effect), even when we cannot see them vibrate. • Use mathematical representations of position versus time graphs generated from a tool used to scale up the vibrations of an object to describe wave patterns and support scientific conclusions about how objects move when they make louder or softer sounds. • Use a model to explain how a force applied to an instrument causes the sound

	source to vibrate (effect) and make a sound even if we cannot see it. ● Construct an argument using evidence from graphs to support an explanation for which patterns of frequency and amplitude of a wave are indicators of attributes of sounds that we can hear. ● Respectfully provide and receive critiques in order to revise initial claims about whether air is being moved (cause) all the way from the sound source to our ears when we hear the sounds or when the window moves (effect). ● Use evidence from investigations to compare and critique competing claims and argue that air or another medium such as liquid or solid is needed (cause) to hear sound or move the window (effect). ● Develop and use a model to describe unobservable parts (particles) of the system and how they would interact with one another in any state of matter to transfer energy from a vibrating sound source through collisions with one another across a medium. ● Apply mathematical concepts to make sense of data generated from a model to test ideas about how changing the frequency and amplitude of the sound source affects the patterns in the wavelengths and compression of particles as energy moves across the system. ● Develop and use a model to describe phenomena using unobservable mechanisms for how a sound source could cause vibrations that produce sounds, which cause particles of matter in the surrounding medium to be compressed and expanded, which then collide with neighbors to transfer energy across the medium, which results in movement of an object farther away. ● Critically read scientific texts adapted for classroom use to determine the central ideas and obtain scientific information to

	describe patterns of how the structures in the ear interact with each other to transfer energy from the eardrum to fluid in the cochlea and to a series of sensory cells that move (more or less) in response to vibrations of particular frequencies, which send signals along different nerve cells to the brain. ● Apply mathematical concepts and processes to find and analyze patterns in numerical data and graphs of how the energy transferred by a vibrating object changes in proportion to changes in the amplitude and/or frequency of the object's vibrations. ● Develop and use a model to explain how loud sounds and the energy transfer associated with high amplitude sound waves cause damage to ear structures.

Interdisciplinary Connections
New Jersey Student Learning Standards-English Language Arts (2016) **SL.8.5** Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest. *(MS-PS4-1 and MS-PS4-2)* **New Jersey Student Learning Standards-Mathematics (2016)** **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)* **New Jersey Student Learning Standards- Computer Science & Design Thinking (2020)** **8.2.8.ETW.1:** Illustrate how a product is upcycled into a new product and analyze the short- and long-term benefits and costs. **8.2.8.ETW.2:** Analyze the impact of modifying resources in a product or system (e.g., materials, energy, information, time, tools, people, capital). **8.2.8.ETW.3:** Analyze the design of a product that negatively impacts the environment or society and develop possible solutions to lessen its impact.

8.2.8.EC.2: Examine the effects of ethical and unethical practices in product design and development.

Student Resources
Primary Source Readings ● Student Edition of Unit 8.2 **Secondary Source Readings** ● How Do Insects Make Sounds ● Where Else Are Lasers Used To Detect Vibrations ● How Does The Motion Detector Work ● Hearing In Elephants, Dogs, and Humans ● Information From The Experts **Supporting Text pages** ● Handouts - All student handouts are within the lesson folders for each unit in the teacher resource section ● Lesson 2 Instrument & Speaker Stations Directions **Technology** ● Turn It Up! Simulation ● Tone Generator ● Sound in a Medium ● Hitting the High Notes ● Feeling the Sound **Videos** ● Overview of Unit ● Truck Playing Music ● Slow Motion Guitar Strings ● Slow Motion Drums ● Slow Motion Speaker ● Slow Motion Tuning Fork ● Slow Motion Insects In Flight ● Slow Motion Bees In Flight ● Music Box Being Played ● Slow Motion Harp ● Phone Ringing In Vacuum Chamber ● Otoscope Demonstration ● Cochlear Animation ● Hair Cell Vibrating ● Invention To Fight Fires ● Truck Sound System

Teacher Resources
Texts: • Overview of Unit • Lesson 1 Folder • Lesson 2 Folder • Lesson 3 Folder • Lesson 4 Folder • Lesson 5 Folder • Lesson 6 Folder • Lesson 7 Folder • Lesson 8 Folder • Lesson 9 Folder • Lesson 10 Folder • Lesson 11 Folder • Lesson 12 Folder • Lesson 13 Folder • Lesson 14 Folder • Elements of NGSS Dimensions • OpenSciEd Teacher Handbook **Technology:** • Turn It Up! Simulation • Tone Generator • Sound in a Medium Simulation • Hitting the High Notes • Feeling the Sound • Data Collector Logger Lite Software from Venier (Tutorial for Using Software) **Websites:** • Ear Model • Dangerous Sounds • Humpback Whales - Alternate Activity **Videos:** • Overview of Unit • Lesson 3 Lab Setup • Motion Detector Software • Lesson 13 Lab Setup • Lesson 13 Lab Setup Part 2 **Materials:** • Materials List From OpenEdSci

Stage 2 – Assessment Evidence
Pre-Assessments: Lesson 1 IInitial model and driving question board (DQB) **Formative Assessments:** Lesson 2 Model construction Lesson 13 Transfer task **Formative- Summative Assessments:** Lesson 6 Summative midpoint assessment Lesson 11 Develop a model to explain a new phenomenon **Summative Assessments:** Lesson 14 Transfer Task LinkIt 8.2 Unit Assessment (TBD)

Stage 3 – Learning Plan
Lesson 1 (3 days): How does a sound source make something like this happen? We observe a perplexing phenomenon: Sound from a truck appears to make a window move from the parking lot. We note observations of this phenomenon as well as of a speaker in the classroom. Our observations, models, and other sound-related phenomena lead us to add a broad set of questions about sound to our Driving Question Board and to list ideas for investigations to pursue. **Lesson 2 (2 days): What is happening when speakers and other music makers make sounds?**When an instrument vibrates (makes sounds) it includes the following actions: ● A force is applied to a part of an object; that part bends or deforms and changes shape. Energy is transferred to the object. ● When the force is removed, that part of the object springs back and overshoots its starting position. ● That part of the object then repeatedly bends back and forth for a bit (we call this vibration) before stopping. When it stops vibrating, it stops making sounds **Lesson 3 (2 days): Do all objects vibrate when they make sounds?** All objects move back and forth (vibrate) when making sounds. Objects vibrate further back and forth (deform more) when a greater force is applied, creating louder sounds. **Lesson 4 (2 days): How do the vibrations of the sound source compare for louder versus softer sounds?** We deform (push) a stick to represent how sound makers move differently for louder or softer sounds. We notice that motion graphs of louder sounds have higher amplitude, and softer sounds have lower amplitude, but the number of vibrations of the stick per second (we called this frequency) didn't change whether we deformed the stick more or less.

Lesson 5 (1 day): How do the vibrations from a sound source compare for higher-pitch versus lower pitch sounds? We use mathematical representations of Position versus Time graphs generated from a tool used to scale up the vibrations of an object to describe wave patterns and support scientific conclusions about how objects move when they make higher-pitch and lower-pitch sounds.

Lesson 6 (2 days): How can any object make so many different sounds? We apply our understanding to explain different sounds coming from different objects, complete a summative mid-unit assessment, and return to our Driving Question Board.

Lesson 7 (1 day): What is actually moving from the sound source to the window? We test the idea that the air from the sound source is traveling to the window or our ears by placing a sound source in an airtight container and testing whether we can still hear it. We also record the mass of the container before and after the sound is produced. We use the understandings we gain from these investigations to revisit our initial models to analyze our earlier claims for what's traveling between the speaker and the window in the anchoring video.

Lesson 8 (1 day): Do we need air to hear sound? We test, through two investigations, whether air is even needed to hear sound. One investigation provides evidence that sound moves through any type of matter, while the other investigation provides evidence that sound can't move across empty space that has no matter in it (a vacuum). Sound can travel through all different kinds of matter (solids, liquids, and gasses), not just air. Sound cannot travel through an empty space with no matter; sound needs matter to travel.

Lesson 9 (1 day): How can we model sound traveling through a solid, liquid, or gas? We recall that models of all states of matter have particles, empty space, and motion. We simulate what happens in the surrounding matter as a vibrating object is interacting with it. This model suggests that motion (or energy) might be transferred through the medium from one end to another through particle collisions.

Lesson 10 (2 days): What exactly is traveling across the medium? We manipulate a computer simulation by changing either the pitch or loudness of the sound produced to see how the motion of the particles in the medium is affected.

Lesson 11 (2 days): How does sound make matter around us move? We develop a model to explain a new phenomenon: salt jumping on plastic wrap when a drum is hit. We develop a checklist that includes the key ideas we have developed about how sounds are caused and how sound can cause other things to move. Then, we apply that checklist to revising the model that explains why a window near the parking lot moved when a truck speaker was blasting music.

Lesson 12 (1 day): What goes on in people's ears so they can detect certain sounds? In order to find answers to their questions about how our ears detect sounds, students read an interview with experts and watch several videos and animations about the structures of the ear and how hearing loss can occur. They synthesize that information to annotate a model showing how energy is transferred through the parts of the ear to the nerve cells that send signals to the brain.

Lesson 13 (2 days): What transfers more energy, waves of bigger amplitude or waves of greater frequency? We conduct two investigations to measure "What transfers more energy, waves of bigger amplitude or waves of greater frequency?" First, we change how many times a marker representing the sound detector is hit by marbles in a given time period (the frequency) and measure the total distance the marker moved (the amount of energy transferred to the detector). Next, we change the force acting upon the marbles (changing the amplitude) and measure how this changes the distance the marker moves.

Lesson 14 (2 days): How can we explain our anchoring phenomenon, and which of our questions can we now answer? We revisit the Driving Question Board and discuss all of our questions that we have now answered. Then we demonstrate our understanding by individually taking an assessment. Finally, we reflect on our experiences in the unit.

Unit Plan Title	8. 3 Forces at a Distance
Suggested Time Frame	30 Days

Overview / Rationale
Music has a central place in the lives of young people. It has never been easier for them to listen to their favorite songs in the car, on the bus, or in the schoolyard. Middle school students spend countless hours cycling through playlists on their devices, using headphones or Bluetooth speakers that are designed and marketed to young people. Speakers, in their various forms, work with the simple movement of a speaker membrane, or speaker cone. But what causes this membrane to move? Can a tiny headphone do something similar to the subwoofer speaker in a car to play music? As speakers have evolved over time, one thing has remained the same: the use of magnets to vibrate the speaker membrane. Students are presented with an anchoring phenomenon focusing on the vibration of a speaker and asked to think about what causes this vibration. The vibration of a speaker connects to a model of sound students have developed previously, but this new unit opens the door for students to investigate the cause of a speaker's vibration as opposed to the effect. Students dissect speakers to explore the inner workings, and they build homemade cup speakers to manipulate the parts of the speaker. They identify that speakers of all kinds have some of the same parts--a magnet, a coil of wire, and a membrane. Students investigate each of these parts to figure out how they work together in the speaker system. Along the way, students manipulate the parts (e.g., changing the strength of the magnet, number of coils, current direction) to see how this technology could be modified to apply to systems in very different contexts, like MagLev trains, junkyard magnets, and electric motors.

Stage 1 – Desired Results
Established Goals: **New Jersey Student Learning Standards in Science (2020)** ● **MS PS 2-3** 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.]*

- **MS PS 2-5** Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact. *[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.]*

- **MS PS 3-2** 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.]*

- **MS PS 4-3 .** 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.]*

Essential Questions: • How can a magnet move an object without touching it? • Do all magnets attract or repulse with the same strength? • How can a magnet make electricity? • How does a magnet interact with a speaker?	***Enduring Understandings:*** *Students will understand:* • Magnets are attracted to certain metals. • Magnets exert a force (push or pull) on certain objects. • Magnets interact with certain substances to make electricity. • Digitized signals are more reliable than analog signals.
Knowledge: *Students will know…* • Vocab Terms: Magnet, Repulsion, Attraction, Paired Forces, Sound Wave, Medium, Magnetic Field, Electricity, Frequency, Volume	**Skills:** *Students will be able to…* • Develop an initial model to describe how interactions between parts of a speaker system (magnet and coil of wire) cause

• How to identify the different parts of a speaker. • How to describe interactions between the different parts of a speaker. • What causes sound in a speaker even though the parts are not touching. • How to collect data and establish causation using magnets • That magnets interact with certain objects in an attractive and repulsive manner. • That energy can transfer from magnet to magnet without transferring through matter. • That the energy transferred through magnets can cause the magnets to move. • How to use diagrams and simulations to model patterns observed in the interactions of magnets with materials. • Synthesize an argument (supported by empirical evidence) that energy can pass through/from one magnet to another. • How to diagram and simulate patterns of observed interactive forces at a distance • How to model forces and energy transfer in magnetic fields. • How to question a cause and effect relationship between the patterns that are observed. • How to explain/represent results garnered from an investigation of the interaction of magnetic forces. • How to investigate the pattern of energy flow through a magnetic system. • How to graph data identified in a magnetic investigation comparing force and distance. • How to use a computer simulation to model the patterns of a magnetic field.	sound without those parts touching each other. • Ask questions about how interactions between parts of a speaker system (magnet and coil of wire) cause sound without those parts touching each other. • Collect data to establish that magnets interact with certain objects to cause paired forces that are either attractive (both pulls) or repulsive (both pushes) and that changing the orientation of either of the magnets will cause both forces to reverse direction. • Collect data to answer questions about the coil of wire and provide evidence to support the claim that connecting the coil of wire to a battery causes the same paired forces between the coil and a magnet as between two magnets. • Develop and test a set of hypotheses to produce evidence that energy can transfer between magnets without transferring through matter, causing the magnets to move. • Construct an argument supported by empirical evidence and scientific reasoning that energy can transfer between magnets without going through matter, causing the magnets to move. • Ask questions about the cause and effect relationships that the patterns we observed (and will observe) in the direction or size of forces in a magnetic field around a permanent magnet as it interacts with another object(s) near it. • Use diagrams and simulations to model the patterns we observe in the forces experienced by test objects placed near a magnet or a coil of wire connected to a battery (magnetic fields). • Use a computer interactive to model the effect on the patterns in the magnetic field when we add an electromagnet to the single magnet system.

	- Develop an initial model to describe how forces and energy transfer in magnetic fields explain cause and effect relationships between parts of a speaker system (magnet and coil of wire). - Ask questions about how interactions between parts of a speaker system (magnet and coil of wire) cause sound without those parts touching each other. - Plan and carry out an investigation using a cart on a track to determine how changing the distance between two magnets affects the amount of energy transferred from the field between them. - Develop an explanation using results from the investigation to explain the interactions and behavior of the cart system using ideas about forces and potential energy - Ask questions and carry out investigations to answer questions about how the pattern of energy flow compares in different systems using a speaker, a wire coil, a lightbulb, a battery, and a computer. - Critically read scientific text to gather evidence to explain the differences in the electric current produced by the computer (the cause) that results in a changing magnetic field within the speaker system (the effect). - Revise a model to describe how changes in a magnetic field due to changing electric current explain cause and effect relationships between parts of a speaker system (magnet and coil of wire). - Ask questions about how changing the speaker system (cause) could affect the strength of the forces in the magnetic field (effect). - Plan an investigation to produce data to support hypotheses about the cause-and-effect relationship between distance and magnetic forces, including identifying independent and dependent variables.

	• Construct and use a graphical display of data to identify patterns in the mathematical relationship between distance and magnetic forces that can be used as evidence to either support or refute a hypothesis. • Plan and carry out an investigation to produce data to support a hypothesis about what factors cause changes in the strength of magnetic forces. • Analyze and interpret data to identify linear and nonlinear relationships between various independent variables and their effect on the strength of magnetic forces. • Revise a model to explain various phenomena that rely on magnetic forces at a distance using a series of cause-effect relationships. • Plan an investigation to determine the effect of changing the metal in an electromagnet on the forces in the system.

Interdisciplinary Connections
New Jersey Student Learning Standards-English Language Arts (2016) **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)* **SL.8.5** Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest. *(MS-PS4-1),(MS-PS4-2)* **New Jersey Student Learning Standards-Mathematics (2016)** **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)* **New Jersey Student Learning Standards- Computer Science & Design Thinking (2020)**

8.2.8.ETW.1: Illustrate how a product is upcycled into a new product and analyze the short- and long-term benefits and costs.
8.2.8.ETW.2: Analyze the impact of modifying resources in a product or system (e.g., materials, energy, information, time, tools, people, capital).
8.2.8.ETW.3: Analyze the design of a product that negatively impacts the environment or society and develop possible solutions to lessen its impact.
8.2.8.EC.2: Examine the effects of ethical and unethical practices in product design and development.

Student Resources

Primary Source Readings

- Student Edition of Unit 8.3

Secondary Source Readings

- Lesson 4 Finding The Way Reading
- Lesson 8 What Is Electric Current Reading
- Lesson 8 Music To My Ears Reading
- Lesson 9 Magnetic Levitation Trains Reading
- Lesson 9 Junkyard Magnets Reading
- Lesson 9 Electric Motors Reading
- Lesson 11 Strong or Weak Reading

Supporting Text pages

- Handouts - All student handouts are within the lesson folders for each unit in the teacher resource section
- Lesson 2 Investigation Instructions
- Lesson 2 Composition of Metals Chart
- Lesson 2 Magnets & Coils Investigation Instructions
- Lesson 9 Reference Guide
- Lesson 10 The identify and Interpret Strategy Guide

Technology

- Magnet Simulation
- Sound Simulation
- High Notes Simulation

Video

- Unit Overview
- Speaker In Slow Motion
- Dissecting a Speaker
- Sound Source in a Vacuum
- Magnetic Field Lines
- 3D Magnetic Field Viewer

Teacher Resources

Texts:

- Overview of Unit
- Lesson 1 Folder
- Lesson 2 Folder
- Lesson 3 Folder
- Lesson 4 Folder
- Lesson 5 Folder
- Lesson 6 Folder
- Lesson 7 Folder
- Lesson 8 Folder
- Lesson 9 Folder
- Lesson 10 Folder
- Lesson 11 Folder
- Lesson 12 Folder
- Elements of NGSS Dimensions
- OpenEdSci Teacher Handbook

Technology:

- Magnet Simulation
- Sound Simulation
- High Notes Simulation

Videos:

- Introduction To Unit
- Building A Cup Speaker
- Removing Wire Enamel
- Building Cup Speaker Part 2
- Setting up Sound Testing Station
- Setting up Magnets & Matter Investigation
- Magnetic Field With One Magnet
- Volume Demo With Speakers & Lightbulb
- Frequency Demonstration With Lightbulb
- Frequency Demonstration With Wire Coil & Compass
- Frequency Demonstration With Amplifier & LED Bulb
- Investigating Speaker System

Materials:

- OpenEdSci Materials List

Stage 2 – Assessment Evidence
Pre-Assessments:

Lesson 1 - The student work in lesson 1 available for assessment should be considered a pre-assessment. It is an opportunity to learn where students are coming in and what ideas they have that you can build on in this unit. The more ideas in your classroom the better. Specifically, look for students' initial understandings of modeling, asking questions, systems and systems models, and cause & effect.

Formative Assessments:

Lesson 3 - This lesson is the first time students build hypotheses -- an important component of the asking questions practice. In Lesson 3, for the first time, students frame a hypothesis, which includes not only an observable cause-and-effect pattern, but also the mechanistic explanation that we hope to uncover through an investigation that establishes the pattern.

Lesson 7 - Students develop a hypothesis for the investigation and do some initial planning for the investigation. This is an opportunity to understand students' progress with respect to developing hypotheses and identifying variables in their investigations.

Lesson 9 - Provides an opportunity for formative assessment of students' models of the speaker system. Students discuss the development of models to explain the speaker system in groups and then individually draw them in their notebooks.

Formative-Summative Assessments:

Lesson 6 **-** This lesson is a putting the pieces together lesson. It includes a summative midpoint assessment that can provide formative information for moving forward in the unit. The teacher reference document provides a scoring guide. This midpoint assessment is important formatively to make sure the class is on the same page and ready to move forward in the unit. At this point, students should be comfortable with the following claims: If a system contains a permanent magnet and we bring a paperclip near the system, we will feel a pull. If a system does not contain a permanent magnet and we bring a paperclip near the system, we will not feel a pull, indicating that there are no forces on the paperclip Connecting a copper coil to a magnet creates an electromagnet creating an attractive magnet field that creates force pairs with metal objects

Lesson 1**1** - Students work in groups to plan and carry out a complete investigation. This is an opportunity to assess students as they work in groups. You could decide to use their group work as a summative assessment opportunity. We recommend reviewing the investigation plans for formative information and giving students feedback.

Summative Assessments:

Lesson 12 - This is a transfer task to give students an opportunity to use the 3 dimensions to make sense of an application of an electromagnet of their choice. This assessment is designed to elicit student ideas about forces at a distance as they design an experiment, using the cause-effect language they have been practicing throughout this unit.

LinkIt 8.3 Unit Assessment (to be created)

Stage 3 – Learning Plan
Lesson 1 (4 days): What causes a speaker to vibrate? We dissect a store bought speaker and then build a homemade speaker. We develop an initial model to describe how interactions between parts of a speaker system cause sound without touching each other. Finally, we generate questions for our Driving Question Board (DQB) using a cause-effect scaffold that we will return to throughout the unit. **Lesson 2 (2 days): What can a magnet pull or push without touching?** We experiment with magnets, coils and other metal objects to establish that while certain metals do interact with magnets, including other magnets, the copper coil does not. We notice force pairs between the magnet and the coil only when the coil is hooked up to a battery. **Lesson 3 (1 day): How does energy transfer between things that are not touching?** We are wondering how energy could transfer between parts of the speaker when the parts aren't touching. We think the energy might be transferring through the air. We write two hypotheses that predict the cause-and-effect relationships we would observe if energy transferred between magnets through the air. **Lesson 4 (4 days): What can we figure out about the invisible space around a magnet?** We wonder about the space around a magnet that seems to push and pull on certain things. We learn that this space is called a magnetic field. We decide to investigate the field with test objects, like iron filings and compasses. We learn what the magnetic field looks like and that the field is not the same in every location around a magnet. **Lesson 5 (1 day): How does the magnetic field change when we add another magnet to the system?** We use a computer interactive to simulate the fields between a magnet and a coil for both attractive and repulsive forces at two different distances apart. We make diagrammatic models of the fields and come to consensus around how to represent the fields. **Lesson 6 (3 days): How can we use magnetic fields to explain interactions at a distance between the magnet and the coil?** We develop an initial model to describe how forces and energy transfer in magnetic fields explain cause and-effect relationships between parts of a speaker system (magnet and coil of wire). We ask questions about how interactions between the magnet and the coil of wire cause sound without those parts touching each other. **Lesson 7 (1 day): How does changing the distance between two magnets affect the amount of energy transferred out of the field?** We plan and carry out an investigation using a cart on a track to determine how changing the distance between two magnets that experience repulsive forces between them affects the energy transferred in a magnetic field between them. We use our

results to explain how changing the distance between two magnets affects the amount of energy transferred into and out of the magnetic field.

Lesson 8 (3 days): How does the energy transferred from a battery to a wire coil compare to the energy transferred from a computer to a speaker? We vary the volume and frequency of sounds being produced by a sound generator on a computer and observe the effects. We gather information using various materials including light bulbs to help explain how changes in the electric current produced by the computer results in changes to a magnetic field within the speaker system.

Lesson 9 (3 days): How do the magnet and the electromagnet work together to move the speaker? We add to our list the cause-and-effect relationships. Then we construct a classroom consensus model to explain these relationships and how they work together to produce the patterns of movement we see in the speaker. After a brainstorm and a reading jigsaw, we wonder what we could do to make magnetic forces strong enough to lift trains and cars.

Lesson 10 (3 days): How does distance affect the strength of force pairs in a magnetic field? We co-design and then carry out an investigation using a digital scale to test the relationship between distance and magnetic force. We analyze graphs to determine the relationship between distance and magnetic force between two magnets.

Lesson 11 (3 days): What else determines the strength of the force pairs between two magnets in a magnetic field? We plan and carry out an investigation to produce data to support a hypothesis about what factors cause changes in the strength of magnetic forces.

Lesson 12 (2 days): What cause-effect relationships explain how magnetic forces at a distance make things work? We took stock of how far we have come and applied our new ideas about the strength of forces to both the speaker and the other electromagnet applications we have considered. We revisited the DQB one last time to answer our remaining questions. Finally, we took an assessment.

Unit Plan Title	8.4 Earth In Space
Suggested Time Frame	31 days

Overview / Rationale
Humans have always been driven by noticing, recording, and understanding patterns and by trying to figure out how we fit within much larger systems. Students begin observing the repeating biannual pattern of the Sun setting perfectly aligned between buildings in New York City along particular streets and then connecting, exploring, and trying to explain additional patterns in the sky that they and others have observed. In this unit they explore scale and develop a model of the solar system and figure out that gravity is the driving force behind the patterns of motion of these objects and the organization of the solar system as well as the driving force behind the organization of more distant systems (galaxies) that we cannot see with unaided eyes from Earth.

<table>
<tr><th colspan="2">Stage 1 – Desired Results</th></tr>
<tr><td colspan="2">Established Goals:
New Jersey Student Learning Standards in Science (2020)
● MS-PS2-4: Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects.
● MS-PS4-2: Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.
● MS-ESS1-1: Develop and use a model of the Earth-sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons.
● MS-ESS1-2: Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system.
● MS-ESS1-3: Analyze and interpret data to determine scale properties of objects in the solar system.</td></tr>
<tr><td>Essential Questions:
● How are we connected to the patterns we see in the sky?
● What patterns are happening in the sky that I have experienced and can observe (through models and tools)?</td><td>Enduring Understandings:
Students will understand:
● The sun sets between buildings in New York City just two days of the year. People across cultures and time have studied the</td></tr>
</table>

• How can we explain the Sun's path change over time? • How do these changes in sunlight impact us here on Earth? • How can we explain phenomena like Manhattanhenge? • Why do we see the shape of the Moon change? • Why do we see eclipses and when do we see them? • What does a lunar eclipse look like and how can we explain it? • Why do the Moon and Sun appear to change color near the horizon? • How does light interact with matter in the atmosphere? • How does the shape of a water droplet or an ice crystal cause sunlight to form into a rainbow? • Why does the Moon always change color during a lunar eclipse? • What new patterns do we see when we look more closely at other objects in the sky? • Why do some solar system objects orbit planets and others orbit the Sun? • How did the solar system get to be the way it is today? • What patterns and phenomena are beyond our solar system that we cannot see with just our eyes? • How are we connected to all of the systems in space beyond the planet we live on?	sky and relied on connections to the sky in their lives. • There are repeating patterns in the paths that the Sun and stars appear to move through the sky over time. • Patterns of the Sun in the sky and sunlight over the globe vary in predictable patterns every year. • When a flashlight shines on graph paper, at different angles, it produces a different sized spot on the paper. • The sun sets between buildings in New York City just two days of the year. • The shape of the Moon seen from Earth changes monthly from full circle to nothing. • Sometimes the Sun gets blocked by the Moon. • The Moon looks reddish during a total lunar eclipse (not dark like we predicted). • The Sun and Moon turn a reddish color when they're rising or setting. Earth is surrounded by an atmosphere that forms a curved layer of gas, water droplets, ice crystals, and dust particles surrounding the entire surface of the Earth, about 60 miles thick, which gets less dense the further up you go. • When we shine a white flashlight through narrow and wide clear tubs of water mixed with a little bit of white particulate matter (milk), the color of the light that's scattered off looks bluer than the flashlight color, and the light that transmits through gets oranger or redder the more of that medium it travels through. • Sometimes when light strikes water droplets in the atmosphere, it produces rainbows. The individual colors are less bright than the original light. • Objects appear in different colors and in different places under water. • Various technologies have been developed over the last 400 years that help us observe changes in the position and

<table>
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<td></td>
<td>appearance of planets in the sky as well as gather additional data from their atmospheres and surfaces.

A computer interactive allows us to adjust the distance, speed, and mass between two objects and simulate the outcomes from simulated gravitational forces between them.
There are many craters visible on moons and planets with little or no atmosphere on them. Simulations that include matter distributed across space in very small particles (dust, molecules, etc.) and gravity force produce outcomes that show how the motion and distribution of that matter changes over time.
Telescope photos show many distant clusters of stars located in what appears to the unaided eye to be empty space.
From far away, Earth looks like a little pale blue dot floating in space.
</td>
</tr>
<tr>
<td>Knowledge:
Students will know…

Changing patterns in the sky connect to our (daily) lives and set the rhythms for life on Earth.
Stories and analogies related to the sky are legitimate ways to preserve knowledge about the stars and planets and aid in observing and decision making.
Light travels in a straight line; it must enter our eye in order for us to see the object it came from.
The Earth rotates about its axis once every day and orbits the Sun once every year.
In order to better explain and understand a complex system, we may need to view/visualize it from multiple perspectives.
In the Northern Hemisphere, Earth's northern axis is always pointed toward the North Star, which explains why it does not appear to move in the night sky.
</td>
<td>Skills:
Students will be able to…

Ask questions about systems in space that arise from observations of patterns in the sky.
Obtain information from images, videos, and podcasts to describe patterns in natural phenomena of objects in the Solar System (and beyond), as seen from Earth.
Develop an initial model of systems in space to describe patterns we observe in the sky.
Use a graphical display (a virtual fisheye projection of the sun, moon, and stars in the sky and compass points across the horizon) to identify temporal and spatial relationships (patterns in location of sunrise/moonrise and sunset/moonset, the paths of motion of the sun and moon, and and how most stars move and which one doesn't in the sky at night) in a large data set (across 6 months from a specific location on earth's surface).
</td>
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</table>

● The Sun and Moon appear to rise in the eastern sky, move across the sky from east to west, and set in the west. ● The stars visible in the night sky in the Northern Hemisphere appear to move counterclockwise in a circular path around the North Star. This is because the Earth spins counterclockwise on its axis when looking down on it from above its North Pole. ● Changes in the length of a day and angle of elevation of the Sun in the sky occur in a regular, repetitive, and cyclical pattern. ● Earth's axis is tilted at an angle and is pointed in the Northern hemisphere towards Polaris, called the "North star". ● As the Earth orbits around the Sun and is tilted on its axis, we observe changes in the amount of daylight and how high the Sun is in the sky over the course of the year. ● Solar elevation causes differences in the intensity of light reaching Earth's surface throughout the year. ● Higher solar elevation results in more direct sunlight and greater light energy reaching Earth's surface causing higher temperatures. ● Lower solar elevation results in sunlight being more spread out and less light energy reaching Earth's surface causing lower temperatures. ● When the sunlight is direct on the top half of Earth (the Northern Hemisphere), it is at an angle in the Southern Hemisphere, and vice versa. This is one reason (in addition to corresponding changes to the amount of daylight hours) why the seasonal patterns are the opposite in places like Australia and South Africa compared to our area. ● The light rays from the Sun at sunset follow a straight path that happens to align down many streets between the	● Use a graphical display (simulated motion from a virtual fisheye projection of the sun, moon, and stars in the sky and compass points across the horizon) to identify temporal and spatial relationships (patterns in solar elevation and length of day) in a large data set (across 6 months from a specific location on earth's surfaces). ● Collect and produce data showing patterns of changes in daylight and the angle of elevation of the Sun in the sky to serve as evidence to evaluate the accuracy of an initial physical Earth–Sun System model. ● Revise a model of the patterns of movement of the Earth around the Sun to explain that changes in the amount of sunlight and angle of elevation of the Sun in the sky during the year is due to Earth's axis being tilted toward Polaris. ● Develop, revise, and use models of the Earth-Sun system to create mathematical relationships of the seasonal patterns of the position of the Sun in the sky and of temperatures over the surface of Earth. ● Develop and use models of the Earth-Sun system to explain the cause-and-effect relationships between Earth's tilt, solar elevation, and sunlight energy on Earth's surface to explain seasonal temperature differences. ● Develop and use a model of the Earth-Sun system to explain how Earth's fixed tilt and orbit would cause a cyclical pattern in the location of the Sun at sunset that repeats every year. ● Develop and use a model of the Earth-Sun-Moon system to explain and predict patterns we observe in the way the apparent shape of the Moon changes over time. ● Develop and use a model of the Earth-Sun-Moon system to explain why and when we can see a solar eclipse.

buildings on either side in Manhattan only 2 times a year. ● There is a reversal (symmetry) in the pattern of change in where the Sun sets (and rises), day length, and the angle of the Sun in the sky that occur between the summer and winter solstice. ● The fixed tilt of Earth's axis and its orbit around the Sun causes this reversal in these patterns of change between the two extreme points in its orbit, in terms of how much the Earth's tilt is pointed toward the Sun (summer solstice and winter solstice). ● People have watched the Moon across time and cultures. ● Light from the Sun shines on only half of the Moon. ● The shape of the Moon we see from one day to the next is a result of its position in space relative to Earth; the appearance of the shape of the Moon that we see on any particular day can be explained in terms of how much of the sunlit side we can see at that time. ● We can see the Moon at different times of the day and night. ● Sometimes the Moon lines up in its orbit between the Sun and the Earth, resulting in the Moon casting a shadow on the Earth. This is what causes a solar eclipse. ● The Moon's orbit is not perfectly flat relative to Earth's orbit around the Sun; it is tilted just a little. This is why we don't see eclipses every month. ● The Moon is full during a lunar eclipse; this is what our model predicted. ● The Moon turns reddish and dimmer (still visible) during a lunar eclipse but does not become completely dark (not visible); this is not what our model predicted. ● There are other times when we have experienced the Moon or Sun changing color like this (to reddish or orange).	● Evaluate the limitations of our system model predicting what we would see during a lunar eclipse. ● Revise our Earth–Sun system model to include ideas about how the Earth's atmosphere causes light from the Sun and Moon to change colors. ● Carry out an investigation to collect data as evidence of the effect of light interacting with a simulated atmosphere. ● Conduct an investigation to collect and produce data as evidence to answer scientific questions about relationships of light interacting with differently shaped objects of varying compositions. ● Develop and use a model to describe the separation of white light into different colors (effect) as it travels through different mediums (cause). ● Develop and use a model of light in the Earth-Sun-Moon system to describe why the Moon changes color during a lunar eclipse. ● Apply science ideas (selective reflection, absorption and transmission of different colors of light by different media and the refraction of light across different media) and evidence to provide an explanation for what causes the apparent color and location of some objects to change under water (effect). ● Read an article and use it to determine some observations people have made of one planet (Venus) in the past, the patterns they noticed over time, and different connections that different cultures have made to Venus. ● Construct an explanation of the patterns in the apparent size and shape (scale properties) of Venus from Earth as it orbits the Sun. ● Analyze and interpret data to identify patterns in and between different scale properties for planets and some of their moons in our solar system (including

- The color (and brightness) of the Moon and Sun seem to change when those objects are seen near the horizon. - Sunlight in space (above the Earth's atmosphere) is whiter (and brighter) than sunlight we see from the surface of Earth through the atmosphere. - Light travels through empty space (even when there is very little or no matter. - Earth's atmosphere forms a layer (about 60 miles thick) of gas, water droplets, ice crystals, and dust particles that gets less dense higher up. That composition can change slightly in different places and from day to day. - The atmosphere looks bluish during the day and from space. - At sunrise and sunset, the light coming from the Sun passes through the atmosphere at a shallow angle compared to other times of day; when this happens, the light from the Sun takes a longer path to get to you, which means it travels through more of the atmosphere. - Sunlight dims slightly in brightness and appears yellower, oranger, and then redder the more of Earth's atmosphere it passes through. - Although sunlight is white in space, some of the colors are scattered out as it passes through Earth's atmosphere, so it appears yellower, oranger, and redder the more of Earth's atmosphere it passes through. Sunlight also dims a bit in brightness the more atmosphere (longer path) it passes through. - When we shine a flashlight through a simulated atmosphere, the original white color becomes oranger or redder the more "atmosphere" it travels through. - We observe a blue color when the white light interacts with the particles in the simulated atmosphere. - When we shine a flashlight through a simulated atmosphere, the brightness of	relative size, orbital distance from the Sun, surface features, if any, and atmosphere). - Develop and revise an initial model of the Earth-Moon system to show the location, strength, and interaction of gravitational forces in the system. - Use a simulation of a two-object system to produce data that can be analyzed to identify patterns to determine how changes in the mass or distance between the objects in the system affects the strength of gravitational forces between those objects in space. - Develop and map evidence from written and media sources to support the claim that the solar system formed from a disk of gas and dust, drawn together by gravity that was once chaotic but has become more stable over time. - Compare and critique two arguments emphasizing the same evidence (images of galaxies) about the organization of systems in space. - Obtain and synthesize information across multiple sources about the organization of space systems in our universe from the human scale to the galactic scale. - Develop a model of the universe that shows how gravity forces cause the patterns of motion and organization of objects in space systems at multiple scales.

the light we see decreases the longer the path the light travels through it. ● When light interacts with water and/or glass of certain shapes and at certain angles, it can produce a rainbow. ● What you observe is dependent on the perspective of the observer. ● Each color in the rainbow that is produced is less bright than the light that reaches the water/glass; the path that each color of that light follows is a straight line after it leaves the water or the glass. ● Materials like water or glass must be able to separate the white light into different colors and change their path based on what color they are. ● White light is a combination of different colors (e.g., red, green, and blue) ● Combining different colors of light together results in more intense light (brighter). ● Because they are used under water, where light gets filtered through the water, fish lures are made in specific colors that transmit better through water at different depths so they will be more visible to the eyes of the fish that are living at those depths than other colors would be. ● Fish appear in different positions under water than they actually are to an observer above the water because the light traveling from the fish to the observer's eye travels out of the water and into the air, bending—or refracting—as it travels from one medium (water) into another medium (air). ● Even though Venus and other planets in the sky look like stars, they move differently and their position changes. ● Planets closer to the Sun are rocky and small, and objects farther out are large and gaseous. ● All solar system objects orbit the Sun in the same direction (counterclockwise if	

looking down on Earth's Northern Hemisphere from above it). ● There are nested patterns of orbits, but smaller objects tend to orbit larger objects. ● Most objects are orbiting the solar system on a similar plane. ● Gravity is an attractive force between all matter. ● More massive objects have stronger attractive gravitational forces between them than objects that are less massive. ● Closer objects have stronger attractive gravitational forces between them than objects farther away. ● More circular orbits occur when there is the right combination between the force of gravity and the speed of the orbiting object. ● The Sun formed in the center of a disk of gas. ● The matter in the disk of gas began to collect to form bigger clumps of matter (e.g., pebbles) due to gravity. ● These pebbles collided and clumped together to form smaller planets. ● The smaller planets collided many times over several millions of years, resulting in the creation of larger planets, asteroids, and comets. ● The collisions became less common as objects in the solar system as the objects had stable orbits. ● Earth orbits the Sun, making the Sun and Earth part of our solar system, along with other planets, asteroids, comets, and so forth. ● Moons orbit planets, creating subsystems of the solar system. ● Earth and its solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe. ● Gravity appears to determine this organization because in the places where	

there is stuff, that stuff is held together by gravity. ● We can explain why there is a similar pattern in the motion structure and organization of the largest scale objects and systems in the known universe, using the same interactions (gravitational forces that are acting on those objects). ● We can answer many of our Driving Question Board questions!	

Interdisciplinary Connections
New Jersey Student Learning Standards-English Language Arts (2016) **WHST.6-8.1** Write arguments focused on discipline-specific content. (MS-PS2-4) **SL.8.5** Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest. (MS-PS4-1),(MS-PS4-2) **SL.8.5** Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest.(MS-ESS1-1) **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) **New Jersey Student Learning Standards-Mathematics (2016)** **MP.2** Reason abstractly and quantitatively. (MS-PS4-1; 1-3) **MP.4** Model with mathematics. (MS-PS4-1; 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-PS4-1; MS-ESS1-1, 1-3) **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; MS-ESS1-1; 1-3) **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) **New Jersey Student Learning Standards- Computer Science & Design Thinking (2020)** **8.2.8.ED.2** Identify the steps in the design process that could be used to solve a problem. **8.2.8.ED.3** Develop a proposal for a solution to a real-world problem that includes a model (e.g., physical prototype, graphical/technical sketch). **8.2.8.ED.4** Investigate a malfunctioning system, identify its impact, and explain the step-by-step process used to troubleshoot, evaluate, and test options to repair the product in a collaborative team.

Student Resources
Primary Source Readings ● 8.4 Earth in Space Student Edition Secondary Source Readings ● Achieve3000 articles ○ The Science of Solar Eclipses ○ A Wonder in the Sky ○ A Magical Sky ○ The Skies Got Dark Supporting Text pages ● Handouts - All student handouts are within the lesson folders ● Technology ○ Websites: ■ 8.4 L14 Exploring Orbits – Adjustable Perspective ■ 8.4 L14 Exploring Orbits – Fixed Perspective ■ 8.4 L6 Moon Shape Patterns ○ Videos: ■ Unit 8.4 Student Video Playlist
Teacher Resources
● **Texts:** ○ **8.4 Earth in Space Teacher Edition** ○ **OpenSciEd Teacher Handbook** ○ **8.4 Elements of NGSS Dimensions** ○ **8.4 Earth in Space Unit Overview Materials** ● **Supplemental Text:** ○ Achieve3000 articles ■ The Science of Solar Eclipses ■ A Wonder in the Sky ■ A Magical Sky ■ The Skies Got Dark ● **Technology** ○ **Websites:** ■ 8.4 L14 Exploring Orbits – Adjustable Perspective ■ 8.4 L14 Exploring Orbits – Fixed Perspective ■ 8.4 L6 Moon Shape Patterns ○ **Videos:** ■ **Unit 8.4 Teacher Video Playlist** ■ **Unit 8.4 Earth in Space Video Links**

Stage 2 – Assessment Evidence
Pre-Assessments: The student work in Lesson 1 available for assessment should be considered a pre-assessment. It is an opportunity to learn more about the ideas your students bring to this unit. Revealing these

ideas early on can help you be more strategic in how to build from and leverage student ideas across the unit.

The Initial Manhattanhenge Model on day 1 of Lesson 1 allows you to pre-assess what students are bringing in from earlier grade bands and OpenSciEd units, across all three dimensions.

The initial model to explain a chosen pattern in the sky developed on day 3 of Lesson 1 is a good opportunity to pre-assess student understanding of which parts of the system are important to explaining patterns and phenomena in the sky, what students already know about space, and areas of engagement to draw up later in the lesson/unit.

Throughout the lesson, students will add ideas to the Patterns and Phenomena in the Sky Poster. Listen for students to not only make DCI level connections to patterns with the objects in the solar system, stars, and galaxy but also to their personal life to leverage their engagement throughout the unit.

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

Formative Assessments:
In this assessment opportunity, students work in groups to develop a Earth-Sun-Moon system model to explain when and why we can see a solar eclipse. During the modeling, students should use their physical models to communicate about the relationship of where an observer is on Earth and the Moon's position relative to the Sun and Earth so that the observer would see a solar eclipse. Students will also have an opportunity to reflect on their use of different models to compare the purpose of each model and identify the boundaries and limitations of each. Students identify the purpose of using both physical and drawn models—including different perspectives—and their various limitations. If time permits, students can complete Lesson 7: Self-Assessment for Collaborative Group Work as part of their reflection.

Summative Assessments:
There is a summative assessment early in this unit because there are several key ideas around seasonal temperature variation that we will not revisit in the unit. This assessment asks students to use their Gotta-Have-It Checklists, seasonal temperature variation data in the assessment, and a model to explain what causes the varied temperatures (effect in different seasons in Australia

like we heard about in the podcasts. The assessment also asks students to explain seasons and temperature variation by comparing the Northern and Southern Hemispheres.

In this assessment, students have an opportunity to demonstrate their understanding of how light travels through different mediums to explain why a certain color of a fishing lure would be a better choice for fishing than other colors that are less visible underwater at the depths where fish live.

Students apply science ideas to explain why some colors are more visible than others underwater and how an object can appear in a different location than they actually are underwater. Students use their ideas about how light travels through the atmosphere to compare to what is visible underwater.

In this assessment, students work in small groups to develop a model to demonstrate their understanding about the role gravity forces play in the organization of objects of various scales (galaxies, solar systems, planet-moon systems) in the universe. During a gallery walk, students notice similarities and differences between their small group model and other small group models and use those to revise their original group's model. Finally, students work to develop a class consensus model of the universe.

Students apply ideas about factors that influence gravity forces to shape the universe and develop explanations for why so much of the universe is composed of empty space. They build a model of the universe showing nested subsystems of galaxies, solar systems within galaxies, and planet-moon systems within solar systems.

Performance Task(s):
The Progress Tracker is a thinking tool that was designed to help students keep track of important discoveries that the class makes while investigating phenomena and figure out how to prioritize and use those discoveries to develop a model to explain phenomena. It is important that what the students write in the Progress Tracker reflects their own thinking at that particular moment in time. In this way, the Progress Tracker can be used to formatively assess individual student progress or for students to assess their own understanding throughout the unit. Because the Progress Tracker is meant to be a thinking tool for kids, we strongly suggest it is not collected for a summative "grade" other than for completion.

Stage 3 – Learning Plan
Lesson 1 (4 days) How are we connected to the patterns we see in the sky? We analyze and consider how light from the Sun aligned with structures made by humans on a particular day and develop an initial model to explain this phenomenon. We gather, connect with,

and jigsaw stories about patterns in the sky they have seen or heard about and how these might be connected to the rhythms of human life. We develop a model of the parts of the system that are needed to explain many of the patterns we have identified.

Lesson 2 (1 day) What patterns are happening in the sky that I have experienced and can observe (through models and tools)?
We gather information from videos of Native American stories about a star that does not move in the night sky. We share our experiences about noticing this star, sometimes called the North Star. We watch a video and share the repeated patterns and changes that we observe in the sky. We develop initial models to explain why the North Star does not appear to move in the night sky.

Lesson 3 (3 days) How can we explain the Sun's path change over time?
We watch a video to observe the simulated motion of the Sun through the sky over a day for different times of the year. We notice that in summer the apparent path of the Sun in the sky is higher and the daytime is longer. We create physical models to see if our understanding about why this is happening is correct. Our physical models cannot account for differences in the length of daylight over a year. We revise our model of the system in small groups to try to account for changes in the amount of daylight.

Lesson 4 (2 days) How do these changes in sunlight impact us here on Earth?
We analyze seasonal temperature data from two cities in the US and argue that changes in Earth's distance from the Sun do not explain seasonal temperature differences. We develop a physical model and use it to collect changes of sunlight energy on Earth's surface as a result of changes in solar elevation. We use this relationship to explain seasonal temperature differences in other parts of the world.

Lesson 5 (1 day) How can we explain phenomena like Manhattanhenge?
We use a video simulation to investigate patterns we think might be responsible for Manhattanhenge. We revise a model of the Manhattan solar phenomenon. We revisit the Driving Question Board to connect what questions we have answered and what questions remain.

Lesson 6 (2 days) Why do we see the shape of the Moon change?
We use a physical model and an online interactive to help make sense of the positions of the objects in the Earth-Sun-Moon system that cause us to see the current shape of the Moon. We also use our physical models to predict the next phase of the Moon.

Lesson 7 (2 days) Why do we see eclipses and when do we see them?
We watch a video of a solar eclipse. We develop a model to explain what we saw in the video using a physical model of the system. We compile the ideas we want to include in a drawn model using multiple perspectives to communicate what is seen when a solar eclipse happens and why. We return to our physical models to figure out why we do not see a solar eclipse every month and how often we might expect to see a solar eclipse.

Lesson 8 (1 day) What does a lunar eclipse look like and how can we explain it?

We analyze images of lunar eclipses and compare them to the lunar eclipse predictive model we made as a class in Lesson 7. The reddish color of the Moon that we observe during a lunar eclipse is unexpected. So we list possible causes of that reddish color and gather examples of related phenomena of objects reddening in the sky. After posting our color-related questions, we generate ideas for investigating them.

Lesson 9 (1 day) Why do the Moon and Sun appear to change color near the horizon?
We examine images of the Sun and Moon and propose that something about the Earth's atmosphere could be contributing to the color changes. We examine diagrams of the atmosphere and images of the Sun from space. We add the Earth's atmosphere to our model of the Earth–Sun system and zoom in on the Sun at different times. We predict different angles of light and/or the amount of the atmosphere affects the color at sunrise compared to midday.

Lesson 10 (1 day) How does light interact with matter in the atmosphere?
We investigate the color and brightness changes we see as light travels through the Earth's atmosphere by using a flashlight to simulate the Sun and a rectangular bin of milky water to simulate the atmosphere. We use our investigation results to co-construct a model of light transmitting and scattering through the simulated atmosphere.

Lesson 11 (2 days) How does the shape of a water droplet or an ice crystal cause sunlight to form into a rainbow?
We investigate times, places and perspectives needed to see white light split into its component colors—making a rainbow. We investigate the effect that different materials and their shapes have on (white) light—causing it to change direction (refract) and sometimes make colors and rainbows. We conduct another investigation to recombine colors of light. We discover that combining light in different ways can change the overall color and brightness of the light that you see.

Lesson 12 (2 days) Why does the Moon always change color during a lunar eclipse?
We celebrate the knowledge we have figured out in previous lessons that can help us explain color change during lunar eclipses. We evaluate models created in those lessons before co-constructing a new model of what is happening during a lunar eclipse. We prepare for and complete a transfer task.

Lesson 13 (3 days) What new patterns do we see when we look more closely at other objects in the sky?
We revisit unanswered DQB questions and decide to focus on other objects in our solar system. We gather information from a reading to identify connections and observations about one other planet, Venus. We notice additional patterns in other observations of Venus and record new questions about these. We use a model showing the relative position of motion of Venus and Earth in the system to explain these patterns. We analyze the scale properties of other planets to look for other patterns.

Lesson 14 (2 days) Why do some solar system objects orbit planets and others orbit the Sun?

We share initial ideas about patterns of motion in the solar system, which leads us to conduct a cause-and effect thought experiment around those patterns. We use a simulation to investigate how changing distance and size affects an object's orbit around another object in the solar system. We build understanding as a class about the relationship between size, distance, and the strength of the force of gravity before demonstrating our understanding on formative assessments.

Lesson 15 (1 day)   How did the solar system get to be the way it is today?
We analyze images of craters on the surface of Mercury and two moons. We watch a video showing the results of a computer simulation that models the formation of the solar system. We develop storyboards to support the claim that the solar system was formed from a disk of gas and dust, drawn together by gravity. We build a class consensus storyboard model of the formation of the solar system

Lesson 16 (1 day)   What patterns and phenomena are beyond our solar system that we cannot see with just our eyes?
We look at a photo taken by the Hubble telescope of blobs in the space between stars. We learn that these are galaxies, islands of stars much like the ones we see in the sky. We watch the Tour of the Universe to visualize how scientists model the universe at various scales. We notice that the universe appears to be organized into systems held together by gravity, separated by vast emptiness.

Lesson 17 (2 days)   How are we connected to all of the systems in space beyond the planet we live on?
We make a classroom consensus model at various scales to show how gravity organizes the universe. We return to the DQB to take stock of how far we have come in this unit and then reflect on the unit and Earth’s place in the universe.

Unit Plan Title	8.5 Genetics
Suggested Time Frame	28 days

Overview / Rationale
This unit on genetics starts out with students noticing and wondering about photos of two cattle, one of whom has significantly more muscle than the other. The students then observe photos of other animals with similar differences in musculature: dogs, fish, rabbits, and mice. After developing initial models for the possible causes of these differences in musculature, students explore a collection of photos showing a range of visible differences. Students gather other examples of trait variation they've seen in their lives and share them with the class. The photos they've seen and discussions they've had about trait variation spark questions and ideas for investigations generally around why there are differences among living things and specifically around the causes of these extra-big muscles.Students use videos, photos, data sets, and readings to investigate what causes an animal to get extra-big muscles. Students figure out how muscles typically develop as a result of environmental factors such as exercise and diet. Students explore selective breeding in cattle. Students use what they've learned from explaining cattle musculature to help them explain other trait variations they've seen. They investigate plant reproduction, including selective breeding and asexual reproduction (in plants and other organisms) and other examples of traits that are influenced by genetic and environmental factors. Students figure out that environmental and genetic factors together play a role in the differences we see among living things.

Stage 1 – Desired Results
Established Goals: ● **MS-LS1-2**: Develop and use a model to describe the function of a cell as a whole and ways parts of cells contribute to the function. ● **MS-LS1-4:** Use arguments based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively. ● **MS-LS1-5**: Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms. ● **MS-LS3-1**: Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism.

MS-LS3-2: Develop and use a model to describe why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation. **MS-LS4-5**: Gather and synthesize information about the technologies that have changed the way humans influence the inheritance of desired traits in organisms.	
Essential Questions: - How do organisms get their differences? - How do extra-big muscles compare to typical ones up close? - How do diet and exercise affect muscle size? - What is different about the food and exercise for cattle with extra-big muscles? - Where do the babies with extra-big muscles get that trait variation? - How do chromosomes cause cattle to be born with extra-big muscles? - How does an animal get extra-big muscles? - Why don’t offspring always look like their parents or their siblings? - How do farmers control the variation in their animals? - How can we use our model to explain a different trait variation? - How can we answer the rest of our questions? - Do plants have genetic material? - How do plants reproduce? (How) do other organisms reproduce without sperm and eggs? - How do we get variations if the genetic information is exactly the same? - How much of trait variation in a population is controlled by genes or by the environment? - Why are living things different from one another?	**Enduring Understandings:** *Students will understand:* - There are cattle (and several other animals) that have extra-big muscles. - Students view videos and images of muscle composition and analyze data from extra-big-muscled animals versus typically muscled animals showing differences in muscle cells. - Data in text, images, graphs, and charts show the effect of diet and exercise on muscle growth. - A farmer talks about the lifestyle and diet of extra-big, heavily muscled cattle. Images of baby cattle show that heavily muscled animals are born with bigger muscles. - Pedigrees of cattle show patterns between relatedness and musculature. We can see chromosomes in images of sperm, eggs, and muscle cells. - The cattle photo cards we analyzed last time and organized into pedigrees now include images of protein(s) found in their bodies and data about their genotype, so we can look for patterns related to the heavily muscled phenotype. - Students put together the pieces of recent phenomena: cattle karyotypes; chromosomes in sperm, egg, and offspring’s cells; genotype; and myostatin data. - Offspring don’t always look like their parents or their siblings even though biological siblings get their genes from the same two parents. - Articles and a computer simulation allow the class to work with selective breeding

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<td>to see how certain combinations of alleles lead to generations with costly or beneficial outcomes.

The probability of a goldfish offspring having certain color scales (brown, transparent, or speckled) can be predicted based on the phenotype of its parents.
Organisms have traits with patterns of variation that are different from what we saw in the cattle musculature.
Genetic material can be visualized inside both animal and plant cells.
The structures of flowers have similar functions to the reproductive structures in humans, which can help us discern the reproductive process in plants.
Planaria reproduce asexually by being cut into pieces then regenerating, as shown in a video. Other organisms also reproduce asexually.
When exposed to light, planaria lose their pigment. Apple redness depends on temperature and light, among other factors. Flamingos get their pink color from the food they eat.
Articles about trait variation in organisms show that the variations are due to a combination of genetic and environmental factors.
Coast redwood trees have variation in their heights in different areas of their environment. Coast redwoods are more successful at reproducing asexually than sexually, although they can do both.

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<td>Knowledge:
Students will know…

Some cattle and other animals have extra-big muscles like we’ve never seen before, and we aren’t sure how they got that way.
There are many variations of characteristics (traits) in living things.
We have a lot of questions and ideas to pursue.

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<td>Skills:
Students will be able to…

Develop and/or use a model to predict what is causing these animals to have extra-big muscles.
Ask questions that arise from careful observation of pictures of animals with different musculature to seek information about what causes these variations in populations.

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• Proteins are important structures in the body made of atoms. • Muscles are composed of bundles of cells, which are made up of smaller strands. • Muscles move by shortening (contracting) and lengthening (relaxing) these strands. • Muscle cells contain specific proteins called actin and myosin, which help the muscles do the job of moving by grabbing onto each other and pulling so the muscle fibers contract. • Extra-big muscles have more muscle cells than typical ones, and those cells are larger in area, as well. • Extra-big muscles have more mass than typical muscles. • Exercise and diet play important roles in building muscles. Exercise has a large influence on musculature. Diet has a small influence on musculature. • During exercise, tension on the muscle fibers leads to microtears, which interfere with actin and myosin. These tears are repaired, resulting in thicker and longer muscle fibers. • Protein from food is required to build and maintain muscle. • Diet has a small influence on musculature for cattle with extra-big muscles. • Exercise also has a small influence on musculature for cattle with extra-big muscles. • Diet and exercise can't explain all the variation we see in musculature so there must be other factors involved. • If an individual is heavily muscled, both parents have extra-big or medium muscles. • Egg and sperm do not contain the same proteins that are found in muscle cells; therefore, parents are not directly passing on muscles or muscle proteins.	• Obtain, evaluate, and communicate information about muscles in various media and visual displays, including models of complex protein structures, to describe (1) how the function of those proteins depends on their shape and (2) how the muscle cells of extra-big-muscled animals compare with those of typical animals. • Obtain, evaluate, and communicate information to determine the effects of exercise and diet in the development of muscle tissue. • Develop and use a model to construct a scientific explanation based on evidence for how different environmental factors (cause) influence variation in a trait (effect). • Use a model to describe and predict the patterns in variations in traits between parents and offspring in a pedigree. • Develop and use a model to describe the unobservable mechanism of fertilization, in which parents each contribute half of the chromosomes an offspring has, by discerning patterns in the number and types of chromosomes in the sex cells of parents and the body cells of offspring. • Develop and use a model to describe correlational relationships among chromosome pairs containing two variants, specific proteins, and the trait of musculature. • Critically read scientific texts to obtain evidence that a distinct gene is the cause for the production of a specific protein related to the trait of musculature. • Develop a model to show how genetic factors influence (cause) variation in a trait (effect) by controlling the production of specific proteins. • Use mathematics and computational thinking to find patterns about genotypic and phenotypic outcomes resulting from

• Chromosomes are passed from parents to offspring when the sperm and egg fuse during fertilization. • Egg and sperm each have half the number of chromosomes as the muscle cells. • The karyotype shows that muscle cells have two of each kind of chromosome. • One chromosome in each pair shown on the karyotype is from one parent (from the egg) and one chromosome comes from the other parent (from the sperm). • Chromosomes have specific regions called genes, and the different possible forms of the genes are called alleles. • The different alleles of the genes (the genotype) determine the protein(s) that gets made. • Different forms of a protein, like myostatin, can lead to variations, like extra-big or typical muscles. • Scientists changed the shape of a gene in mice to figure out that a different allele causes the different-looking myostatin protein, which results in the heavily muscled phenotype. • Animals that are heavily muscled have two copies of the allele that causes the partial myostatin protein. • Myostatin is a protein. Its function is to fit into a receptor on a cell. When it fits in correctly, muscles develop typically. When it doesn't fit correctly, the result is extra-big muscles. • The alleles an animal gets from the sperm and egg of its parents (its genotype) determine the myostatin protein(s) that animal produces, which influences the musculature (phenotype) we see. • Our model predicts that siblings will look the same, but that’s not the case in real life for cattle (or other examples we know). • Two homozygous parents produce offspring with the same genotype, but	crossing individuals with specific genotypes. • Plan and carry out an investigation to collect data and uncover patterns that support the idea that chromosome pairs separate when sex cells form and then recombine at fertilization, so each parent contributes half of the genes acquired (at random) by the offspring. • Obtain, evaluate, and communicate information regarding the effect of selective breeding in one type of sexually reproducing organism. • Use mathematics and computational thinking to determine the beneficial and harmful effects of selective breeding in sexually reproducing organisms by examining the frequency of certain trait variations and combinations in a population over time. • Critically read scientific texts and construct an explanation using models and math to describe how sexual reproduction results in offspring with genetic variation in the context of goldfish coloration. • Ask questions to refine our model explaining the causes of trait variations we see in other organisms. • Plan and carry out an investigation to produce data to serve as the basis for evidence that plants have genetic material inside their cells that can be visualized (scale). • Construct an explanation, using a representation of plant reproductive parts, for how these specialized structures support sexual and asexual reproduction in plants (function). • Obtain, evaluate, and communicate information about how organisms reproduce asexually and transfer their genetic information to their offspring, which results in offspring with identical genetic information.

heterozygous parents result in offspring with a variety of genotypes. ● The proportion of offspring with different phenotypes can be predicted using a simple mathematical model when we know the genotypes of the parents. ● The likelihood of getting various genotypes for the myostatin protein is related to the phenomenon that parents' alleles separate into different sex cells and can recombine in different ways to produce the offspring's genotype. ● The patterns of separation of chromosomes into sex cells and the combination of chromosomes in fertilization allows us to develop a mathematical model to predict the probabilities of certain genotypes. ● A mutation is a structural change in the genetic information that can result in changes to proteins produced, which can affect the structures and functions of the organism, thereby changing its trait. ● Farmers can use selective breeding to change the frequency of specific trait variations over time in a population of sexually reproducing organisms. ● Mutations can have beneficial or harmful effects on an organism. ● In selective breeding, people choose which individuals with selected trait variations are bred more often together than individuals without those selected trait variations. ● Our model to explain trait variations from the parents' genotypes to the offspring's phenotype can be used to explain a phenomenon other than cattle musculature. ● Variations can be a continuous range, not always distinct types or categories. ● We have a lot of questions about other organisms and the variations we see in their traits.	● Construct an explanation using a model to explain the influences of environmental and genetic factors on trait variation. ● Analyze and interpret patterns in data to provide evidence that a combination of genes and environment is causing the variation we see in traits. ● Develop and use models to show multiple causes of variation within a trait. ● Ask questions to clarify and refine our model explaining what causes living things to be different from one another. ● Construct an explanation about how environmental and genetic factors influence the growth of organisms and how organisms reproduce, either sexually or asexually, and transfer their genetic information to their offspring.

● Genetic material is so small we can't see it when it is from a single cell (and we normally can't see single cells without a microscope). ● There is a lot of genetic material in each cell because there are thousands of genes in each cell. ● There are many cells in a small sample of muscle or plant tissue, so we are able to get enough genetic material out of the cells to see it. ● Flowers have structures that support plants reproducing sexually, including structures equivalent to sperm and egg cells. ● Some structures of the flowers (and/or seeds) increase the chances of the plant's reproduction by attracting and using animals. ● Sexual reproduction in plants results in genetic variation that people can take advantage of to selectively breed for desirable trait variations. ● Some plants can also reproduce asexually (on their own or with human assistance), resulting in offspring with the identical phenotype as their parents. ● Several different methods of asexual reproduction all result in genetically identical offspring. ● Environmental factors can cause a continuous range of variation. ● We begin to notice that different environmental factors and genetic factors can influence trait variation to different degrees. ● Different traits and variations are influenced differently by genes and environment. ● Most trait variations are influenced by a combination of multiple genes and the environment and to varying degrees, depending on the trait. ● It is rare to have a single gene influence a trait variation.	

• All living things have genetic information. • Genetic information is passed from parents to offspring either sexually (which can result in variations) or asexually (the offspring get exactly the same genetic information as the parent). • Genetic information has instructions to put together building blocks to make different-shaped proteins. • The shape of a protein influences its job. • Differences in those proteins in combination with environmental factors (to varying degrees depending on the trait) result in the variations that exist among living things.	

Interdisciplinary Connections
New Jersey Student Learning Standards-English Language Arts (2016) **SL.8.5** Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest. (MS-LS1-2, 3-1. 3-2) **RST.6-8.1** Cite specific textual evidence to support analysis of science and technical texts. (MS-LS1-4, 1-5, 3-1, 3-2, 4-5) **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-LS1-5) **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),(MS-LS3-2) **RST.6-8.7** Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (MS-LS3-1),(MS-LS3-2) **RI.6.8** Trace and evaluate the argument and specific claims in a text, distinguishing claims that are supported by reasons and evidence from claims that are not. (MS-LS1-4) **WHST.6-8.1** Write arguments focused on discipline content. (MS-LS1-4) **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-LS1-5) **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) **WHST.6-8.9** Draw evidence from informational texts to support analysis, reflection, and research. (MS-LS1-5) **New Jersey Student Learning Standards-Mathematics (2016)**

MP.4 Model with mathematics. (MS-LS3-2)
6.EE.C.9 Use variables to represent two quantities in a real-world problem that change in relationship to one another; write an equation to express one quantity, thought of as the dependent variable, in terms of the other quantity, thought of as the independent variable. Analyze the relationship between the dependent and independent variables using graphs and tables, and relate these to the equation. (MS-LS1-2)
6.SP.A.2 Understand that a set of data collected to answer a statistical question has a distribution which can be described by its center, spread, and overall shape. (MS-LS1-4, 1-5)
6.SP.B.4 Summarize numerical data sets in relation to their context. (MS-LS1-4, 1-5)
6.SP.B.5 Summarize numerical data sets in relation to their context. (MS-LS3-2)

Student Resources

Primary Source Readings
- 8.5 Genetics Student Edition

Secondary Source Readings
- Achieve3000 articles
  - Lessons from the San
  - **Frozen in Time**
  - **Were You Born to be a Sports Star?**
  - **Is It All In Your Genes?**
  - **When Genes Don't Work**
  - **More People Living to 100**
  - **The Perfect Apple?**

Supporting Text pages
- Handouts - All student handouts are within the lesson folders
- Technology
  - Websites:
    - 8.5 L9 Bird Breeder Simulation
    - 8.5 L5 L6 Cell Size and Scale
    - 8.5 L16 Middle School Student Arm Span Data Set
  - Videos:
    - Unit 8.5 Student Video Playlist

Teacher Resources

- **Texts:**
  - **8.5 Genetics Teacher Edition**
  - **OpenSciEd Teacher Handbook**
  - **8.5 Elements of NGSS Dimensions**
  - **8.5 Genetics Unit Overview Materials**
- **Supplemental Text:**
  - Achieve3000 articles
    - Lessons from the San
    - **Frozen in Time**
    - **Were You Born to be a Sports Star?**
    - **Is It All In Your Genes?**

        - **When Genes Don't Work**
        - **More People Living to 100**
        - **The Perfect Apple?**
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        - 8.5 L9 Bird Breeder Simulation
        - 8.5 L5 L6 Cell Size and Scale
        - 8.5 L16 Middle School Student Arm Span Data Set
    - **Videos:**
        - **Unit 8.5 Teacher Video Playlist**
        - **Unit 8.5 Genetics Video Links**

Stage 2 – Assessment Evidence
Pre-Assessments: The student work available for assessment in Lesson 1 should be considered a pre-assessment. It is an opportunity to learn more about the ideas your students bring to this unit. Revealing these ideas early can help you be more strategic in how to build from and leverage student ideas across the unit. The initial models developed during Lesson 1 are a good opportunity to pre-assess student understanding of genetics. The two most important times to do this are (1) after students have developed their initial models and (2) during the Consensus Discussion. Refer to assessment guidance sections listed in the Lesson-Level Assessment table below and in the Lesson 1 Teacher Guide. ***Formative Assessments:*** This is a key formative assessment moment because students are capturing their ideas about how the environmental factors (though we don't yet call them that) of diet and exercise can influence muscle growth. Students independently revise their original models from Lesson 1 to explain how an animal other than cattle got extra-big muscles. This is an opportunity for students to articulate the chain of cause-effect relationships in the genotype-to-protein-to-phenotype process. ***Summative Assessments:*** Students use a checklist to critically read and evaluate a research study adapted for classroom use to determine how the brown, speckled, and transparent trait variations of goldfish scales are inherited. They use this information to develop models explaining the inheritance patterns of this trait variation and to give a recommendation for selective breeding of the speckled phenotype. They also apply mathematical concepts of probability and use basic operations to calculate the chances of various goldfish phenotypes resulting from certain matings.

This summative assessment ends the first lesson set and will allow you to provide feedback to your students about their work with several key ideas and practices in this unit. Key for Goldfish Assessment, Key for Checklist for Obtaining and Evaluating Information from Scientific Text, and Rubric for Goldfish Assessment are available to support you in providing this feedback.
This unit includes a transfer task to give students an opportunity to use the 3 dimensions to make sense of a different phenomenon. In the context of redwood tree heights, students construct an explanation about how environmental and genetic factors influence the growth of organisms and how organisms reproduce, either sexually or asexually, and transfer their genetic information to their offspring.
This summative assessment ends the unit and will allow you to provide feedback to your students about their work with several key ideas and practices from the second lesson set. Key for Redwoods Assessment and Rubric for Redwoods Assessment are available to support you in providing this feedback.

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

Stage 3 – Learning Plan
Lesson 1 (3 days) How do organisms get their differences? We observe a bull and other animals that have extra big muscles. We develop initial models to explain what could be causing this phenomenon. We also realize that there is a range of musculature in animals, and we identify variations in traits other than musculature in different organisms. After listing related phenomena, we develop a Driving Question Board and ideas for future investigations. **Lesson 2 (1 day) How do extra-big muscles compare to typical ones up close?** We observe images and video animations about what muscles look like up close and how muscles work. We compare photos and data about muscle cells from extra-big-muscled animals and typical ones **Lesson 3 (1 day) How do diet and exercise affect muscle size?** We evaluate information in texts, images, graphs, and tables in order to determine the effect of diet and exercise on muscle growth.

Lesson 4 (1 day) What is different about the food and exercise for cattle with extra-big muscles?
We update our classroom consensus model to include our findings about the role diet and exercise play in making muscles. We attempt to apply our class model to explain how the extra-muscled cattle would have developed their muscles, but we realize the model cannot explain the differences in musculature we see. We learn more about the diet and habits of these cattle by listening to a farmer who raises them, and we also find out that the calves that grow up to be heavily muscled are born with more muscles than calves that don't grow up to be heavily muscled. We discuss how this information impacts our model.

Lesson 5 (2 days) Where do the babies with extra-big muscles get that trait variation?
We analyze cattle family photos to find patterns between relatedness and musculature. We wonder how muscles actually get from parents to offspring, and we zoom in to look at the chromosomes inside sperm and egg cells. We make connections between the karyotype of an offspring's muscle cell and chromosomes in the sex cells of the parents.

Lesson 6 (2 days) How do chromosomes cause cattle to be born with extra big muscles?
We consider the scale of chromosomes and proteins, then reorganize cattle photos that include new information about each individual's chromosomes and myostatin proteins. We construct initial models showing the patterns we found, and construct a consensus model to explain the correlations we see. We read and synthesize articles to find evidence of cause-effect relationships among allele, protein, and phenotype.

Lesson 7 (2 days) How does an animal get extra-big muscles?
We update our classroom consensus model and revise our initial models to include our recent findings about the roles of genes, alleles, and the myostatin protein in development of the typically, medium-, and heavily muscled phenotypes. Using our model, we predict that a sibling's phenotype will be the same, but we see examples of cattle siblings with different phenotypes,

Lesson 8 (2 days) Why don't offspring always look like their parents or their siblings?
We investigate the inheritance patterns of the myostatin gene by comparing the proportion of different genotypes collected from pedigrees that show the results of known crosses. We use simple mathematical models to help us predict the outcome of known genetic crosses.

Lesson 9 (2 days) How do farmers control the variation in their animals?
We read three articles about how farmers breed animals for selected-for trait variations, and we run a computer simulation to control breeding in order to create individuals with selected-for trait variations.

Lesson 10 (1 day) How can we use our model to explain a different trait variation?
After a brief navigation conversation, we work independently to demonstrate understanding on a midpoint assessment--a transfer task involving goldfish breeding.

Lesson 11 (1 day) How can we answer the rest of our questions?

We check in on our DQB to acknowledge what we've figured out so far and take note of where we still have questions about organisms other than cattle and traits other than muscles. We sort images of other organisms and discover that their variations encompass a continuous range rather than a few distinct phenotypes. Based on our model, we record new questions to drive further investigation.

Lesson 12 (1 day)   Do plants have genetic material?
We question whether plants also have genetic material and wonder if there is an investigation that would allow us to see that material. We watch a video of a scientist isolating genetic material from animal cells and then we plan an investigation to break open plant cells (strawberries) and see if we can isolate the same material from them. We carry out our investigations and discuss the results as a class.

Lesson 13 (2 days) How do plants reproduce?
After determining that flowers are involved in plant reproduction, we investigate their structures, comparing their functions to reproductive structures in humans. We obtain information about how the structures of flowers can interact specifically with different pollinators. Revisiting the trait variations that we saw in Lesson 11, we read and watch videos about how farmers breed and propagate plants.

Lesson 14 (2 days)   (How) do other organisms reproduce without sperm and eggs?
We work in small groups to research and share about an organism that uses asexual reproduction. We discuss how the genetic information of offspring from asexual reproduction compares to that of the parent. We observe a video of planarian regeneration, and we discover that the resulting planaria do not always look identical.

Lesson 15 (1 day)   How do we get variations if the genetic information is exactly the same?
We integrate information from images and text about how planaria color was affected by light exposure, and we consider how environmental factors like light might influence other ranges of variation we've seen. We obtain scientific information from texts about color variation in apples and flamingos and then construct and use models to explain the different environmental factors that cause the range of variation we see in apple and flamingo colors.

Lesson 16 (2 days)   How much of trait variation in a population is controlled by genes or by the environment?
We investigate the variation found in wheat kernel coloration to learn this trait is controlled by more than one pigment-producing gene. We use this new idea in addition to what we learned about environmental factors in Lesson 15 to update our classroom consensus model explaining variation we see in cattle musculature. We investigate the distribution of human arm span lengths and independently use our model to explain which factor(s) affect arm span. Finally, we share our models in small groups and hold a Consensus Discussion about what we figured out about these influences on all traits.

Lesson 17 (2 days)   Why are living things different from one another?

We revisit our Driving Question Board to evaluate and answer our questions. We use this time to ask any clarifying questions to refine our understanding about our models for how living things are different from one another. Then we demonstrate understanding on a summative assessment transfer task involving redwood trees.

Unit Plan Title	8.6 Natural Selection & Common Ancestry
Suggested Time Frame	31 days

Overview / Rationale
In this unit, students investigate the connections between ancient and modern organisms. Students develop a model for natural selection and use it to account for patterns between the body structures and behaviors of ancient organism fossils and similar organisms living today. The unit begins with students hearing about the surprising fossil of an ancient penguin (nicknamed "Pedro") in a podcast from the researchers who found and identified the fossil. Students also read a photo journal from their research. Students question how penguins living today could be connected to this fossil of a much larger penguin from long ago and record their noticings and wonderings. Students then explore the different species of penguins alive today through a series of videos and data cards. Students develop initial explanations for how today's penguins could be connected to Pedro or other penguins from long ago. Students investigate the connections between organisms living today and those that lived long ago. Students explore heritable traits in modern penguins and examine similar data for ancient penguins. Students then revise their initial models of how modern penguins could be connected to ancient penguins to account for the time-related and trait-related patterns they have uncovered . Students analyze data from ancient and modern species of horses, whales, and horseshoe crabs to see whether these organisms have similar patterns. Students work on explaining these patterns to develop and use a model of adaptation by natural selection. Students use their natural selection model to explain how some body structure variations in different species of modern penguins could result from natural selection and how these penguins could descend from a common ancient ancestor penguin population. Students analyze embryological data from different stages of development for different species to add to their argument about how different types of living things (species) may be connected.

Stage 1 – Desired Results
Established Goals:

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- **MS-LS1-4:** Use arguments based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively.
- **MS-LS4-1:** Analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth under the assumption that natural laws operate today as in the past.
- **MS-LS4-2:** Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships.
- **MS-LS4-3:** 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.
- **MS-LS4-4:** 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.
- **MS-LS4-6: U**se mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time.

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Essential Questions:

- How could penguins and other things living today be connected to the things that lived long ago?
- How similar or different are different species of penguins?
- How do the body structures of other ancient penguins compare to modern penguins?
- Why are there similarities and differences in the body structures of modern and ancient penguins?
- How might other living things be connected to ancient organisms?
- How could organisms living today be connected to organisms that lived long ago?
- How do traits found in a population change over a shorter amount of time?
- How can we model what is causing the changes in the populations happening across all our case studies?
- How well does our General Model predict and explain the changes happening over time in a different population?

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Enduring Understandings:
Students will understand:

- A giant fossil penguin, named Pedro, that lived 36 million years ago and was discovered in Peru has important anatomical similarities to and differences from penguins that are alive today.
- Heritable physical structure and behavior variations have been measured for different modern penguins, and some of these have been measured for Pedro.
- Body structure data from fossils for different penguin species found at different sites provide information on how old the fossils are and the environment the ancient penguins lived in.
- When multiple fossils of the same species are found, they have the same variations. We also put pieces together from all phenomena we explored in Lessons 1 through 3.
- Body structure variation data have been collected from modern whales, horses, and horseshoe crabs, as well as from ancient fossils of these organisms. The specific locations where these fossils were found also provide information on how old they

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• Why does our General Model tend to produce different outcomes in different environmental conditions? • Can we use our General Model for Natural Selection to explain changes over time in green anole lizards? • Can our model explain changes over really long periods of time? • Can we apply the General Model for Natural Selection over millions of years to explain how all the ancient and modern penguins are connected? • What do the patterns in embryo development tell us about how things living today could be connected to the things that lived long ago? • What can we explain now, and what questions do we still have?	are and what their local and global environments were like at that time the fossils formed. • In five different populations (cliff swallows, peppered moths, finches, sticklebacks, and mustard plants) scientists measured a rapid shift in the distribution of a trait variation in a population over multiple generations. • A simulation that includes trait variation in a salmonella bacteria population and two types of white blood cells produces shifts in the distribution of the bacteria trait variations. • A simulation of two different bacteria populations produces different shifts in the distribution of trait variations in the populations over time depending on the type of distribution of food in the environment. • On islands with green and brown anole lizards, the green lizards now live higher (than in the past) in the trees than on islands without brown anole lizards. • Ancient and modern horses and horseshoe crabs have body structures that help(ed) them survive in their specific environments. • Similarities exist between the physical structures of embryos for different animal species that are not evident in the fully formed anatomy. • Asking questions about phenomena gives us a mission for our science learning.
Knowledge: *Students will know…* • There are 18 different species of penguins alive today. All have similar body structures and behaviors as well as some noticeable differences. • Scientists found a giant penguin fossil (nicknamed "Pedro") that lived 36 million years ago in Peru. It is bigger and it had a much longer beak than any penguins alive today.	**Skills:** *Students will be able to…* • Analyze and interpret data using data cards containing photos, maps, charts, measurements, and descriptive text to find patterns in penguins that are alive today. • Develop an initial explanation and identify evidence needed to determine what caused the observed changes in the existence, diversity, and disappearance of different kinds of penguins throughout history.

● We have different ideas about where the penguins (and other organisms) of today come from: maybe none, some, or all of the penguins (and other organisms) of today are descendants of Pedro (or other organisms from long ago). ● Penguins have heritable external structures like feather color and shape, beak color, and eye ring patterns. ● Penguins have heritable behaviors such as the number of eggs each penguin lays at a time and where they lay their eggs. ● Penguins have heritable internal structures like bones. There is some variation in these across different species of penguins. ● Some species of penguins share many more structures and behaviors in common with other species of penguins than others. ● None of the ancient penguins have all the same body structure variations in common with any modern penguins. ● Ancient penguin fossils tend to have more body structure variations in common with each other the closer they are in time. Modern penguins have more body structures in common with less-ancient penguin fossils than with more-ancient ones. ● The overall size of many but not all ancient penguins was larger than the largest modern penguins; the beak size and shape of many ancient penguins was longer and/or more curved than modern penguins. ● Earth's climate, the positions of the continents, and sea levels have changed many times over the last 60 million years. ● Ancient penguins lived in some of the places modern ones do. Some of the other organisms that lived in these areas have changed over time. ● Some species (one or multiple) of ancient penguins must have produced the 18 lines	● Ask questions that arise from initial observations of patterns in the images depicting anatomical similarities and differences of penguins that are alive today and of a fossil of a penguin from long ago. ● Analyze and interpret data to find patterns across heritable body structures and behaviors among different species of modern penguins and an ancient penguin. ● Ask questions about ancient ancestors of modern penguins based on close analysis of patterns in the body structure and behavior data for modern penguins and Pedro; describe the type of data that would be needed in order to answer some of these questions. ● Develop and use a timeline of a large data set to identify patterns in variations in body structures found in different penguins across different points in time. ● Analyze and interpret data from data tables, images, maps, and descriptive text to identify patterns of similarities and differences in variations in body structures, environments, and geographic locations of ancient penguin fossils across time. ● Develop an explanation based on preliminary evidence to illustrate that changes over time occur in the existence, diversity, and disappearance of different kinds of penguins throughout history. ● Develop an explanation that predicts what the variation in a chosen body structure or behavior of Galápagos penguins and king penguins looks like at different scales (between species versus between individuals within a population). ● Analyze and interpret data from images to identify patterns of similarities and differences in modern organisms and the fossil record and use the patterns to look for relationships between ancient and modern organisms.

of descendants that are alive today. We think we are missing the fossils of penguins from long ago that are more similar to or identical to the ones of today. ● If penguins have been changing over many generations, we suspect that these different species of penguins live(d) in different places. We think this because the penguins that live in different places have different body structure variations that could help them survive better in that environment. ● We establish that a sample of one penguin fossil might be representative, on average, of the entire population at that time, but there is variation among individuals within a population. Since there are not very many penguin fossils available, we want to look at fossils of other organisms. ● The structures of some other living things today (like whales, horses, horseshoe crabs) look similar to but not exactly like the most similar-looking fossils we can find. ● Sometimes, but not always, there are noticeable differences in specific body structures (limbs, skulls, teeth, shells). Sometimes, but not always, there are changes in overall size of the organism. ● The further back in the fossil record we go, the more pronounced those structural differences are (and the less horseshoe crab-like, horse-like, whale-like that type appears to be). ● Sometimes, but not always, body structures of organisms seem to match the environment in which they live(d) (e.g., teeth or limbs adapted for forests or grasslands). ● There are clear patterns of differences in the body structures of certain types of organisms over really long periods of	● Respectfully provide and receive critiques about models of the similarities and differences (patterns, stability, and change) in some of the body structures of organisms observed over time and in different environments based on evidence from the fossil record. ● Construct, use, and/or present an oral and written argument supported by empirical evidence and scientific reasoning to support an explanation for whether the types of things that lived long ago are ancestors to the modern organisms we see today (stability and change). ● Ask questions related to what is causing changes in a whole population of organisms. ● Analyze and interpret data representing mean, median, mode, or variability to examine patterns of changes over time that affect the predominance of certain traits in a population. ● Communicate and evaluate scientific information about a system of cause and effect relationships to explain how traits that support successful survival and reproduction become more common and those that do not become less common. ● Using models, construct an explanation of changes over time in the distribution of traits in a population in response to changes in environmental conditions. ● Respectfully provide and receive critiques about one's explanations and model ideas related to what in the system is remaining stable (e.g., traits within individuals and patterns of inheritance) and what is changing (e.g., distribution of traits) and what causal mechanisms (e.g., competitive advantages, selection events) are at work on different populations in different (eco)systems. ● Use a model that includes unobservable mechanisms describing more than one cause and effect relationship between

time (multiple generations) and across different environments. ● There must have been some population(s) of ancient organisms that had offspring that were lines of descendants that led to modern organisms. ● We don't agree on what those lines of descent were, but we have some possible candidates. ● The body structure variations are somehow changing in a line of descendants from one of the ancient populations to one of the modern ones. ● We have some different ideas about what might be causing such changes in a whole population of descendants. ● Scientists collect a lot of different kinds of data to try to figure out what caused the shift in trait distribution in a population over time. ● Thinking about the relationship among structure and function, change and stability over time, and the causes and effects on both individuals and the population can provide useful lenses for developing a model to explain a complex biological system. ● We have ideas from specific cases that changes in the distribution of traits in a population is related to successful survival (and reproduction) in certain environments. ● There was variation in specific traits between individuals in a population in the past. ● Individuals with certain trait variations are sometimes able to more easily access available resources needed for survival, causing them to survive better and reproduce more than other individuals. ● The traits that grant an advantage for surviving or reproducing can be passed on to their offspring.	different parts and components in a system to make predictions about how natural selection leads to a change in the distribution of traits in a population over time, while heritable traits of each individual remain stable. ● Construct an argument that changes in environmental conditions may increase or decrease the probability of specific trait variations being passed on in a population, using evidence derived from analysis of graphical data representations generated from an investigation using a computer simulation. ● Plan and carry out an investigation in a simulated environment to collect data about how environmental conditions may increase or decrease the probability of specific trait variations being passed on in a population, using evidence derived from analysis of graphical data representations generated from a computer simulation in two different investigations. ● Construct explanations based on evidence collected from running a simulation and using science ideas included in our General Model for Natural Selection for how and why small changes in an environment may cause large changes in trait variations in a population over long periods of time. ● Construct and revise an explanation using a model to explain why a change to the environment (cause) leads to a predominance of certain genetic variations of traits in a green lizard population that increase some individuals' probability of surviving and reproducing (effect). ● Construct a scientific explanation for how natural selection acting over generations has caused organisms' body structures to change over time in response to changes in environmental conditions. ● Use patterns in shared body structures resulting from natural selection and

• Distribution shows more individuals with the trait variation that allows them to survive or reproduce better. • Changes in the environment can lead to different changes in the traits of the population. • Trait variations that provide an individual a competitive advantage in one environment may give it a disadvantage in another environment. • Competitive advantage affects the chances (or probability) of certain individual outcomes. • The longer this process (natural selection) continues (over more generations), the more variations tend to be removed from the descendant population. • Our model (General Model for Natural Selection) tends to produce different outcomes in different environmental conditions. • Any change in the environment that affects the resources needed for survival and reproduction can lead to shifts in the distribution of trait variations in a population. • Natural selection tends to remove certain variations from a population over time; this outcome becomes more pronounced as time goes on. • Green lizards live higher in the trees after the brown lizards are introduced to their habitat because of trait variation in the initial population of green lizards. • Green lizards with larger toe pads and more sticky scales have a competitive advantage to climb higher for food and habitat that allows them to survive long enough to reproduce and pass down those trait variations to their offspring. • This results in a shift in trait variation distribution in the green lizard population after the change (the introduction of brown lizards), with an increase in toe pad size and amount of sticky scales.	mutations to develop a model to explain how modern penguins are connected to ancient penguins. • Construct a scientific explanation proposing relationships between all modern penguins and ancient penguins using the similarities and differences in accumulated body structure changes over time to estimate how relatively long ago they shared a recent ancestor. • Analyze and interpret sketches of different species at different stages of embryological development to identify similarities and differences (patterns) in physical structures not evident in the fully formed anatomy. • Outline a scientific argument for how new model ideas or application of old models could explain and/or ask questions based on patterns in sketches of the physical structures apparent in different species at different stages of embryological development emphasizing new ideas about how different species may be connected. • Ask questions that arise from careful observation of phenomena, models, or unexpected results to clarify and/or seek additional information regarding cause and effect relationships and stability and change in lines of evolutionary descent.

• Mutation is the source of new variation and can explain body structures in modern organisms that are not seen in ancient organisms. • Natural selection could be the mechanism that is causing the greater changes we see over longer periods of time. • Mutations and natural selection could link modern organisms with their ancestors far back in time. • We have questions about how our model might explain how there are so many species of penguins (and other organisms) with such different body structures. • When populations are in different environments for longer amounts of time, the accumulation of random mutations combined with natural selection leads to differences in body structures in each population. • Penguins that have fewer differences in body structures shared the same environment (and a common ancestor) more recently than penguins that have more differences in body structures. • The relationship between the amount of time populations have been separated and the number of differences in body structures can be used to propose which organisms shared the most recent ancestors and to propose explanations for how modern penguins are connected to ancient penguins. • Early in development, there are similarities in the structures that make up different organisms, including both egg-layers and mammals. These similarities in structures are not always evident later in development. • Similar structures early in development point to similar processes responsible for growth and development for different organisms.	

Interdisciplinary Connections
New Jersey Student Learning Standards-English Language Arts (2016) **RST.6-8.1** Cite specific textual evidence to support analysis of science and technical texts. (MS-LS1-4) **RI.6.8** Trace and evaluate the argument and specific claims in a text, distinguishing claims that are supported by reasons and evidence from claims that are not. (MS-LS1-4) **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),(MS-LS4-2),(MS-LS4-3),(MS-LS4-4) **RST.6-8.7** Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (MS-LS4-1),(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),(MS-LS4-4) **WHST.6-8.1** Write arguments focused on discipline content. (MS-LS1-4) **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-LS4-2),(MS-LS4-4) **WHST.6-8.9** Draw evidence from informational texts to support analysis, reflection, and research. (MS-LS4-2),(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-LS4-2),(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-LS4-2),(MS-LS4-4) **New Jersey Student Learning Standards-Mathematics (2016)** **6.SP.A.2** Understand that a set of data collected to answer a statistical question has a distribution which can be described by its center, spread, and overall shape. (MS-LS1-4) **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-LS4-4),(MS-LS4-6) **6.SP.B.4** Summarize numerical data sets in relation to their context. (MS-LS1-4) **6.SP.B.5** Summarize numerical data sets in relation to their context. (MS-LS4-4),(MS-LS4-6) **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),(MS-LS4-2) **7.RP.A.2** Recognize and represent proportional relationships between quantities. (MS-LS4-4),(MS-LS4-6) **New Jersey Student Learning Standards- Computer Science & Design Thinking (2020)** **8.2.8.ED.2** Identify the steps in the design process that could be used to solve a problem.

8.2.8.ED.3 Develop a proposal for a solution to a real-world problem that includes a model (e.g., physical prototype, graphical/technical sketch). **8.2.8.ED.4** Investigate a malfunctioning system, identify its impact, and explain the step-by-step process used to troubleshoot, evaluate, and test options to repair the product in a collaborative team.

Student Resources

Primary Source Readings

- 8.6 Natural Selection & Common Ancestry Student Edition

Secondary Source Readings

- Achieve3000 articles
    - **Lizards vs. the Wind**
    - A New Dinosaur Family Tree?
    - A Whole Lotta Penguin
    - A Real Cold Fish
    - What the Toucan Can Do
    - A Story with Legs

Supporting Text pages

- Handouts - All student handouts are within the lesson folders
- Technology
    - Websites:
        - 8.6 L9 Salmonella Hunt
        - **8.6 Lesson10 Comparing Bacteria in Different Environments**
        - Build a Fish!
    - Videos:
        - Unit 8.6 Student Video Playlist

Teacher Resources

- **Texts:**
    - **8.6 Natural Selection & Common Ancestry Teacher Edition**
    - **OpenSciEd Teacher Handbook**
    - **8.6 Elements of NGSS Dimensions**
    - **8.6 Natural Selection _ Common Ancestry Unit Overview Materials**
- **Supplemental Text:**
    - Achieve3000 articles
        - **Lizards vs. the Wind**
        - A New Dinosaur Family Tree?
        - A Whole Lotta Penguin
        - A Real Cold Fish
        - What the Toucan Can Do
        - A Story with Legs
- **Technology**
    - **Websites:**
        - 8.6 L9 Salmonella Hunt
        - **8.6 Lesson10 Comparing Bacteria in Different Environments**

- ■ Build a Fish!
- ○ **Videos:**
  - ■ **Unit 8.6 Natural Selection and Common Ancestry Video Links**

Stage 2 – Assessment Evidence
Pre-Assessments: The student work in Lesson 1 available for assessment should be considered a pre-assessment. It is an opportunity to learn more about the ideas that your students bring to this unit. Revealing these ideas early on can help you be more strategic in how to build from and leverage student ideas across the unit. This initial explanation can be used as a baseline pre-assessment for three areas of your students' thinking: initial student understanding of connections between penguins of today and penguins of long ago (For example, do students think they are two different types of organisms, or do students think they are related somehow?) initial student ability to know what kind of evidence would be needed to support or refute specific claims initial ideas about types of mechanisms students think could be the cause of the changes in penguin populations ***Formative Assessments:*** Students construct three mini explanations in response to these questions: "Where did all the ancient penguins go? Where did all the different species of modern penguins come from? Why are there similarities and differences in the body structures of modern and ancient penguins?" To construct these explanations, students use various representations in the Penguin Timeline Model with Cards they are developing as a class to represent the similarities and differences in body structures. Students complete an argument and have a Consensus Discussion to make and defend a claim about whether ancient penguins (and other organisms) are the ancestors of modern penguins (and other organisms). This argument provides another opportunity to see how students' ideas have shifted since Lessons 1 and 4. Students should be converging on an explanation that is closely aligned to MS-LS4-1. This is an embedded assessment as students complete an exit ticket to use our General Model for Natural Selection to make predictions about how natural selection leads to a change in the distribution of trait variations in a population over time, while heritable trait variations of each individual remain stable. Students' responses can be used in planning additional support or

interventions, for use in the upcoming lessons, that may be needed by classes or by specific individuals.

This two-part assessment is embedded as students work through the lesson. The first part of the assessment is well aligned to MS-LS4-4. In this part students plan and carry out investigations in a simulated environment to collect data derived from analysis of the generated graphical data representations and use that evidence to explain how and why environmental conditions may increase or decrease the probability of specific trait variations being passed on in a population. Their data analysis is recorded in Different Environmental Conditions and Results.

The second part of the assessment is well aligned to MS-LS4-6. In this part students construct an explanation based on evidence collected from running a simulation and using science ideas included in our General Model for Natural Selection for how and why small changes in an environment may cause large changes in trait variations in a population over long periods of time. Their explanation will be recorded on My Model for Changes in Bacteria Populations, which you will collect at the end of day 2.

Summative Assessments:
This assessment is a transfer task that asks students to use their General Model for Natural Selection to explain a new phenomenon tailored to MS-LS4-4. Allow students to choose how to share their understanding through oral presentation, written response, pictorial response, or a combination of both.

In this assessment, students construct an explanation using the key parts of the General Model for Natural Selection (developed in Lessons 8-10). Look for how students apply these key parts of the General Model as well as how they incorporate data from the task to support a specific explanation for why the green lizard population is changing over time. Specifically, students use their understanding of natural selection and of the population before and after the change; changes in the environment; and the effect on survival, reproduction, offspring, and inheritance to explain how a trait variation in a population changes over time.

This individual assessment is well aligned to MS-LS4-2. Students use their General Model for Natural Selection acting over generations combined with the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships and to construct a scientific explanation to account for how natural selection (cause) could explain how modern penguins are connected by common ancestry.

Performance Task(s):
The Driving Question Board is another opportunity for pre-assessment. Reinforce for students to

generate open-ended questions, such as “how” and “why” questions, to post to the board, but celebrate any questions that students share even if they are close-ended questions. If your students are asking mostly closed questions, you can provide a copy of a photo of the questions on the Driving Question Board and ask them to work on refining three or more of these questions so that they become “how” or “why” questions. Listen for questions that address parts of the initial Penguin Timeline model, and if a part of the model has few or no questions, prompt students to generate more questions in this space so that each part of the model has a set of questions with which to guide investigations.

Stage 3 – Learning Plan
Lesson 1 (4 days) How could penguins and other things living today be connected to the things that lived long ago? We record what we notice and wonder about a fossil of a giant penguin from long ago and we analyze data about penguins living today. We develop initial explanations of how these penguins could be connected. We brainstorm possible mechanisms to help explain two things: (1) Where did all the ancient penguins go? and (2) Where did all the different species of modern penguins come from? We develop a DQB to guide future investigations. **Lesson 2 (2 days) How similar or different are different species of penguins?** We analyze a data set of heritable external structures and behavior in modern penguins to look for patterns and infer connections among them and Pedro. We develop questions on how other heritable internal structures would compare for these penguins and for other ancient penguin fossils. **Lesson 3 (2 days) How do the body structures of other ancient penguins compare to modern penguins?** We analyze data tables of bone structures for ancient penguin fossils and modern penguins and develop a timeline-based representation of the patterns in the data. We analyze images, maps, and descriptions of where these fossils formed. **Lesson 4 (3 days) Why are there similarities and differences in the body structures of modern and ancient penguins?** We revise our initial explanation to account for the patterns in data from previous lessons, including several candidate ideas for what might be causing these patterns. We revisit our Driving Question Board and our list of related phenomena and decide to investigate connections among other ancient and modern organisms. **Lesson 5 (2 days) How might other living things be connected to ancient organisms?** We investigate organisms other than penguins to see if patterns of connections between ancient and modern organisms also occur in other types of organisms. We sort data cards for ancient and

modern horseshoe crabs, horses, and whales to see what patterns of similarities and differences exist in their body structures. We discuss how patterns we notice in their body structures might be connected to when or where they live(d).

Lesson 6 (2 days) How could organisms living today be connected to organisms that lived long ago?
We argue for whether the fossil data we've been investigating represents what is found in only one individual or represents what is typical of any individual in their population. We construct revised explanations for how modern organisms are connected to ancient organisms.

Lesson 7 (3 days) How do traits found in a population change over a shorter amount of time?
We explore five cases where trait distributions in the population changed over a few generations. We use a jigsaw strategy to analyze data from different studies on our group's assigned case. We develop a model to explain what was causing the shift in trait distribution over time for our individual cases.

Lesson 8 (2 days) How can we model what is causing the changes in the populations happening across all our case studies?
We compare case-specific system models (for finches, moths, swallows, sticklebacks, and plants) and argue for which parts and interactions these cases have in common. We develop a general model to explain what causes changes in the population and use it to make predictions about what would happen in any population, in any environment, and over a different number of generations.

Lesson 9 (2 days) How well does our General Model predict and explain the changes happening over time in a different population?
We carry out two investigations using a computer simulation. We argue for why we get different outcomes when we simulate different types of white blood cells in the environment with the same starting population of bacteria.

Lesson 10 (2 days) Why does our General Model tend to produce different outcomes in different environmental conditions?
We plan and carry out an investigation using a new bacteria simulation to test what will happen when we change the environment by a different factor other than predation. We run our investigation, collect data, and use our General Model for Natural Selection to explain our results.

Lesson 11 (1 day) Can we use our General Model for Natural Selection to explain changes over time in green anole lizards?
We demonstrate what we have learned on an assessment. We give and receive peer feedback on our explanations. We revise our explanation based on peer feedback.

Lesson 12 (2 days) Can our model explain changes over really long periods of time?

We update our General Model for Natural Selection to include mutation and use it to explain differences in body structures in horses and horseshoe crabs over very long periods of time.

Lesson 13 (1 day) Can we apply the General Model for Natural Selection over millions of years to explain how all the ancient and modern penguins are connected?
We use what we know about natural selection and mutation to develop a model to show how modern penguins could be connected to one another and to ancient penguins. We construct a hypothetical explanation for how the penguins are connected and compare our explanations with others.

Lesson 14 (2 days) What do the patterns in embryo development tell us about how things living today could be connected to the things that lived long ago?
We analyze sketches of embryos at different points in development for a variety of living things, such as a chicken, a turtle, a rabbit, and a human. We construct an argument and raise questions about how and why different organisms share so many physical structures in common in their embryological development. We share these arguments and questions as a class.

Lesson 15 (1 day) What can we explain now, and what questions do we still have?
We identify the questions from our DQB that we can now answer. We celebrate all that we have learned in this unit and across the school year. We spend time identifying the questions that we did not answer and build a new DQB of these questions. We create a plan to answer some of them on our own and in school next year and beyond.

Accommodations and Modifications:

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

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

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

English Language Learners:
All modifications and accommodations should be specific to each individual child's LEP level as determined by the WIDA screening or ACCESS, utilizing the WIDA Can Do Descriptors.

- Pre-teach or preview vocabulary
- Repeat or reword directions
- Have students repeat directions
- Use of small group instruction
- Scaffold language based on their Can Do Descriptors
- Alter materials and requirements according to Can Do Descriptors
- OpenSci Ed -All student handouts (Spanish Version)

Students at Risk of Failure:

- Use of self-assessment rubrics for check-in
- Pair visual prompts with verbal presentations
- Ask students to restate information and/or directions
- Opportunity for repetition and additional practice
- Model skills/techniques to be mastered
- Extended time
- Provide copy of class notes
- Strategic seating with a purpose
- Provide students opportunity to make corrections and/or explain their answers
- Support organizational skills

High Achieving:

Extension Activities

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

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