NEPTUNE CITY SCHOOL DISTRICT

Science
Curriculum
Grade 7

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

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Acknowledgements

The Grade 7 Science curriculum was developed through the dedicated efforts of Pamela Kellett and Amy Corbet-Elsbree, middle school science teachers, with guidance of the district's curriculum steering committee members including Dolores Dalelio, Department Chairperson, Stacie Ferrara, Ed.D., STEM Supervisor, and Sally A. Millaway, Ed.D., Director for Curriculum, Instruction and Assessment.

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

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

NEPTUNE CITY SCHOOL DISTRICT

DISTRICT MISSION STATEMENT

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

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

NEPTUNE CITY School District

Educational Outcome Goals

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

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

SCIENCE
GRADE 7

COURSE DESCRIPTION

The Science Grade 7 curriculum takes an integrated approach to teaching science, and includes the following topics: chemical reactions; matter and energy; metabolic reactions; matter cycling (photosynthesis); ecosystem dynamics and biodiversity; natural resources and human impact. 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 will be able to 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:
● 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	7.1 Chemical Reactions & Matter
Suggested Time Frame	25 Days

Overview / Rationale
By the end of the unit, students have a firm grasp on how to model simple molecules, know what to look for to determine if chemical reactions have occurred, and apply their knowledge to chemical reactions to show how mass is conserved when atoms are rearranged.

Stage 1 – Desired Results

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

- **MS-PS1-1**: Develop models to describe the atomic composition of simple molecules and extended structures. [*Clarification Statement: Emphasis is on developing models of molecules that vary in complexity. Examples of simple molecules could include ammonia and methanol. Examples of extended structures could include sodium chloride or diamonds. Examples of molecular-level models could include drawings, 3D ball and stick structures, or computer representations showing different molecules with different types of atoms.] [Assessment Boundary: Assessment does not include valence electrons and bonding energy, discussing the ionic nature of subunits of complex structures, or a complete description of all individual atoms in a complex molecule or extended structure is not required.]*
- **MS-PS1-2**:Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred. *[Clarification Statement: Examples of reactions could include burning sugar or steel wool, fat reacting with sodium hydroxide, and mixing zinc with hydrogen chloride.]*
- **MS-PS1-5**: Develop and use a model to describe how the total number of atoms does not change in a chemical reaction and thus mass is conserved. *[Clarification Statement: Emphasis is on law of conservation of matter and on physical models or drawings, including digital forms, that represent atoms.]*
- **MS-LS1-8**. Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories.

Essential Questions:	**Enduring Understandings:**
● How can we make something new that was not there before? ● Where do the materials for the new substance(s) come from? ● Can essential properties be used to identify the new substance(s)?	● Law of Conservation of Matter: Matter can not be created nor destroyed, only transformed. ● Each substance has its own properties which are based upon its structure. ● Each substance has its own properties so that when the same substances are added

• How can the particles of a new substance be formed out of the particles of an old substance? • Do new substances formed have an overall different mass? • Does the behavior of substances depend on the structure at the atomic and molecular levels?	together the resulting output will be the same.
Knowledge: ***Students will know…*** • Macroscopic patterns are related to the nature of microscopic and atomic-level structure. • Patterns in rates of change and other numerical relationships can provide information about natural and human designed systems. • Patterns can be used to identify cause and effect relationships. • Graphs, charts, and images can be used to identify patterns in data. • Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. • Phenomena that can be observed at one scale may not be observable at another scale • Matter is conserved because atoms are conserved in physical and chemical processes. • Within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter. • Energy may take different forms (e.g., energy in fields, thermal energy, energy of motion). • The transfer of energy can be tracked as energy flows through a designed or natural system. • Every substance has characteristic properties that can be used to identify it (e.g., solubility, odor, melting point,	**Skills:** ***Students will be able to…*** • Develop models of atomic composition of simple molecules and extended structures that vary in complexity. • Collaboratively plan and carry out an investigation in a closed system to answer the question, "Where does the gas produced by the bath bomb come from?" • Construct and present an oral and written argument supported by empirical evidence and scientific reasoning to support the claim that gas is not trapped in the bath bomb to start with but must come from some change to the matter that was already in the system to begin with. • Analyze and interpret data to identify patterns in the characteristic properties of substances. • Plan and carry out an investigation to collect data to identify patterns in the characteristic properties of substances. • Describe the relationships in the atomic model. • Use a model to describe and visually represent that the behavior of substances is dependent on their structure at the atomic and molecular level. • Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred. • Develop and use a model to describe how the total number of atoms does not change

boiling point, flammability, density, color). These do not change regardless of the amount of the substance. ● Substances are made from different types of atoms, which combine with one another in various ways. The number, type, and arrangement of atoms in the molecules that make up a substance are unique to that substance. ● Atoms form molecules. ● In a chemical reaction, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. ● In a chemical reaction, the total number of each type of atom is conserved, and thus the mass does not change. ● There are two ways to break apart matter—physical processes and chemical processes. ● Chemical processes involve the rearrangement of particles that make up the matter; this includes chemical reactions, phase changes, and dissolving.	in a chemical reaction and thus mass is conserved. ● Explain that mass is conserved during chemical reactions because the number and types of atoms that are in the reactants equal the number and types of atoms that are in the products, and all atoms of the same type have the same mass regardless of the molecule in which they are found. ● Use mathematical and computational thinking by graphing mass vs. volume data for different substances and finding the ratio of mass to volume (a unit rate) [scale, proportion, quantity] for the samples measured to determine the density of different clear liquids. ● Construct an explanation for how the atoms in the molecules of the starting substances rearrange to form new products, but the number and types of atoms do not change and thus mass is conserved and evaluate two different molecular models for different ratios of reactant and product molecules to determine which better supports this explanation. ● Read scientific texts adapted for classroom use to determine how the molecular structure of different substances (patterns) is related to their odor, how those molecules reach our nose (cause), and how those molecules interact with different sensory receptors there that each cause a different signal to travel through our nerve cells that leads to the perception of different scents (effect)

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. RST.6-8.3 Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks. 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). 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. **New Jersey Student Learning Standards-Mathematics (2016)** MP.2 Reason abstractly and quantitatively. 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. 6.EE.A.2 Write, read, and evaluate expressions in which letters stand for numbers. 6.RP.A.1 Understand the concept of ratio and use ratio language to describe a ratio relationship between two quantities. 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. 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. 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 7.RP.A.2 Recognize and represent proportional relationships between quantities. 8.EE.A.1 Know and apply the properties of integer exponents to generate equivalent numerical expressions **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
All student handouts are in the lesson folders for each unit in the teacher resource section Primary Source Readings: Student edition unit 7.1 Technology: Student video playlist for lessons

Teacher Resources
Texts: **7.1 Lesson Specific Slides 1-14** **7.1 Chemical Reactions Teacher Edition** **7.1 Chemical reactions and matter unit lesson folder** **Technology:** Teacher video playlist for lessons **Websites:** https://www.openscied.org

Stage 2 – Assessment Evidence
Pre-Assessments: The student work in Lesson 1 available for assessment should be considered a pre-assessment. It is an opportunity to learn where students are coming in and what ideas they have that you can build on in this unit. Specifically, look for students' initial understandings of modeling, asking questions, patterns, cause and effect, and matter and energy. Students' initial models on What Happens to a Bath Bomb When Put in Water? and Initial Model-based Explanation at the end of day 1 to pre-assess their fluency in three-dimensional learning. Look for students to include both macroscopic and microscopic elements in their initial models of the bath bomb. The Driving Question Board Listen for questions that are open (how/why) and testable versus closed (yes/no) in the classroom. Also listen for questions that are specific to the bath bomb and questions that are about related phenomena when solids are added to liquids. ***Formative Assessments:*** In lesson 2 students construct their first written argument with scaffolding. This serves as a formative assessment for where students are in their development of this practice. Look for the use of key model ideas and observations as evidence in their responses. See Sample Student Response for Written Argument and the related Assessment callout box for additional guidance.

In lesson 5 Check students' responses on My Predictive Explanations for the Gas from a Bath Bomb at the end of day 1 and provide feedback. See Assessment callout box in the teacher guide at the end of day 1.

In lesson 13 Students develop an explanation for what an odor is and how it is detected after conducting an investigation and reading informational text. Since this is only the second time in the OpenSciEd scope and sequence that students will have gathered and synthesized information that sensory receptors respond to stimuli by sending messages to the brain, and students will still have two additional experiences with this related NGSS PE: MS-LS1-8] in later 8th grade units: OpenSciEd Unit 8.1: Why do things sometimes get damaged when they hit each other? (Collisions Unit) and OpenSciEd Unit 8.2: How can a sound make something move? (Sound Unit), it is recommended that you use this as a formative assessment.

Summative Assessments:
Lesson 5 Collect students' written arguments at the end of the lesson (end of day 2). Use Elements to look for in students' written arguments for guidance on what to look for in their written arguments.

Lesson 6 This lesson offers students an opportunity to use their ideas to explain a related phenomenon. This is the first time in the unit that students have tried to explain a different phenomenon than the bath bomb. This offers a good midpoint summative assessment opportunity but also can be used to inform whether additional remediation or review is needed in subsequent lessons.

Collect students' written arguments on Explaining another phenomenon or Alternate: Explaining another phenomenon. Use Elements to look for in students' written arguments for guidance on what to look for in their written arguments.

In lesson 10, students collect evidence from an investigation where energy is added to water using a battery. Two gasses are formed when this happens and students use property data to determine this and write an argument. At the end of the lesson, they construct an argument about whether the gas(es) produced from water using energy from a battery is made of the same particles that were produced from heating the water. Use Sample Student Response for Written Explanation for guidance on what to look for in their written arguments.

Lesson 12 In this assessment students construct two explanations having to do with the bath bomb reaction. One explanation is around how the same atoms that are in the molecules of the starting substances rearrange to form new products made of different molecules. The second explanation is about whether more than one substance can be produced during a chemical reaction. Use Explaining New Aspects of the Anchoring Phenomena for guidance on what to look for in their explanations.

Lesson 14 Students analyze data about interactions between different substances in the environment around the Taj Mahal and the marble surface of the monument to determine if a chemical reaction is occurring between any of the substances and the marble that could be causing it to be crumbling and falling apart. Through this summative, students will show growth toward all components of the three unit level PEs.

The lesson as written gives students the choice to select which option to follow (part 2a or 2b) after completing part 1. However, you may wish to choose part 2b for students that you think would benefit from the challenge. Or you may want to reserve some or all the questions from part 2b as a set of items that students can try again at a later time if they struggle with any of the original items on the test.

Stage 3 – Learning Plan
LESSON 1 (4 days) What happens when a bath bomb is added to water (and what causes it to happen)? We observe different bath bombs and what they do when added to water and then develop individual models and explanations to show what is happening at a scale smaller than we can see. We develop an initial class consensus model, brainstorm related phenomena, develop a DQB and ideas for investigations to pursue **LESSON 2 (2 days) Where is the gas coming from?** We investigate bath bombs, measuring their mass in a closed and open system before and after crushing them and before and after we add the bath bomb to water. We argue from evidence about where the gas came from. **LESSON 3 (2 days) What's in a bath bomb that is producing the gas?** In this lesson, we make observations and collect data on each of the main ingredients in a bath bomb, recording the properties of each. We also investigate each ingredient as it mixes with water and record our observations. However, we see that the ingredients interact with water in different ways. **LESSON 4 (2 days) Which combinations of the substances in a bath bomb produce a gas?** We will discuss and record what we've figured out so far in the unit. We will plan and carry out an investigation to test different combinations of substances from a bath bomb, and we will use the results to argue that the gas produced must be a new substance. **LESSON 5 (2 days) What gas(es) could be coming from the bath bomb?** We brainstorm phenomena related to gases and identify some different properties. We analyze the data by taking into account common gases and their known densities and flammabilities. We test the flammability of air from the room, gas from the bath bomb, and helium gas. We carry out an investigation to see if gas from the bath bomb rises or sinks. We argue from evidence (density

and flammability data) that the gas from the bath bomb can be narrowed down to three candidate substances.

LESSON 6 (1 day) How can we explain another phenomenon where gas bubbles appear from combining different substances together? We apply what we have figured out about properties to explain a related phenomena (elephant's toothpaste). We revisit our DQB and reflect on what other related phenomena we might explain using the same key model ideas.

LESSON 7 (1 day) How can we revise our model to represent the differences in the matter that goes into and comes out of the bath bomb system? We work as a class to summarize and review all of the science ideas we have figured out through the investigations we have done so far in order to put all the pieces together. We develop a new way to represent what we figured out, using an input/output table. We identify an unanswered question about where the particles that make up the substance(s) of the gas came from and individually develop a model to try to explain this.

LESSON 8 (1 day) How can particles of a new substance be formed out of the particles of an old substance? We develop alternate models for how new particles might be made from old particles using manipulatives (printed colored circles). We formulate questions we have about how we could figure out what happens when new substances are made from old. We read about what Dalton and other scientists did to see if adding energy to water could form new particles.

Unit Plan Title	7.2 Chemical Reactions & Energy
Suggested Time Frame	21 days

Overview / Rationale
This unit on chemical reactions and energy starts off with students thinking about how they would heat up food without having typical methods available. Students develop an initial model to consider how a flameless heater works, but they also notice some problems with prepackaged MREs. In order to solve some of the identified problems, the class decides to help people in situations in which typical heating methods aren't available to heat up food by designing a homemade flameless heater with instructions that others could follow.

<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-PS1-6: Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes.
● MS-ETS1-2: Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
● MS-ETS1-3: Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
● MS-ETS1-4: Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.</td></tr>
<tr><td>Essential Questions:
● How can we heat up food when we don't have our typical methods available?
● How do heaters get warm without a flame?
● What other chemical reactions could we use to heat up food?
● How much of each reactant should we include in our homemade flameless heater?
● How can we refine our criteria and constraints?
● How can we redesign our homemade flameless heater?
● How did our design compare to others in the class?</td><td>Enduring Understandings:
● The temperature increases when substances in air-activated hand warmers and flameless heaters are undergoing a chemical reaction.
● Different chemical reactions cause an increase, decrease, or no change in temperature. Changing the amount of reactants changes the amount of energy transferred and warming more food requires more energy transfer.
● Adjusting the proportion of reactants causes different temperature changes and different levels of leftover reactants and products.
● The class seems to be repeating some of the work they are doing as engineers.</td></tr>
</table>

- What effects might result from our design changes? - What is our optimal design for a homemade flameless heater? - How can we decide between competing designs?	- Copper sulfate and aluminum in saltwater can be used in a homemade device to heat up food. - Sharing designs among teams helps to determine which flameless heater design characteristics are more promising than others with respect to the identified criteria and constraints. - When a change is made to a design, there are downstream consequences of varying degrees that may result in different effects on stakeholders. - Test results inform the redesign of our homemade flameless heater
Knowledge: *Students will know…* - Prepackaged MREs are useful, but they are expensive, possibly confusing to use, and can be difficult to get to people. - We want to design an effective, inexpensive, easy-to-use flameless heater that people can make at home and use to heat food when typical methods are not available. - We need to gather more-detailed information from testing and data analysis to inform and improve further redesigns. - We have a lot of questions and ideas for investigations that will continue to drive our design work. - Energy transfers from the system of atoms that rearrange during the chemical reaction to surrounding systems (which includes the water and air inside the heater device, the material the device is made out of, the thermometer, the container the food is in, the food, and the environment outside of the MRE). - In our homemade heater designs we need to maximize energy transfer to the food, and minimize transfer to the outside environment.	**Skills:** *Students will be able to…* - Ask questions that arise from careful observation of a flameless heater that is able to heat food (effect) using a chemical process (cause). - Define a design problem that can be solved through the development of a homemade flameless heater with multiple criteria and constraints that uses a chemical process (system 1) to heat up food (system 2). - Apply scientific ideas to design a solution for a flameless heater that heats food by a chemical process that transfers energy. - Conduct an investigation to serve as the basis for evidence to confirm that the devices are undergoing a chemical reaction when the temperature increases as energy is transferred from the substances in the devices to its surroundings (what the thermometer measures). - Develop a model to describe how energy is transferred between different parts of our reaction system to inform the next steps of the design process. - Collect data that support choosing the chemical reaction that can transfer the most energy to the food system.

● Our research helped us figure out that the substances that are in each device we investigated are not good candidates for our homemade heater. We need to find another chemical process. ● Root killer and aluminum foil mixed together in saltwater caused a large increase in temperature. ● Exothermic reactions transfer energy to the surroundings; these reactions feel warm. Energy transfers from the surroundings to an endothermic chemical reaction; these reactions feel cold. ● Chemical reactions can transfer energy to other systems. ● The more reactants we use in a chemical reaction, the more energy is being transferred into or out of the system. The evidence of this is a greater temperature change. ● To raise the temperature of a larger amount of food, more reactants are required. ● The combination of reactants that results in the greatest temperature change is 8% aluminum and 92% $CuSO_4$. ● We identify our stakeholders and decide to survey them to understand their needs. ● Our optimal solution needs to ○ cost no more than $12 ($3 for the heater), ○ have a total mass of less than 700 grams, and ○ heat food to 40-47°C. ● Engineers use a cyclical process (Define, Develop, Optimize) to design solutions. ● Designs need to be tested to inform modifications that will lead to a better solution. ● Different kinds of models are helpful for testing design solutions. ● The instructions we write to help people build a heater are critical to the success of the solution.	● Develop a model to describe and/or explain the unobservable mechanism related to chemical reactions and the flow of energy to or from the reaction system and its surroundings. ● Evaluate and use accurate methods of data collection to define an optimal proportion of reactants that result in the greatest temperature change and least amount of reactants left over. ● Analyze data to identify patterns in numerical relationships and images to define an optimal proportion of reactants that result in the greatest temperature change and least amount of reactants left over. ● Analyze data by identifying patterns to define an optimal operational range for our homemade flameless heater designs that best meets criteria for success because the more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. ● Undertake a design project to construct and test a solution that meets specific design criteria and constraints, including the transfer of energy. ● Apply scientific ideas, results from testing designs, and the interactions identified on system models to modify our designs in order to improve the flow of energy to food. ● Respectfully provide and receive critiques about design solutions to evaluate competing designs with respect to how they meet criteria and constraints and consider patterns across multiple designs to determine which design characteristics caused more-effective outcomes in performance. ● Evaluate competing design solutions based on jointly developed and agreed-upon design criteria using systematic processes to consider how

• We identify which design characteristics cause the best performance, and we want to optimize our flameless heater designs by incorporating different combinations of these characteristics. • We need to systematically examine how changes in one part of our design might cause changes in another part. • We need other groups to test our designs to see if our instructions are clear. • Intentional design changes result in unintentional changes to other design characteristics. • Thinking about the ways in which stakeholders are impacted by design changes is important when making decisions about optimizing the design. • Design performance needs to be optimized by revising and retesting. • Parts of different solutions can be combined to create a solution that is better than any of its predecessors. • Peer testing of designs and instructions can inform modifications that lead to a better solution. • Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. • There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. • Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of the characteristics may be incorporated into the new design. • Some chemical reactions release energy. • Increasing the amount of reactants in an exothermic reaction corresponds to an increase in energy transferred out of that system.	small changes in one design characteristic might cause unexpected changes in other design characteristics. • Prioritize criteria and consider trade-offs that occur as a result of design changes to decide which changes to incorporate for the optimal homemade heater design. • Communicate technical information in writing about how to transfer energy through a system that was designed to perform better than any of its predecessors by using parts of different solutions. • Optimize performance of a design that represents systems and energy flows between systems by revising and retesting to incorporate characteristics of the most promising solutions. • Make a written argument that supports or refutes the advertised performance of a sea turtle incubator based on evidence concerning whether the incubator meets relevant criteria and constraints, such as transferring the right amount of energy to the sea turtle eggs. • Apply the Energy Transfer Model to show how the energy is transferred between the reaction occuring in the heat pack and the system containing the turtle eggs.

Interdisciplinary Connections
New Jersey Student Learning Standards-English Language Arts (2016) RST.6-8.3 Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks. (MS-PS1-6) 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-PS1-6) RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts. (MS-ETS1-2, 1-3) RST.6-8.9 Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic. (MS-ETS1-2) WHST.6-8.7 Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration. (MS-ETS1-2, 1-3) WHST.6-8.9 Draw evidence from informational texts to support analysis, reflection, and research. (MS-ETS1-2, 1-3) SL.8.5 Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest. (MS-ETS1-4) **New Jersey Student Learning Standards-Mathematics (2016)** MP.2 Reason abstractly and quantitatively. (MS-ETS1-2, 1-3, 1-4) 7.EE.3 Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form (whole numbers, fractions, and decimals), using tools strategically. Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies. (MS-ETS1-2, 1-3) 7.SP Develop a probability model and use it to find probabilities of events. Compare probabilities from a model to observed frequencies; if the agreement is not good, explain possible sources of the discrepancy. (MS-ETS1-4) **New Jersey Student Learning Standards- Computer Science & Design Thinking (2020)** 8.2.8.NT.1 Examine a malfunctioning tool, product, or system and propose solutions to the problem. 8.2.8.NT.3 Examine a system, consider how each part relates to other parts, and redesign it for another purpose. 8.2.8.ED.2 Identify the steps in the design process that could be used to solve a problem.

Student Resources
Primary Source Readings ● Student Edition of Unit 7.2 Chemical Reactions & Energy ● OpenSciEd 7.2 Chemical Reactions & Energy Student Edition

Secondary Source Readings

- Foodborne Germs and Illnesses
- Safe Minimum Internal Temperatures
- Military Mystery Meat

Supporting Text pages

- Handouts - All student handouts are within the lesson folders for each unit in the teacher resource section

Technology

- Chromebook with internet access

Teacher Resources

OpenSciEd Unit 7.2 - Chemical Reactions & Energy Storyline

Texts:

- OpenSciEd Unit 7.2 Chemical Reactions & Energy
- OpenSciEd Unit 7.2 Chemical Reactions & Energy - Elements of NGSS Dimensions
- OpenSciEd Teacher Handbook
- OpenSciEd Unit 7.2 Chemical Reactions & Energy Teacher Edition

Technology

- **Chromebook with internet access**
- **Desktop with internet access**
- **SmartBoard/Promethean board**

Websites:

Videos:
Eating an MRE
Contents of an MRE Heater
7.2 Lesson 2 Contents of the Hand Warmer
7.2 Lesson 2 Timelapse of MRE Heater Set-Up
7.2 Lesson 2 Timelapse of Handwarmer Set-Up
7.2 Lesson 6 Massing MRE Entree

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.

The initial model developed on day 1 about the question—"How does a flameless heater heat up food just by adding room-temperature water?"—is a good opportunity to pre-assess student understanding of all three dimensions: chemical reactions and transfer of thermal energy at the particle level.

The Design Questions 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. 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 as they relate to the investigations underway. Students' questions for the DQB should be connected to the observations that they had previously made and be directed at seeking additional information about how they could design a device that will heat food without electricity or flame (possibly using a chemical process).

Formative Assessments:
Lesson 3 does a lot to ground student thinking in energy transfer between parts of a system. To demonstrate understanding of the necessary pieces to move forward with productive ideas for design solutions, it is important to check in to ensure students are comfortably using and are able to build on disciplinary core ideas and cross cutting concepts they secured in OpenSciEd Unit 6.2: How can containers keep stuff from warming up or cooling down? (Cup Design Unit) and OpenSciEd Unit 7.1: How can we make something new that was not there before? (Bath Bombs Unit).

Teams of students will submit their design solutions. Their designs should include all of the characteristics listed on Design Must-Haves. Then teams self-assess for how well they did as a team using Engineering Design Rubric. Teachers should also use this rubric to give feedback to teams. This should be considered an important opportunity to learn as this point in the unit. They will have opportunities to improve their engineering design work as the unit progresses.

Using Teamwork Self-Assessment, students will individually self-assess their teamwork. This assessment is intended as a space for student reflection, but if you are interested in responding to their thoughts, you might ask students to leave their notebooks open to this page after class today so that you can see it.

Summative Assessments:
Similar to Lesson 6, teams of students will submit their revised design solutions. Their designs should include all of the characteristics listed on Design Must-Haves. Then teams self-assess their group work using Engineering Design Rubric. Teachers should also use this rubric to assess the revised designs. This can be considered a summative assessment for their engineering

designs, and teachers should be looking for improvement between the Lesson 6 and Lesson 9 team designs.

In Lesson 10, students will have an opportunity to demonstrate understanding on a summative assessment transfer task about sea turtle incubators. They will also have a chance to demonstrate understanding and surface any unanswered or new questions as they review their Progress Trackers in combination with the Design Questions board with a partner.

Stage 3 – Learning Plan
LESSON 1 (3 days) How can we heat up food when we don't have our typical methods available? We develop an initial model to consider how the flameless heater in an MRE works, but we also notice some problems with prepackaged MREs. After brainstorming criteria and constraints for a homemade flameless heater, we create designs. We build a Design Questions Board and gather ideas for investigations. **LESSON 2 (2 days) How do heaters get warm without a flame?** We revise an investigation to see how hot flameless heaters and hand warmers get. We collect more data to support the idea that a chemical reaction is happening when the devices heat up. We research the different ingredients and observe changes in the substances as they warm up to confirm new substances are made. We model energy transfer in the MRE system using what we learn. **LESSON 3 (3 days) What other chemical reactions could we use to heat up food?** We test different chemical reactions to determine if any of them cause an increase in temperature for use in our flameless heater designs. We choose the reaction that increases the temperature the most. We model the reaction as particles and the transfer of energy out of the reaction system to the food system and investigate the weight of each system. **LESSON 4 (2 days) How much of each reactant should we include in our homemade flameless heater?** We plan and conduct an investigation to determine which proportion of reactants will work best to heat up our food. Then, we reflect on what makes good instructions and identify our stakeholders. Finally, we administer a survey to our potential stakeholders to figure out what aspects they find most important. **LESSON 5 (1 day) How can we refine our criteria and constraints?** We analyze readings about food temperatures to revise our criteria and constraints. We determine the optimal solution for our homemade flameless heater, including total cost and mass. We reorganize and refine our What We Do as Engineers board to reveal the cyclical process of engineering design. **LESSON 6 (3 days) How can we redesign our homemade flameless heater?** We work in teams to draw designs for our homemade flameless heaters. Our teacher checks our plans for safety before we build prototypes and test them using a Design Testing Matrix based on our criteria and constraints. After testing, we complete a self assessment of how well our team works as engineers and how well we individually meet expectations as teammates.

LESSON 7 (1 day) How did our design compare to others in the class?
We provide and receive critique about our flameless heater designs with other teams and work as a class to identify the most promising design characteristics.

LESSON 8 (2 days) What effects might result from our design changes?
We consider possible changes to implement in our design and chart the effects on the other characteristics of our homemade heater.

LESSON 9 (3 days) What is our optimal design for a homemade flameless heater?
We work in teams to optimize our homemade flameless heaters, build optimized prototypes, and test them using a Design Testing Matrix. We solidify our how-to instructions, and a partner team uses our instructions to build and test our homemade heater. After testing, we complete two self-assessments of how we did as a team in our engineering work. We revisit our Design Questions Board to evaluate and answer any remaining questions.

LESSON 10 (1 day) How can we decide between competing designs?
We demonstrate understanding on a summative assessment transfer task involving sea turtle incubators. In this assessment we evaluate different designs and develop an argument for which sea turtle incubator design or combination of design features would work best based on relevant criteria and constraints. Then we celebrate our designs by thinking of other applications for our homemade heaters.

Unit Plan Title	7.3 Metabolic Reactions
Suggested Time Frame	29 Days

Overview / Rationale
Students will ask questions and gather ideas for investigations around trying to figure out which pathways and processes in a body might be functioning differently than a healthy system and why. Students investigate data specific to a case in the form of doctor's notes, endoscopy images and reports, growth charts, and micrographs. They also draw from their results from laboratory experiments on the chemical changes involving the processing of food and from digital interactives to explore how food is transported, transformed, stored, and used across different body systems in all people. Through this work of figuring out what is causing the symptoms, the class discovers what happens to the food we eat after it enters our bodies and how the different symptoms are connected.

<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-PS1-1: Develop models to describe the atomic composition of simple molecules and extended structures.
● MS-PS1-2: Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.
● MS-LS1-3: Use arguments supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.
● MS-LS1-7: Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism.
● MS-LS1-5: Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.</td></tr>
<tr><td>Essential Questions:
● How do things inside our bodies work together to make us feel the way we do?
● What happens to the different substances in food as it travels through the digestive system?
● How can a problem in one body system cause problems in other systems?
● What happens to matter when it is burned?
● Do all animals do chemical reactions to get energy from food like humans?</td><td>Enduring Understandings:
● Sub-systems need to work together in order to form the overall system.
● If there is a problem in one system, it may impact the overall system.
● Identify patterns within systems to form hypotheses for other systems.
● How to identify and gather the necessary data to address a system’s functionality.
● How data can support a claim.</td></tr>
</table>

Knowledge:	Skills:
Students will know… ● In multicellular organisms, the body is a system of multiple interacting subsystems. These subsystems are groups of cells that work together to form tissues and organs that are specialized for particular body functions. ● The growth of an animal is controlled by food intake. ● Within individual organisms, food moves through a series of chemical reactions in which it is broken down and rearranged to form new molecules, to support growth, or to release energy. ● Cellular respiration in animals involves chemical reactions with oxygen that release stored energy. In these processes, complex molecules containing carbon react with oxygen to produce carbon dioxide and other materials. ● Other living things, such as anaerobic bacteria, don't need oxygen for chemical reactions to get energy. ● Animals might have different structures in their bodies that do the same functions.	*Students will be able to…* ● Gather data and analyze data to answer student generated questions. ● Identify the structure and function of multiple parts of a system. ● Design a model to show how the body rearranges matter; the processes, outputs and energy flow within the systems. ● Develop models based on evidence to predict the relationships between components of a system (organs and body systems). ● Analyze and interpret data to identify patterns in how the structures of the digestive system and relative amounts of substances in a food sample appear in a healthy person and an unhealthy person. ● Plan and conduct an investigation in order to produce data to determine whether food molecules can travel from one side of a system to the other side separated by a solid structure with properties similar to the walls of the small intestine. ● Argue from evidence to revise a model to show how the results of this investigation and graphs of different types of food molecules traveling through the small intestine explain how the structure of the walls impacts the function of the small intestine. ● Analyze and interpret data to identify a relationship within the data that shows that the amount of certain food molecules (complex carbohydrates) decrease, and other food molecules (glucose) increase as they move through the mouth, which is a correlational relationship. Students argue that we need more data to determine the cause of the observed increases and decreases in food molecules. ● Plan and conduct an investigation to produce data to determine whether food containing complex carbohydrates, but not glucose, undergoes a chemical reaction in

	the mouth and that this reaction turns the complex carbohydrates into glucose when mixed with a substance found in saliva (amylase), which is identified by a pattern change in the color of the food indicator. ● Analyze and interpret these data as evidence that the digestive system is a system of interacting subsystems composed of organs that each perform different functions. ● Develop a model based on multiple lines of evidence to represent the inputs, processes, and outputs of the digestive system and the role that the system, and the subsystems within it, play in breaking down matter inputs through chemical reactions, absorbing food, and excreting unused matter. ● Construct an explanation using both qualitative and quantitative data and scientific reasoning (that burning food produces energy, in the form of heat and light, and products, such as carbon dioxide and water) to describe why the mass of oil burned in an open system changes, while it stays the same in a closed system. ● Develop models of three possible pathways showing how food is rearranged in the body to create energy, store matter for later use, and use matter for growth within a body system. ● Develop a model to explain how bears can rearrange matter in food through chemical reactions to release energy and use stored food in the form of fat to survive during hibernation. ● Construct an explanation by applying scientific ideas and evidence to show how bears obtain energy to survive for several months without eating during hibernation.

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.

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

New Jersey Student Learning Standards-Mathematics (2016)
MP.2 Reason abstractly and quantitatively.
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.
6.EE.A.2 Write, read, and evaluate expressions in which letters stand for numbers.
6.RP.A.1 Understand the concept of ratio and use ratio language to describe a ratio relationship between two quantities.
6.RP.A.2 Understand the concept of a unit rate a/b associated with a ratio a:b with $b \neq 0$, and use rate language in the context of a ratio relationship.
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.
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.
7.RP.A.2 Recognize and represent proportional relationships between quantities.
8.EE.A.1 Know and apply the properties of integer exponents to generate equivalent numerical expressions
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 $\sqrt{2}$ is irrational.
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.

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 Unit 7.3 Metabolic Reactions** Secondary Source Readings: **A Winning Wheat** **No Peanuts Here, Please** **Human Microbiome: Your Body Is an Ecosystem** Supporting Text pages: ● Handouts - All student handouts are within the lesson folders for each unit in the teacher resource section ● **7.3 Metabolic Reactions Student Edition.pdf** Technology: ● **Virtual Microscope: Human Tissue** ● **NetLogo: Villi Absorption** ● **A Look Inside the Digestive System** **Videos:** ● **Overview of Unit** ● **M'Kenna's Symptoms Interview Lesson 1** ● **Animation of a Person Chewing-Lesson 5** ● **Burning the Wick Alone Lesson 10 Video 1** ● **Oil Burning on a Scale Lesson 10 Video 2** ● **Duck Fat Burning on a Scale Lesson 10 Video 3** ● **Measuring Gases in a Closed System with a Flame Lesson 11** ● **Burning in an Open System Lesson 11 Video 3** ● **Burning in a Closed System Lesson 11 Video 4** ● **Blowing bubbles into Bromothymol Blue with Water Lesson 12**
Teacher Resources
Texts: ● **OpenSciEd Unit 7.3 Metabolic Reactions** ● **OpenSciEd Teacher Handbook** ● **OpenSciEd Teacher Edition** ● **Elements of NGSS Dimensions** **Technology:** ● **Virtual Microscope: Human Tissue** ● **NetLogo: Villi Absorption** ● **A Look Inside the Digestive System**

Videos:

- [7.3 Metabolic Reactions Teacher-Preparation Videos]
- [Lab Set Up Demonstration of Sealing and Filling Dialysis Tubing Lesson 3]
- [Lab Set Up Demonstration of Dialysis System Investigation Day 2 Lesson 3]
- [Lab Set Up Demonstration of Amylase Investigation Lesson 5]
- [Lab Set Up Demonstration of Burning Fats Lesson 10]
- [Lab Set Up Demonstration of Closed System Burning Oil Lesson 11]
- [Lab Set Up of Closed System Burning Oil and Measuring Gases Lesson 11]

Stage 2 – Assessment Evidence
Pre-Assessments: The student work in lesson 1 available for assessment should be considered a pre-assessment. It is an opportunity to learn where students are coming in and what ideas they have that you can build on in this unit. The more ideas in your classroom the better. Use students' initial models to highlight the range and diversity of ideas the class as a whole has. Also, use the Consensus Discussion about the initial class model to assess which ideas students are bringing up in their models to explain the cause or underlying mechanism of M'Kenna's symptoms. Look for agreement on key components of the models, such as (1) the digestive system, (2) input of food, and (3) some connections to other body systems. Students have opportunities to pose and build on other students' questions during the construction of the Driving Question Board (DQB). Look for how or why questions about phenomena that seek to investigate interactions inside of the body, either within a system or between different systems. Use your judgment on how to press students to form how and why questions. If a student struggles with sharing, choose to celebrate going public with questions over getting to a how or why question. If students do not ask questions about the phenomenon that seek to investigate how different body systems work together, that's okay at this point. They will have another opportunity to add questions to the DQB in Lesson 9. Also, questions can be added to the DQB at any point throughout the unit. We recommend always having sticky notes or index cards on hand to capture students' evolving questions. ***Formative Assessments:*** Lesson 7 is a group or pair formative assessment. Its intent is to give you information about where students are at with using evidence to begin to reason about the cause and effect of M'Kenna's illness. The key is meant to support you in facilitating students, there are no correct answers. In this formative lesson you should be listening for students' use of evidence from the unit so far and students' understanding of what that evidence can tell them and not tell them.

Lesson 10 connects Lesson Set 1 with Lesson Set 2. As a formative, pre-assessment for Lesson Set 2, use the Initial Ideas Discussion in the Navigation activity about what could be causing M'Kenna's weight loss to see if students could connect to what was figured out in Lesson Set 1 when she could not get enough matter inside her body because her villi in her small intestine are damaged. If students do not make this connection, that's OK. They will have the opportunity to do so later on.

Lesson 14 Students have an opportunity to develop arguments using evidence from their Gotta-Have-It Checklists. Then students do a gallery walk to provide each other with specific feedback using an argumentation rubric. With feedback from their peers, students can revise their work with a group. Although students can use the self-assessment rubric for giving and receiving feedback at any time, this is a designated spot for having students reflect.

Summative Assessments:
Lesson 8 is a putting the pieces together lesson. It includes a summative midpoint assessment that can provide formative information for moving forward in the unit. There is an argument rubric specific to this unit that should be used to score student responses. The goal of this assessment is to get students writing complex arguments on their own. You can decide how much or how little scaffolding your students need. Some prompts are included in the assessment. 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 evidence and reasoning laid out in the rubric for this assessment.

Lesson 15 includes a transfer task to give students an opportunity to use the 3 dimensions to make sense of a different phenomenon. This is meant to be a summative assessment task for the unit and it gives you a grading opportunity. The task includes a teacher reference with a scoring guide as well as a modeling rubric for scoring the modeling question. Scoring guides are meant to highlight important ideas students should be including in their responses to the prompts. They are listed as bullet points so you can decide how to score them appropriate to the norms in your classroom. If students share these ideas elsewhere in the assessment, it is up to you to decide if that understanding is sufficiently demonstrated.

Stage 3 – Learning Plan
LESSON 1 (3 days) What is going on inside M'Kenna's body that is making her feel the way she does? M'Kenna, a 13-year-old girl, seems to be really sick and we aren't sure why. We notice she has symptoms in all different parts of her body and some symptoms started before others.

LESSON 2 (2 days) Can we see anything inside M'Kenna that looks different? We examined M'Kenna's endoscopy report and some graphs that show what happens to food as it travels through M'Kenna's digestive system in comparison to a healthy one.

LESSON 3 (2 days) Why do molecules in the small intestine seem like they are disappearing? We plan and conduct an investigation to determine whether food molecules can pass through or travel across a surface with a structure similar to the small intestine. We argue for how our results and molecular models of the substances we used might help explain how some kinds of food molecules could be absorbed into the body by passing through openings in the wall of the small intestine and others could not.

LESSON 4 (1 day) What happens to food molecules as they move through the small intestine and large intestine? We investigate food data from the mouth to the large intestine and determine that (1) most of the molecules are gone by the time they reach the large intestine, and only fiber and water remain, and (2) M'Kenna has other molecules in her large intestine. We examine poop data to confirm what molecules should be expected.

LESSON 5 (3 days) Why do large food molecules, like some complex carbohydrates, seem to disappear in the digestive system? We make observations about what happens to complex carbohydrates, other than fiber, in the mouth. We analyze data from a graham cracker noting how the complex carbohydrates and glucose change in the mouth. We also notice that glucose molecules look like smaller pieces of complex carbohydrates. We plan and conduct an investigation to determine whether complex carbohydrates, other than fiber, undergo a chemical reaction when mixed with a substance in saliva to produce glucose.

LESSON 6 (1 day) What happens to the different substances in food as it travels through the digestive system? We analyzed food data, noting how the food changes in different parts of a healthy digestive system. We noticed patterns in which some molecules decreased by the same amount that other molecules increased. We argued that this is a sign of chemical reactions happening in the digestive system.

LESSON 7 (2 days) What is the function of the digestive system, and how is M'Kenna's digestive system different? We developed a model to represent the inputs, processes, and outputs of the digestive system and the role that the system plays in breaking down matter through chemical reactions, absorbing food, and excreting unused matter. We constructed an argument, based on evidence, to eliminate two of five possible conditions that could be causing the symptoms that M'Kenna is experiencing in her digestive system.

LESSON 8 (2 days) What does the surface of M'Kenna's small intestine look like up close compared with a healthy one? We zoom in on the small intestine to better understand its structure and function. First, we take stock of where we are in the body by mapping M'Kenna's system to the organization of the human body systems. We identify structures called "villi" that line the small intestine and use an interactive simulation to learn more about the villi.

LESSON 9 (1 day) How can a problem in one body system cause problems in other systems? We revisit the Driving Question Board (DQB) to see the progress we have made on our initial questions. We add new questions to the DQB and reorganize them in clusters related to the system to which they are connected. We revisit M'Kenna's Doctor's Note to look at her symptoms in other systems and realize that, although her symptoms started in the digestive system, there are still other systems having symptoms. We add two big questions to our DQB: "How can a problem in one body system cause problems in other systems?" and "How are these different systems connected?".

LESSON 10 (2 days) Why is M'Kenna losing so much weight? We analyze trends in M'Kenna's weight and look at images of weight loss over time. It looks like the fat is disappearing, which makes us wonder, where is the fat going? We read an article that says that, when kids lose weight, the fat is being "burned." We wonder if this is the same "burning" as when we light something on fire. We do an experiment and light different types of fats on fire, weigh them, and compare their properties before and after they burn.

LESSON 11 (2 days) What happens to matter when it is burned? We conduct two investigations to trap the gases produced by burning food. First, we burn vegetable oil in a closed versus an open system and compare the masses of the systems. Second, we burn vegetable oil in a closed system and track carbon dioxide and water in the air within the system using a sensor.

LESSON 12 (2 days) Does this chemical reaction to burn food happen inside our bodies? We gather evidence showing that a chemical reaction happens in the cells of the body to provide them with energy. The reaction helps us explain why certain materials that we take into our bodies, like oxygen and food, are different from the materials that leave our bodies, like carbon dioxide and water. If our activity level increases, the chemical reaction happens faster to meet cells' needs.

LESSON 13 (2 days) How does a healthy body use food for energy and growth, and how is M'Kenna's body functioning differently? We developed a model to show how food is rearranged in the body in terms of matter inputs, processes, outputs, and energy flows within a body system. We constructed an explanation to explain the relationships between differences in M'Kenna's digestive system and a healthy digestive system to predict symptoms (effects), such as M'Kenna's decreased growth rate.

LESSON 14 (2 days) Do all animals do chemical reactions to get energy from food like humans? We investigate an organism of our choice to see if it does metabolic reactions similar to the way humans do. We argue from evidence whether (1) our organism does chemical reactions to break down and burn food molecules the same way as humans and (2) it has the same structures inside its body that work together to do those processes. Then we come together to share our findings with other groups to give and receive feedback.

LESSON 15 (2 days) What questions on our Driving Question Board can we now answer? We investigate an organism of our choice to see if it does metabolic reactions similar to the way humans do. We argue from evidence whether (1) our organism does chemical reactions to break down and burn food molecules the same way as humans and (2) it has the same structures inside its body that work together to do those processes. Then we come together to share our findings with other groups to give and receive feedback.

Unit Plan Title	7.4 Matter Cycling & Photosynthesis
Suggested Time Frame	29 days

Overview / Rationale
This unit on matter cycling and photosynthesis begins with students reflecting on what they ate for breakfast. Questions about where their food comes from lead them to consider which breakfast items might be from plants. Students explore what else is in food, and discover that foods from plants they ate, like bananas, peanut butter, beans, avocado, and almonds, not only have sugars but proteins and fats, as well.

<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-PS1-3: Gather and make sense of information to describe that synthetic materials come from natural resources and impact society. [Clarification Statement: Emphasis is on natural resources that undergo a chemical process to form the synthetic material. Examples of new materials could include new medicine, foods, and alternative fuels.]
MS-LS1-6: Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms. [Clarification Statement: Emphasis is on tracing movement of matter and flow of energy.]
MS-LS2-3: Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem. [Clarification Statement: Emphasis is on describing the conservation of matter and flow of energy into and out of various ecosystems, and on defining the boundaries of the system.]</td></tr>
<tr><td>Essential Questions:
Where does food come from, and where does it go next?
Where does this stuff come from?
Do plants get their food molecules by taking them in?
What other inputs could be sources of food molecules for the plant?
Are any parts that make up food molecules coming into the plant from above the surface?
How are these gases getting into and out of leaves?
How are all these things interacting together in this part of the plant?
Why do plants need light?
Where are plants getting food from?</td><td>Enduring Understandings:
Synthetic materials come from natural resources.
Photosynthesis is the beginning of energy flow through organisms.
Photosynthesis is the beginning of energy flow through systems.
Energy flows through all living and nonliving parts of an ecosystem.</td></tr>
</table>

● Where do the food molecules in the maple tree come from? ● Why don’t plants die at night? ● Why don’t plants die when they can’t make food? ● Where does the rest of our food come from? ● What happens to food that doesn’t get eaten? ● Where does food come from and where does it go next? ● Where does food come from, and where does it go next?	
Knowledge: *Students will know...* ● All plant foods we looked up nutrition information for have food molecules in them. Not all of the plants have the same food molecules (carbohydrates, fats, proteins), but all of them have some sugar. ● Plants might get their food molecules from different sources (i.e., water, sunlight, soil). ● Carbon dioxide enters plants through the leaves. ● Since carbon dioxide is the only input containing carbon, it is the source of carbon in food molecules. ● Plants also release water and oxygen from their leaves. ● Leaves have small openings on the leaf surface that allow gases like carbon dioxide, oxygen, and water to enter and exit the leaf. ● Leaves are made of cells. ● Plant cells have chloroplasts in them that move in response to light. ● Water and carbon dioxide molecules, along with light, interact in chloroplasts in plant cells, where they are used to make oxygen and sugar molecules. Each of these inputs is needed to produce these outputs.	**Skills:** *Students will be able to…* ● Develop an initial model to describe the inputs of the system where plants get food molecules (matter). ● Plan and carry out an investigation collaboratively by identifying controls to produce data as evidence to determine whether hydroponic plant food contains food molecules as inputs. ● Engage in argument from evidence to support or refute possible inputs of where plants get their food molecules from, such as hydroponic plant food or soil. ● Construct an explanation by applying scientific reasoning to show why data found in images and charts show patterns that parts of inputs could be the source of food molecules in a plant. ● Analyze and interpret data and graphs to identify patterns to show that plants are taking in (inputs) carbon dioxide and releasing water and oxygen (outputs). ● Obtain information from scientific texts to describe how chloroplasts (microscopic leaf structures) respond to light (an external stimuli). ● Plan and carry out an investigation to support a claim about how the inputs to a plant are related to what the plant cell

• In this process, molecules of water and carbon dioxide are broken apart and the atoms that make them up (carbon, hydrogen, and oxygen) are rearranged to form new substances. • As more inputs are provided to the plant cell, the more oxygen and sugar are produced. • Water and carbon dioxide don't provide energy (measured in calories) for the body, but glucose does. • The plant must be getting energy from the light. • Plants must use sunlight as an input for energy so that they can do chemical reactions to make sugar (glucose and other complex food molecules). • Plants use energy from the sun to make sugars (food) from carbon dioxide and water. Plants release oxygen as an additional output in this process. This process is called photosynthesis. • During the process of photosynthesis, energy is transferred from the sunlight to the plant.Plants, algae (including phytoplankton), and many microorganisms use the energy from light to make sugars (food) from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use. • Plants, algae (including phytoplankton), and many microorganisms use the energy from light to make sugars (food) from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use. • Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and	can produce from chemical reactions in the chloroplasts (outputs). • Engage in argument from evidence about what plants need to make food molecules using evidence from the computer simulation and scientific reasoning to support an explanation for why decreasing the amount of water, carbon dioxide, light, or chloroplasts (cause) in a plant cell decreases the amount of sugar and oxygen it produces (effect). • Obtain, evaluate, and communicate information to show the relationships among matter and energy between the inputs and outputs for the process by which plants use energy from light to make sugars from carbon dioxide and water (photosynthesis). • Engage in argument from evidence and scientific reasoning to support the claim that plants use sunlight for energy to convert carbon dioxide and water into sugar that provides a form of energy the body can use. • Develop and use models based on multiple sources of evidence to show that plants use energy from light to make sugars (food) from carbon dioxide and water through the process of photosynthesis and release oxygen as an output and that energy is transferred from the sunlight to the plant through this process. • Argue from evidence that carbon dioxide is an input for plants and oxygen is an output. • Ask questions to refine our model of plants to show the inputs and outputs, and energy and matter flows over time to explain how food molecules can be present during times that plants do not have leaves or chloroplasts.

decomposers as the three groups interact within an ecosystem. ● Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. ● The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem. ● Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it. ● Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. ● The chemical reaction by which plants produce complex food molecules (sugars) requires an energy input (i.e., from sunlight) to occur. In this reaction, carbon dioxide and water combine to form carbon-based organic molecules and release oxygen. (secondary). ● Everything we eat contains matter that came from either plants or animals. ● Some foods we eat have been processed either physically or chemically, but we can still trace them back to originally coming from plants. ● Most animals, including humans, eat plants, other animals that once ate plants, or both. ● Most animals, including humans, use the food molecules they eat to build up larger molecules for growth, to get energy by burning glucose through cellular respiration, or to store for later use.	● Use a model of the plant system to predict that plants do not do photosynthesis in the dark. ● Analyze and interpret data to identify patterns that show that in the dark, plants take in oxygen and release carbon dioxide and water. ● Communicate information about the relationship between energy and the cycling of carbon dioxide and oxygen (matter) in and out of plants. ● Obtain and evaluate information from scientific texts to clarify the claim that the plant system doesn't die when it can't do photosynthesis because the sugars it produced can be stored for later use in the form of starches. The stored food molecules can be used for energy via cellular respiration or for growth. ● Construct an explanation by applying scientific ideas and evidence to explain: (1) why a tree that loses leaves in the winter doesn't die, (2) where it gets its energy during that time, and (3) where it gets the matter to grow new leaves and wood in the spring. ● Obtain information from text and a video to determine that the processed foods we eat contain matter (atoms) that came from plants; use this information to communicate and synthesize related information presented to peers. ● Integrate scientific information about the inputs and outputs of decomposers. ● Communicate information to demonstrate how matter and energy is transferred between producers, consumers, and decomposers. ● Construct an explanation to describe the cycling of atoms (matter) into and out of organisms within a system, and respectfully provide and receive

• The decomposers we investigated took in oxygen and food molecules and gave off carbon dioxide and water (cellular respiration). • Decomposers recycle dead plant and animal matter and put energy back into the system. • Decomposers use matter for food that humans (and many animals) cannot use for energy and matter. • The outputs of living things become the inputs of other living things and part of the nonliving components of the system. • Atoms are continuously recycled between living (producers, consumers, and decomposers) and non-living (air and water) components in our world.	feedback on respective explanations with a partner. • Develop and revise a model to describe the cycling of matter and flow of energy among living and nonliving parts of a system. • Construct an explanation based on evidence for the necessary role of photosynthesis in the cycling of matter and flow of energy in a system into and out of organisms. • Obtain information from multiple sources to describe that synthetic materials come from the matter and energy in natural resources and impact society.

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. RST.6-8.3 Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks. 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). 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. **New Jersey Student Learning Standards-Mathematics (2016)** MP.2 Reason abstractly and quantitatively. 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. 6.EE.A.2 Write, read, and evaluate expressions in which letters stand for numbers. 6.RP.A.1 Understand the concept of ratio and use ratio language to describe a ratio relationship between two quantities. 6.RP.A.2 Understand the concept of a unit rate a/b associated with a ratio a:b with $b \neq 0$, and use rate language in the context of a ratio relationship. 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. 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.7.RP.A.2 Recognize and represent proportional relationships between quantities.
8.EE.A.1 Know and apply the properties of integer exponents to generate equivalent numerical expressions

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: 7.4 Matter Cycling and Photosynthesis Student Edition **Secondary Source Readings:** Achieve3000: A New Way to Grow Food **Supporting Text pages:** Handouts - All student handouts are within the lesson folders for each unit in the teacher resource section 7.4 Matter cycling and photosynthesis student edition.pdf **Technology:** Hydroponics kit setup
Teacher Resources
Texts: 7.4 Matter Cycling and Photosynthesis Teacher Edition **Supplemental Workbooks:** National Geographic: Matter and Energy Cycles CK12 - Flow of Matter in Ecosystems **Websites:** https://www.openscied.org/access-the-materials/ **Videos:** 7.4 Matter Cycling & Photosynthesis - Teacher Introduction

Stage 2 – Assessment Evidence
Pre-Assessments: The student work in Lesson 1 available for assessment should be considered a pre-assessment. It is an opportunity to learn where students are coming in and what ideas they have that you can build on in this unit. The more ideas in your classroom the better. Specifically, look for students' initial understandings of modeling, asking questions, systems and systems models, and matter and energy. Developing and Using Models; Systems and System Modeling When to check for understanding: At the end of day 2, collect students' How Plants Get Food Initial Model to use their initial models as a three-dimensional pre-assessment. Asking Questions; Matter and Energy When to check for understanding: At the end of day 2 students will record questions as an exit ticket. These questions will be refined at the beginning of day 3 and then posted to the Driving Question Board (DQB). What to look/listen for: Look for the kinds of questions students are asking. Are they all about one aspect of the maple syrup (plant food) phenomenon? Are their questions only focused on energy? Or matter? Are there parts of the cycle of matter or flow of energy with no questions? What to do: When students are sharing their questions with their partners, ask students which part of the phenomenon their question comes from and if there are any other parts of the phenomenon they are curious about. As students ask and post their questions, have them reflect on any parts of the matter cycle or energy flow that have few or no questions posted on the DQB. Prompt students to generate more questions in this space so that each important part of the cycle has some questions that we can investigate to help figure out how energy and matter flow are part of this process. ***Formative Assessments:*** In Lesson 4 students complete a formative assessment focused on argumentation and the core ideas and using data collected in their investigations. There are multiple places in this lesson to monitor student thinking and learning across the DCIs, SEP, and CCC (systems and systems models). Lesson 8 offers students an opportunity to use their ideas to explain an adjacent phenomenon. We call this formative + summative because it offers a midpoint grading opportunity but should also be used to gain insight into student understanding and to inform subsequent instruction.

In Lesson 11 there is an assessment opportunity to monitor students' progress on the DCIs, constructing explanations, and energy and matter as they write an explanation of how trees or saplings that do not have leaves can survive.

In Lesson 13, there is a focus on obtaining, evaluating, and communicating information using DCIs and systems and system models. Use this formative assessment opportunity to give students feedback and support their growth in communicating science ideas.

Lesson 14 This is an opportunity for students to put together all the pieces they have figured out about where our food comes from and where it goes at an atomic level. Students are encouraged to use their resources (science notebook, Gotta-Have-It Checklist, Progress Tracker, and two-page model) to help them write their story of an atom from a breakfast food. In addition, they have the freedom to choose how they want to represent their tracing of an atom from a breakfast food through the system model. They could write a story starting "with once upon a time," write in bullet points, or write out as steps. Once finished, they will exchange with a partner to provide and receive feedback about how to make their story stronger. Though this is a student assessment, it is set up as practice before the final transfer task in the next lesson. This scaffolded approach, where students are receiving feedback from peers and the teacher is not the sole feedback provider, will support students in taking their understanding to a deeper level prior to the final transfer task.

Summative Assessments:
Lesson 8 offers students an opportunity to use their ideas to explain an adjacent phenomenon. We call this formative + summative because it offers a midpoint grading opportunity but should also be used to gain insight into student understanding and to inform subsequent instruction.

Lesson 15 includes a transfer task to give students an opportunity to use the three dimensions to make sense of a different phenomenon. This is meant to be a summative assessment task for the unit and it gives you a grading opportunity. The task includes a teacher reference with a scoring guide as well as a modeling rubric for scoring the modeling question. Scoring guides are meant to highlight important ideas students should include in their responses to the prompts. They are listed as bullet points so you can decide how to score them appropriate to the norms in your classroom. If students share these ideas elsewhere in the assessment, it is up to you to decide if that understanding is sufficiently demonstrated.

Stage 3 – Learning Plan
LESSON 1 (3 days) Where does this stuff come from? We brainstorm food we eat that we think comes from plants, animals, or other sources. We taste maple syrup and maple sap - foods that we are surprised come from plants and watch a video of sap being extracted from a tree. We

review nutrition labels for the plant foods we ate. All the plants have some food molecules. We know we get our food from eating, but how do plants get their food? Where is the food in plants coming from? We develop a model to try to explain this and develop a Driving Question Board to guide future investigations.

LESSON 2 (2 days) Do plants get their food molecules by taking them in? We use a hydroponic plant system and indicators of food molecules to investigate whether soil, plant food, water, or air could be potential sources of food molecules in plants. We develop a list of candidates coming into contact with the hydroponic plants both below and above the surface that light is shining on.

LESSON 3 (1 day)) What other inputs could be sources of food molecules for the plant? We revisit the composition of air and light to look for possible sources of food molecules. After looking at air and light (in addition to water and hydroponic plant food) we figure out none of our initial candidates contain whole food molecules. We realize that we might have to adjust our question and look to find whether plants could be putting together parts of food molecules, instead of directly taking in whole food molecules.

LESSON 4 (2 days) Are any parts that make up food molecules coming into the plant from above the surface? We conduct an investigation and produce data showing carbon dioxide decreasing and water increasing in the air surrounding plant leaves exposed to light. We analyze and interpret second hand data, confirm carbon dioxide and water patterns, and discover that oxygen levels are increasing around the plant. This sparks questions about how these gases are getting into and out of the leaves.

LESSON 5 (1 day) How are these gases getting into and out of leaves? We observe the surface of real leaves along with microscopic leaf images and a video. We see small openings on the leaf surface and discuss how these could allow plants to "breathe," by letting gases in and out. Inside the leaves, we see moving green circles inside repeating structures. We gather information from a reading that the repeating structures are plant cells, and the green circles, or chloroplasts, are moving in response to light. We discuss how light and chloroplasts fit in our plant model and review the other inputs and outputs. We discuss how a simulation could help us figure out what exactly is happening inside plant leaves.

LESSON 6 (2 days) How are all these things interacting together in this part of the plant? We use a computer simulation to explore how water, carbon dioxide, light, and chloroplasts interact in a plant cell. We use the simulation to carry out an investigation into how changing the amount of one of these inputs affects the outputs of the plant cell. We use the evidence we collect to argue that decreasing the amount of water, carbon dioxide, light, and chloroplasts decreases the amount of oxygen and sugar produced by the plant cell. We also argue that removing any one of these inputs prevents the plant from producing oxygen or sugar.

LESSON 7 (1 day) Why do plants need light? We know sunlight is needed for plants to make food, but we aren't sure what it's doing. We think sunlight gives plants energy, but so far our models only account for matter. We investigate the role of sunlight by examining food labels to figure out how much energy water, carbon dioxide, and glucose can provide for the body. We argue from evidence that since glucose (an output of plants) provides energy for our bodies in the form of calories, but inputs of plants, water and carbon dioxide, do not have energy in the form of calories, the energy must be coming from some other input. The sunlight must be the source of the energy for plants to rearrange the Cs, Hs, and Os through chemical reactions.

LESSON 8 (2 days) Where are plants getting food from? This lesson marks the end of the first lesson set. We develop a Gotta-Have-It Checklist to highlight the key ideas that we figured out in Lessons 1–7. On day 2, students take an individual assessment, applying what we have learned to explain new phenomena. We revise our consensus model by drawing and explaining what we figured out in Lessons 1–7 to explain how plants get food molecules. Our models include key inputs and outputs and differentiate between matter and energy.

LESSON 9 (1 day) Where do the food molecules in the maple tree come from? We apply our models to try to explain how maple trees can produce sap in the winter, but our models predict that plants only make food molecules when leaves are present and sugar comes out of maple trees when leaves aren't there. We realize that our models can't yet explain how food molecules can be found in plants when all the inputs or structures needed are gone. We develop initial explanations for how food molecules can be found in plants when leaves aren't present. Then we add new questions to our Driving Question Board (DQB).

LESSON 10 (2 days) Why don't plants die at night? We use our model to predict when plants don't make food molecules and wonder why plants don't die at night. We conduct an investigation and produce data showing that plants release carbon dioxide and water when in the dark. We analyze and interpret second hand data and discover that plants take in oxygen in the dark. We argue that photosynthesis doesn't happen in the dark, but now we are curious about what is happening. We wonder, are plants breathing like us? We compare our findings to humans and theorize that maybe plants burn stored food through cellular respiration when they can't make food molecules through photosynthesis.

LESSON 11 (3 days) Why don't plants die when they can't make food? We plan and carry out an investigation to see whether plants without leaves are doing cellular respiration. We use the results to argue from evidence that the food plants make is able to provide them energy (just as in humans). We read about where this happens in plant and animal cells and what plants do with extra food they produce from photosynthesis. We use the ideas from this and the evidence we collected to construct an explanation of what is happening to a maple tree in a time-lapse video filmed over five years.

LESSON 12 (3 days) Where does the rest of our food come from? We obtain information from ingredients lists for common processed foods and argue that they are made of matter from plants and/or animals. We obtain information from nutrition facts and data about animal diets and argue that animals have food molecules in them that come from eating plants or other animals that once ate plants. We argue that processed foods are made of matter from plants and/or animals.

LESSON 13 (2 days) What happens to food that doesn't get eaten? In this lesson, we watch videos of decomposers that recycle matter and energy from dead plants and animals. We examine data (for changing inputs and outputs of the system) from bread mold (a decomposer) in the light and dark. We read about decomposers in systems around the world and revise our model to include decomposers as a living part of the system.

LESSON 14 (2 days) Where does food come from and where does it go next? We share photographs and pictures of decomposers we have seen in our own lives. We revise our consensus model to include arrows representing the continuous cycling of matter and energy. We create a Gotta-Have-It Checklist from our final revised consensus model using what we figured out from each investigation.

LESSON 15 (2 days)) Where does food come from, and where does it go next? We revisit the DQB 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	7.5 Ecosystem Dynamics & Biodiversity
Suggested Time Frame	33 days

• **Overview / Rationale**
This unit on ecosystem dynamics and biodiversity begins with students reading headlines that claim that the future of orangutans is in peril and that the purchasing of chocolate may be the cause. Students then examine the ingredients in popular chocolate candies and learn that one of these ingredients--palm oil--is grown on farms near the rainforest where orangutans live. Students will establish the need for a better design for oil palm farms, which will support both orangutans and farmers. Students then investigate how oil palm farming impacts other populations of animals and how rainforests and oil palm systems differ in terms of resources and their resilience to disruptions. The final set of lessons engage students in investigations of alternative approaches to growing food compared to large-scale monocrop farms.

<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-LS2-1: Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.
• MS-LS2-2: Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.
• MS-LS2-4: Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.
• MS-LS2-5: Evaluate competing design solutions for maintaining biodiversity and ecosystem services.
• MS-ESS3-3: Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
• MS-ETS1-1: Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.</td></tr>
<tr><td>Essential Questions:
• How could buying candy affect orangutan populations in the wild?
• Can we replace palm oil with something else?
• Can we grow oil palm trees somewhere else so that we're not cutting down tropical rainforests?
• Why do people cut down tropical rainforests when they know it is harmful to the animals that live there?</td><td>Enduring Understandings:
• Buying candy in the United States could lead to the death of orangutans in Indonesia.
• Vegetable oils require land and produce different yields of oil.
• Oil palm grows best in equatorial regions because of the non living conditions suitable for plant growth, which is the same reason that tropical rainforests are found in these locations.</td></tr>
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● How have changes in our community affected what lives here? ● If palm oil is not going away, how can we design palm farms to support orangutans and farmers? ● How many orangutans typically live in the tropical rainforest? ● Why do orangutans need so much forest space? ● Would planting more rainforest fruit trees help the orangutan population increase? ● How do changes in the amount of resources affect populations? ● How does planting oil palm affect other populations? ● What would happen if orangutans go extinct? ● How does an ecosystem change when the plants change? ● Are there ways people can grow food without harming the tropical rainforest? ● How can people benefit from growing food in ways that support plants and animals in the natural ecosystem? ● What approach to growing food works for everyone and why? ● How can we redesign the way land is used in Indonesia to support orangutans and people at the same time? ● How do our designs work for orangutans and people in Indonesia? ● How can we inform others in our community about the palm oil problem and convince them to take action? ● What should we do to take care of our local land, plants, and animals?	● Interviews with people who work to grow oil palms in developing countries reveal that this practice, though harmful to animals like orangutans, provides them with a way to make money to support themselves, their families, and their communities. ● Some plants and animals seem to be doing OK, even with changes humans have made in our community, but others are missing altogether. ● Palm farms that grow a single crop do not function well for tropical rainforest animals, leading to declines in these populations. ● Orangutans at different times in 4 different protected areas show stable populations, with about 1-3 orangutans per 1 km^2. ● Orangutans compete for food resources in three different environmental conditions. ● Orangutan population sizes increase when resources are plentiful and decrease when resources are limited. ● The loss of short and tallgrass prairies to soybean oil production in the Midwest of the United States has caused declines in local monarch butterfly populations. ● Rat and snake populations are exploding in the oil palm system, but those populations are not exploding in the rainforest system. ● Many seeds from fruit trees are found in spit and fecal samples of orangutans. These seeds germinate better compared to control seeds. ● Disruptions, like drought, fire, disease, or loss of a seed disperser, cause shifts in populations in an ecosystem. ● Farmers and other community members in Indonesia and Costa Rica observe positive impacts on plant and animal populations when growing food using different approaches from large-scale monocrop farms.

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Farmers gain ecosystem services (food, water, soil health, protection from crop disease, and the like) when they grow food differently from large-scale monocrop farming.
People can use many approaches to growing food, and there are trade-offs to using them that have consequences for plants, animals, and humans in nearby ecosystems.
Students redesign and optimize the way land is used to support orangutans and people.
The design solutions with mixed land use and some intact forests worked best for people and orangutans.
Public service announcements (PSAs) inform people and communities about issues like the palm oil problem and encourage them to take actions to help preserve natural systems.
A local population is declining (Pathway A) or we notice interesting patterns about the way our community is currently caring for the land (Pathway B).

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Knowledge:
Students will know…

One of the main ingredients in many types of candy and cosmetic products is palm oil. Palm oil is one of the most commonly used oils.
Farmers/companies are cutting down rainforests to plant oil palm plants.
As oil palm numbers increase, orangutan and tiger populations decrease.
As oil palm numbers increase, rats, pigs, and snake populations also increase.
Different kinds of oils that we consume in foods or products come from various ecosystems (via farms).
Native plants are removed to make space for farming.
Palm oil is more efficient than other oils because oil palms require less land to grow.

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Skills:
Students will be able to…

Develop an initial system model to describe a phenomenon in which changes to one living component of an ecosystem (cause) affect the other living parts of the ecosystem (effect).
Ask questions that arise from initial observations of populations in an ecosystem to help seek additional information about the parts of the ecosystem and how they interact.
Define a pattern of design problems for systems that provide food resources that humans need (cause) but transform the land and the biosphere once occupied by native plants and animals (effect).
Define a problem in which oil palm is dependent upon the same environmental

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● Oil palm plants need a certain amount of sunlight, precipitation, and warm temperatures to grow. ● Oil palm plants grow in the same locations as tropical rainforests (near the equator) because of these good growing conditions. ● In many places in which oil palms are grown, people do not have a lot of opportunities to make money to support their families. ● Cutting down tropical rainforests to sell or grow resources may be the only way for people in these areas to support themselves. ● If we want a solution, we will have to make sure that these farmers can still support themselves and their families. ● People in our community have changed natural habitats for their homes, buildings, roads, etc. ● Some plants and animals are still around, despite the changes, but others have disappeared from the area. ● A better-designed palm farm needs to support living things in the tropical rainforest and farmers, too. ● populations of organisms are made up of many individuals living in the same area, and ● individual organisms and populations of organisms are dependent on a certain amount of space. ● Orangutans in the same population compete with each other for food. ● Orangutans like food sources that give them more energy, but can eat things with less energy to survive. ● Competition between individual orangutans within a population increases when the availability of resources is limited. ● If orangutans do not get enough energy from food resources, it may constrain	interactions with nonliving factors as other tropical rainforest plants (pattern). ● Define a new criterion for a solution to more sustainably grow oil palm in ways that protect the tropical rainforest ecosystem but that also recognize the needs of local farmers, who are part of the palm oil production system. ● Ask questions to clarify and/or refine a model for explaining how (patterns in) human activities have altered the biosphere and changed habitats locally and in Indonesia. ● Define a problem that can be solved through designing a palm farm that will maintain the stability of orangutan populations and support farmers who depend on the farms for their livelihoods (criteria). ● Apply mathematical concepts (ratio) to find patterns in numerical relationships about the number of orangutans that can live in a 1 km2 or 100 hectare area. ● Carry out a series of investigations using a simplified computer simulation (system model) to produce data about how individual orangutans compete with each other for food resources in three different environmental conditions to answer a question about forest space. ● Analyze measures of central tendency and range in class-constructed histograms to make claims about how populations of orangutans responded to three different environmental conditions and the ways in which the environmental conditions contributed to the stability of the population or changes in the population. ● Collect data from an investigation to draw conclusions about how stable populations of orangutans fluctuate over time based on resource availability. ● Use mathematical representations to draw conclusions about trends in orangutan

their growth or limit their potential for survival. ● It's normal for population sizes to increase and decrease (i.e., fluctuate). ● If there are a lot of resources available, population sizes go up. If the resources are limited, population sizes go down. ● When there aren't enough resources, orangutans have to compete for them, and some orangutans don't get what they need to survive. ● When an orangutan gets enough resources, it survives and reproduces. ● If an orangutan can't get what it needs, it may not reproduce. Over the years, this means the population goes down and not enough are born to keep the population stable. ● Minor disruptions in resource availability may lead to small fluctuations in population sizes, while major disruptions in resource availability may cause populations to increase or decrease drastically in number. ● Running multiple trials on an experiment can provide more data to get more certainty about the conclusions being drawn. ● Organisms depend on specific resources to survive and reproduce. ● An organism's population size depends on the amount of resources available. When resources decrease significantly, the population also decreases. When resources increase, the population increases. ● It is normal for populations to fluctuate depending on resource availability from year to year. Drastic changes to resource availability can cause unusual and unstable changes to populations. ● When there are many resources both snakes (predators) and rats (prey) do well.	population sizes over time, depending upon resource availability. ● Analyze and interpret data to draw conclusions about how changes in resource availability affect populations in the short and long term. ● Develop a system model for a palm farm to explain why both snake (predator) and rat (prey) populations are increasing at the same time. ● Develop a system model to explain how populations in a complex rainforest ecosystem interact to keep populations stable, compared to interactions in an agricultural system where some of the same populations are increasing. ● Gather information from text, images, and data tables to clarify claims that a change in the orangutan population could affect fruit trees because there is a mutually beneficial relationship between the two. ● Use a model to make predictions and test ideas about how disruptions, or changes, to one part of the system affect populations throughout the system. ● Construct an argument supported by empirical evidence that releasing the tamarisk beetle (change) affects the willow flycatcher population when there are fewer nesting tree types available. ● Critically read scientific texts to obtain information about how different ways to grow food (cause) can have a positive impact on populations in ecosystems (effect). ● Critically read text and listen to interviews to obtain information about how people receive ecosystem services from farming practices that also maintain and promote stability in natural systems. ● Integrate qualitative information obtained from written text and media to clarify claims about farming practices that reduce risk to disruptions and that maintain and

• When there is competition between populations for the same resource, it keeps numbers from increasing too much. • The tropical rainforest is a lot more complex than the palm farm, with a lot more plants and animals interacting with each other. • Populations interact for more than just resources (like shelter and safety). • If one population (like orangutans) were to go extinct, then it could cause changes to other populations because everything is connected. • Orangutans disperse seeds throughout the tropical rainforest by spitting and defecating. • Both orangutans and fruit trees benefit from each other because orangutans get food from fruit trees and fruit trees get their seeds spread throughout the tropical rainforest. • If orangutans go extinct, some fruit tree populations may decrease, because seeds may not get spread and grow into trees, which could affect other populations. • There are more populations and more connections in the rainforest system compared to the oil palm system. • Any change to the ecosystem, or disruption, will affect some populations. Some disruptions affect many populations. • If an ecosystem has many connections between populations, the ecosystem has a better chance of being OK when a change happens. • A disruption in a monocrop system will impact all the populations in the system. • There are multiple ways communities grow food while also helping populations in ecosystems. • There are multiple ways communities grow food while also helping populations in ecosystems.	promote stability of populations in natural systems. • Refine criteria and constraints for designing a way to use the land to increase precision and to take into account the potential impacts and the ways in which potential solutions are limited by the natural environment. • Apply ideas about ways of growing food to design a better way to use the land to minimize human impact on orangutan populations. • Evaluate competing design solutions for supporting and/or increasing a stable orangutan population and meeting people's income needs. • Construct an argument grounded in evidence and scientific reasoning to recommend a design solution that will support a stable orangutan population and protect the needs of people (effect). • Ask questions about and define problems that arise when humans design land-use systems that have positive and negative effects on biodiversity and ecosystem services. • Communicate information in writing, drawing, and oral presentation about how even small changes in people's habits or behaviors, like buying different brands of products at the store, can have large impacts on the preservation of natural systems, like the tropical rainforests where orangutans live, over time. • Ask questions about a local phenomenon, based on careful observations and patterns from graphs, charts, or images. • Obtain information from texts, videos, or speakers about why the local population (Pathway A) or the way our community has cared for the land (Pathway B) has changed over time. • Apply scientific ideas to take small actions that will positively impact organisms in our local communities.

● Diversified farming involves growing multiple crops together. ● Sustainable oil palm farms do not clear forested areas and incorporate wildlife habitat on their farms. ● Villages with Customary Forest permits cultivate and harvest food, medicine, and craft plants from within the forest that they can use and sell. ● Diversified farming like intercropping helps farmers have stable incomes if diseases, pests, or storms hurt one crop, but not the other(s). ● Sustainable oil palm farms maintain healthy soils that help improve harvests, which means more income for farmers. ● Customary forests provide people with stable food, water, and materials, and protection from landslides. ● There are trade-offs in how we approach growing our food; some approaches work better for humans than for animals and plants in the natural ecosystem. ● Some approaches to growing food work for some people and farmers, but not all people. ● We can grow food in ways that minimize the effects of disruptions on natural and designed systems. ● Some potential design solutions work well for the people and the orangutans but are not realistic due to land-use changes and time. ● Using a variety of different ways to grow food can maintain or increase orangutan populations and people's income. ● People can reasonably set aside a portion of their land to support orangutan populations without reducing their income. ● Neighboring farms can coordinate their approaches to increase space for orangutans.	

• Rainforest corridors connecting intact areas of forest increase orangutan populations. • Some potential design solutions work well for the people and the orangutans but are not realistic due to land-use changes and time. • Using a variety of different ways to grow food can maintain or increase orangutan populations and people's income. • People can reasonably set aside a portion of their land to support orangutan populations without reducing their income. • Neighboring farms can coordinate their approaches to increase space for orangutans. • Rainforest corridors connecting intact areas of forest increase orangutan populations. • People and communities can take small and large actions that aid the preservation of natural systems like the tropical rainforest. • Small actions, like changes in people's habits and behaviors, when combined with others' actions or extended over time, can have a large impact on the preservation of natural systems. • Some actions are more feasible for communities or individuals to implement, while others are more challenging. • We apply many ideas that we figured out (during our examination of the palm oil problem and orangutans) to populations and lands in our local communities.	

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-LS2-1, 2-2, 2-4, 2-5; MS-ESS3-3; MS-ETS1-1) RST.6-8.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (MS-LS2-1; MS-ESS3-3) RST.6-8.8 Distinguish among facts, reasoned judgment based on research findings, and speculation in a text. (MS-LS2-5) RI.8.8 Trace and evaluate the argument and specific claims in a text, assessing whether the reasoning is sound and the evidence is relevant and sufficient to support the claims. (MS-LS2-5, 2-4) WHST.6-8.1 Write arguments to support claims with clear reasons and relevant evidence. (MS-LS2-4; MS-ESS3-3) WHST.6-8.2 Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content. (MS-LS2-2, 2-5) WHST.6-8.7 Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration. (MS-ESS3-3) WHST.6-8.8 Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation. (MS-ESS3-3; MS-ETS1-1) WHST.6-8.9 Draw evidence from literary or informational texts to support analysis, reflection, and research. (MS-LS2-2, 2-5; MS-ESS3-3) SL.8.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 8 topics, texts, and issues, building on others' ideas and expressing their own clearly. (MS-LS2-2, 2-5) 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-LS2-2, 2-5) **New Jersey Student Learning Standards-Mathematics (2-16)** MP.2 Reason abstractly and quantitatively. (MS-ESS3-2; MS-ETS1-1) MP.4 Model with mathematics. (MS-LS2-5) 6.RP.A.1 Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities. (MS-ESS3-3),(MS-ESS3-4) 6.RP.A.3 Use ratio and rate reasoning to solve real-world and mathematical problems. (MS-LS2-5) 6.SP.B.5 Summarize numerical data sets in relation to their context. (MS-LS2-2) 7.RP.A.2 Recognize and represent proportional relationships between quantities. (MS-ESS3-3),(MS-ESS3-4) 6.EE.B.6 Use variables to represent numbers and write expressions when solving a real-world or mathematical problem; understand that a variable can represent an unknown number, or,

depending on the purpose at hand, any number in a specified set. (MS-ESS3-2),(MS-ESS3-3),(MS-ESS3-4)
7.EE.B.4 Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities. (MS-ESS3-2),(MS-ESS3-3),(MS-ESS3-4)
7.EE.3 Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form (whole numbers, fractions, and decimals), using tools strategically. Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies. (MS-ETS1-1)

New Jersey Student Learning Standards in Computer Science and 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

- 7.5 Ecosystem Dynamics & Biodiversity Student Edition

Secondary Source Readings:

- Achieve 3000
    - New Life at Yellowstone
    - Oil Spill Bad for Bay
    - Can Trees Keep Air Clean?
    - For the Love of Vultures

Supporting Text pages:

- Handouts - All student handouts are within the lesson folders

Technology

- Collaborative Oil Palm Model
- Orangutan Population Model
- Orangutan Energy Model 1
- Orangutan Energy Model 2

Videos:

- Unit 7.5 Student Playlist

Teacher Resources

Texts:

- 7.5 Ecosystem Dynamics & Biodiversity Unit Overview Materials
- OpenSciEd Teacher Handbook

- 7.5 Elements of NGSS Dimensions
- 7.5 Ecosystem Dynamics & Biodiversity Teacher Edition

Supplemental Workbooks:

Technology:

- Collaborative Oil Palm Model
- Orangutan Population Model
- Orangutan Energy Model 1
- Orangutan Energy Model 2

Videos:

- **Unit 7.5 Teacher Playlist**

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

Formative Assessments:

Lesson 6 is a critical moment to re-anchor the unit. After students have spent Lessons 2 through 5 digging deeper into the problem, the students are ready to re-articulate the problem, define a design goal, and take a second pass at the DQB.

This lesson offers several opportunities for formative assessment, including (1) when the class articulates the problem during a Consensus Discussion and (2) when the students articulate a design goal and criteria for a successful palm farm.

When defining the problem, students should identify the multiple aspects of the problem that make it complex to solve (e.g., oil palm uses less land than alternatives, it grows in the same place as tropical rainforests, and it provides income to farmers). Students should set a goal for the design that functions for farmers, orangutans, and other living things. Students should also suggest criteria that are in line with this goal, such as (1) the newly designed palm farm supports animal populations, like orangutans and tigers, and (2) the newly designed palm farm supports the farmers' income. Students may struggle to suggest constraints, and that is OK at this point. Students may suggest constraints, such as not taking land away from farmers, not cutting down new forests, and so forth.

Summative Assessments:
There is a formative and summative assessment at the end of Lesson Set 3.

The lesson-level performance expectation is: Construct an argument supported by empirical evidence that releasing the tamarisk beetle (change) affects the willow flycatcher population when there are fewer nesting tree types available.

This assessment is building towards MS-LS2-4. Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

This is a summative assessment focused on students' understanding of ecosystem interactions and disruptions that can change systems over time. The context of the assessment is a real-world debate in the southwestern United States. The case focuses on the southwestern willow flycatcher population, which has been impacted by invasive tamarisks and tamarisk (leaf) beetles. The assessment is an opportunity to engage your students in authentic argumentation based on a small subset of data. To prepare your students for this transfer task, you will spend at least 20 minutes orienting students to the new case by mapping the new case model to the orangutan model. Students will also make predictions about the outcome of different disruption scenarios in the new context before they engage in individual argumentation on the assessment.

Performance Task(s):
The 5-day design task and its corresponding moments of assessment build towards:
- MS-LS2-5. Evaluate competing design solutions for maintaining biodiversity and ecosystem services.
- MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
- MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

Lesson 17 and 18 include instructionally-embedded tasks within the context of students redesigning oil palm farms in Indonesia to support orangutan populations, while also supporting farmers and local villagers. As students work in groups you can circulate among groups to provide feedback on their design content and process, using Teacher Feedback on Land Redesign Projects. Have your students complete Part H individually to explain how features of the design, and their design as a whole, work to support people and orangutans. In Lesson 18, groups will present their optimized designs. Two rubrics are provided as options to score and provide feedback on the group and individual portions of the design task (see Rubric Option 1:

Redesign the Land or Rubric Option 2: Redesign the Land). Students will then construct an argument around the recommendation (claim) they want to make for redesigning the land. They receive and give peer feedback on these arguments. A rubric is also provided: Rubric: Engaging in an Argument from Evidence for a Land Redesign.

Stage 3 – Learning Plan

Lesson 1 (4 days) How could buying candy affect orangutan populations in the wild?
We read headlines that claim that our candy-buying habits could affect orangutan populations in the wild. We examine candy ingredients and realize that one ingredient, palm oil, is produced in the same location in which orangutans live. We read about tropical rainforests in Indonesia being cut down to grow oil palm. We wonder how oil palm trees lead to a decrease in the orangutan population. We develop a Driving Question Board (DQB) to guide future investigations.

Lesson 2 (1 day) Can we replace palm oil with something else?
We explore other crops as a substitute for palm oil. We analyze data for soybean and canola oil and realize that palm oil requires much less land and produces way more oil than the other oils. We conclude that any oil would require clearing land for farming and that palm oil is very efficient, so it is probably not going away. This makes us wonder if there is somewhere else to grow oil palm, so we won't harm orangutans.

Lesson 3 (1 day) Can we grow oil palm trees somewhere else so that we're not cutting down tropical rainforests?
We wonder if we can grow oil palm in other places. We obtain more information about the nonliving conditions that the oil palm plant needs to grow and examine maps that meet these conditions. We figure out that oil palm grows best in equatorial regions, which is also where tropical rainforests are located. We conclude that both kinds of plants share the same nonliving requirements and compete for the same space to grow. This makes us wonder how oil palm farmers and other farmers grow crops in places where they harm the ecosystem that was there first.

Lesson 4 (1 day) Why do people cut down tropical rainforests when they know it is harmful to the animals that live there?
We decide we need to learn more about the people who farm oil palms. We watch interviews with some of these farmers, and we learn that cutting down tropical rainforests to sell or grow resources is sometimes the only way for people in these areas to support themselves. We revisit our original problem with a new priority: We need to make sure that our solution allows all people to support themselves and their families. This makes us wonder if there are better ways for farmers to grow oil palms that could also save tropical rainforest animals.

Lesson 5 (2 days) How have changes in our community affected what lives here?
We share our murals documenting changes in our own community since major human disturbance. We make outdoor observations of evidence of the plant and animal life around the school, along with observations about the changes humans have made to the land. We share what we notice and compare the changes in our own community to those in Indonesia. We modify our model, and then we add questions to the DQB about our local community.

Lesson 6 (1 day) If palm oil is not going away, how can we design palm farms to support orangutans and farmers?
We reflect on what we have figured out to define the problems associated with palm oil farms. We think about how we can design a better palm farm system that will support both the farmers and the orangutan and tiger populations. We use what we learn to co-construct criteria and constraints to guide our design decisions. We revisit our Driving Question Board to add new questions that will help us design a system that is more stable and will help us refine our criteria and constraints.

Lesson 7 (2 days) How many orangutans typically live in the tropical rainforest?
We examine a StoryMap that presents information about the number of orangutans in four protected areas with intact tropical rainforests. We notice that the number of orangutans in each area fluctuates some but is relatively steady. We notice that larger areas seem to have more orangutans. We calculate how many orangutans are in 1 km for each park and realize that it is similar across parks, and only about 1- 3 orangutans can live in 1 km^2.

Lesson 8 (2 days) Why do orangutans need so much forest space?
We gather data from a computer simulation in which individual orangutans compete with each other for food resources (fruit and termites). We run multiple trials of experiments to test three different environmental conditions with more or less rainforest fruit available (independent variable). After constructing class histograms using data from each trial, we examine how well individual orangutans and the orangutan population overall responded by analyzing averages and ranges of energy points for orangutans (dependent variables). We make claims about food resources and competition between individuals within the population.

Lesson 9 (2 days) Would planting more rainforest fruit trees help the orangutan population increase?
We conduct experiments in a simulation, manipulating the amount of food resources (independent variable) over time to observe how orangutan population sizes increase or decrease (dependent variable).

Lesson 10 (2 days) How do changes in the amount of resources affect populations?
We analyze other cases where populations changed due to a change in available resources. Across these cases, we see a pattern that connects the population of an organism to the availability of resources that organism needs. Afterward, we apply these understandings to an assessment in which we explain why the loss of short and tallgrass prairies has caused monarch butterfly populations to decrease.

Lesson 11 (2 days) How does planting oil palm affect other populations?
We are curious about other populations affected by the palm oil industry. We develop system models for the oil palm system and realize that when there are unlimited resources, both predators and prey do well. We develop system models for the tropical rainforest and realize there is more competition within this system to keep populations at a stable size. We decide that the rainforest system has more components and interactions than the oil palm system

Lesson 12 (1 day) What would happen if orangutans go extinct?
We are curious about what would happen if orangutans went extinct. We read an interview with Andrea Blackburn, who studies orangutans. We watch videos, examine images, and make

noticings from data tables from her research. We support tentative claims with the data, and identify additional questions and data that would help clarify those claims.

Lesson 13 (2 days) How does an ecosystem change when the plants change?
We use an updated system model to make predictions and test ideas about different kinds of disruptions to the rainforest and oil palm systems. We figure out that the rainforest system can withstand some disruptions due to its interconnectedness, but the oil palm system cannot. We apply ideas to a new case and complete a short individual assessment. We summarize what we know about monocrop oil palm farming to motivate us to design a better way to farm it.

Lesson 14 (1 day) Are there ways people can grow food without harming the tropical rainforest?
We wonder how people cultivate food without harming living things. We read about one of the following approaches: (1) diversified farming, where farmers grow multiple crops together; (2) sustainable oil palm, where farmers don't clear forest and include wildlife habitat on the farm; and (3) Customary Forests, where people cultivate and harvest plants from intact forests.

Lesson 15 (1 day) How can people benefit from growing food in ways that support plants and animals in the natural ecosystem?
We wonder how people can benefit from growing food in ways that help plants and animals. We view StoryMaps that include people's perspectives about (1) diversified farming where farmers grow different crops together; (2) sustainable oil palm and prairie strips where farmers do not expand their farms and include wildlife habitat on their farms; and (3) customary forests where people cultivate and harvest plants from existing tropical rainforest.

Lesson 16 (2 days) What approach to growing food works for everyone and why?
We summarize what we know about monocropped farms. We jigsaw to synthesize information about different approaches to growing food. We rank how the approaches work for plants and animals and people. We discuss the trade-offs between each approach and clarify claims about which approach we think will work best. We brainstorm how to test our claims in a simulation

Lesson 17 (3 days) How can we redesign the way land is used in Indonesia to support orangutans and people at the same time?
Working in groups of three, students use a computer simulation to redesign the way land is used in Indonesia to support orangutans and people at the same time. Students evaluate design solutions created by other groups and optimize their own design solutions.

Lesson 18 (3 days) How do our designs work for orangutans and people in Indonesia?
We present our best designs to our peers and evaluate each other's designs based on the agreed upon criteria and constraints. We consider how well each design would work in the real world and tradeoffs made in the design process. We argue for which designs work best for people, orangutans, and both, and make claims about why they work well.

Lesson 19 (0 days) How can we inform others in our community about the palm oil problem and convince them to take action?
We have figured out that the problem will require large-scale solutions combined with individual action. We create public service announcements (PSAs) to inform stakeholders in our community about the palm oil problem and how they can act to address this problem. We present our PSAs to our peers, teachers, and/or stakeholders and receive feedback on our approach.

Unit Plan Title	7.6 Natural Resources & Human Impact
Suggested Time Frame	33 days

Overview / Rationale
This unit on Earth's resources and human impact begins with students observing news stories and headlines of drought and flood events across the United States. Students figure out that these drought and flood events are not normal and that both kinds of events seem to be related to rising temperatures.This initial work sets students up to ask questions related to the query: How do changes in Earth's system impact our communities and what can we do about it? Through investigations, students will analyze and interpret data that indicate long-term climate variables (temperature and precipitation) are changing in communities.

<table>
<tr><th colspan="2">Stage 1 – Desired Results</th></tr>
<tr><td colspan="2">Established Goals:
● MS-ESS3-1: Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes.
● MS-ESS3-3: Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
● MS-ESS3-4: Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.
● MS-ESS3-5: Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.
● MS-ETS1-2: Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.</td></tr>
<tr><td>Essential Questions:
● Why are floods and droughts happening more often?
● What would we normally expect for these places and how do we know it's really changing?
● What would we normally expect for these places and how do we know it's really changing?
● Are rising temperatures affecting anything else in Earth's water system?
● How are rising temperatures changing water stories in these communities?
● How are rising temperatures connected to two seemingly different phenomena?
● Are there any changes in the air that could be related to rising temperatures?</td><td>Enduring Understandings:
● Floods and droughts are increasing across the US and there is a pattern of rising temperatures associated with both.
● Long-term measurements show that changes in temperature and precipitation are not normal for these places.
● When we warm wet and dry soil at the surface we observe an increase in evaporation. This increases the overall water vapor in the air which does not move around the atmosphere evenly.
● Snow, ice, glaciers, and groundwater are decreasing in many areas, while sea level is rising. Earth's water system is changing
● Changes in community water sources can be explained through data and evidence.</td></tr>
</table>

• Are changes in carbon dioxide and methane related to or causing temperatures to increase? • Are the changes in the amount of CO_2 in the atmosphere part of normal cycles that Earth goes through? • What is happening in the world to cause the sharp rise in CO_2? • Why could burning fossil fuels create a problem for CO_2 in the atmosphere? • How are changes to Earth's carbon system impacting Earth's water system? • Why is solving the climate change problem so challenging? • What things can people do to reduce carbon dioxide going into the atmosphere? • How can large-scale solutions work to reduce carbon in the atmosphere? • How are these solutions working in our communities? • What solutions work best for our school or community? • What can we explain now, and what questions do we still have?	• Changes reported by headlines and by an Alaskan whaler can be explained through the increasing temperatures in Alaska. • The concentration of some atmospheric gasses have stayed relatively stable over time, while other gases have increased at an unusual rate. • Greenhouse gases absorb and release energy in the atmosphere regulating Earth's temperature. • Ice core samples contain trapped bubbles of gases. • Data shows a rapid increase in fossil fuel use, CO_2 emissions, and human population in the last two centuries. • Burning fossil fuels adds CO_2 to the atmosphere at a faster rate than is taken out by photosynthesis. • Some social media posts need additional clarification to reflect accurate science ideas. • As CO_2 emissions increase, so do global temperatures. To reach equilibrium, emissions need to be cut by 9 gigatons per year. • Everyday actions and behaviors emit CO_2, and changes to those behaviors can reduce emissions. • Solutions have differing effects towards the reduction of atmospheric CO_2. Implementing multiple solutions can compound the reduction in CO_2 emissions. • Community plans include ways to mitigate carbon or adapt to changes. • Schools, communities, and businesses adopt new behaviors or technologies to contribute to rebalancing carbon and to build resilience to changes happening now. • Asking questions about phenomena gives us a mission for our science learning.

Knowledge: Students will know…	**Skills:** Students will be able to…
● Droughts and floods are happening more often, and both cases seem to be linked to warmer temperatures. ● Changes in evaporation may be related to why, where, and when droughts and floods occur. ● We have some ideas and many questions about what might be causing the warmer temperatures. ● Earth's freshwater is distributed in the air, at the ground, and below the ground and moves in between these spaces. ● Year-to-year variability in precipitation and temperature is a normal pattern. ● Data averaged over long periods of time can give us the trends for an area. ● Precipitation or heavy storm events show increasing trends in the areas where there are more floods. ● Precipitation, groundwater, and snowpack show decreasing trends in areas where there are more droughts. ● Temperatures are increasing for all of the places we investigated. ● Increased temperatures cause an increase in evaporation and more water vapor in the atmosphere. ● Evaporation happened in all cases, but more moist conditions had higher evaporation rates than drier conditions. ● The amount of water vapor in the atmosphere is not the same for every location and winds move the water vapor to different locations. ● Areas that are dry or have droughts may be getting drier when water vapor moves away from the location, while areas that are flooding may be getting wetter because more water vapor moves toward the location. ● Cooler ocean water and landforms like mountains may affect how much water vapor gets to a location, too.	● Develop a model to explain how a small change in temperature can cause large scale changes in precipitation leading to floods and droughts. ● Develop a model to explain what could cause an increase in temperatures that are linked to an increase in floods and droughts. ● Ask questions that arise from initial observations of stories and headlines about rising temperatures, floods, and droughts to clarify whether increasing temperatures are related to or causing both floods and droughts. ● Develop and use a model to describe the components, interactions, and processes of water distribution and movement on Earth. ● Use graphical displays (e.g., maps, charts, graphs, and/or tables) of large data sets to identify temporal patterns in temperature, total precipitation, and seasonal precipitation in the local community and at case sites. ● Analyze and interpret data about patterns in rates of change and numerical relationships to determine similarities and differences between drought and flood sites. ● Analyze evaporation investigation data for patterns to provide evidence that increased temperatures cause an increase in evaporation leading to more water vapor entering the atmosphere. ● Modify a model - based on evidence - to match how a change in atmospheric temperature causes a change in evaporation in Earth's water system. ● Integrate scientific information with media and graphical displays of data to clarify how a small change in temperature affects components of Earth's water system. ● Construct a scientific explanation based on valid and reliable evidence that

• Changes to sources of water affect communities in different ways. • A small change in temperature in the atmosphere can have big changes in Earth's water system. • Small changes in one part of Earth's system can have big impacts on another part. • Changes in atmospheric temperature are related to changes in the components and processes of Earth's water system. • Small changes in one part of Earth's system can have big impacts on another part. • Changes in atmospheric temperature are related to changes in the components and processes of Earth's water system. • The atmosphere is made from different concentrations of gases. • Some gases have not really changed over time, but some show an unusual increase. • Carbon dioxide and methane are a small percent of the atmosphere but are increasing at a high rate. • GHGs are gas molecules in the atmosphere that absorb, vibrate, and release energy back into the atmosphere. This keeps Earth at a livable temperature. • As the amount of GHGs increases in our atmosphere, they cause the atmosphere to get warmer. • CO_2 levels over the last 100 years have been rising consistently. • CO_2 levels are higher than at any time in the past normal cycles and seem to be increasing really fast. • When we analyze ice core data from hundreds of thousands of years, we find that there are normal cycles, but the last 100 years are not following the normal cycle. • Large deposits of mineral resources (such as "fossil fuels") are used to power our communities and transportation networks.	changes in temperature can have impacts on the water sources available for communities. • Compare graphs and charts depicting a changing climate in Alaska looking for similarities and differences to determine that trend lines and patterns across Alaskan claims are caused by increasing temperatures. • Analyze graphs and charts from multiple claims to identify the similarities and differences in patterns to determine that changes in the environments are caused by increasing temperatures. • Apply mathematical concepts of percent to understand the proportion and quantity of and stability and/or change in the concentration of gases in the atmosphere over time. • Develop and use a model to describe how greenhouse gas molecules respond to energy transfer from Earth to the atmosphere and cause the temperatures to rise. • Analyze and interpret data on graphs of carbon dioxide levels collected from ice cores to collect evidence of whether the changes in these levels are cyclical in nature and a normal occurrence or are changing at an non-normal rate. • Integrate qualitative and quantitative scientific information in written text with digital tools to analyze trends of atmospheric CO_2 levels, energy consumption, and human population over time to determine a correlation between human activities and CO_2 emissions. • Ask questions that require sufficient and appropriate evidence as to whether CO_2 comes from combustion of fossil fuels for energy, and is causing the rising CO_2 levels in the atmosphere . • Apply mathematical concepts to compare the rate of combustion and cellular respiration putting CO_2 into the

• Population growth and increasing per capita consumption of fossil fuels are correlated with rising CO_2 levels. • Carbon dioxide and water vapor (both greenhouse gases) are products of the combustion of fossil fuels. • The increased combustion of fossil fuels by a growing population causes an increase in CO_2 emissions as a by-product of the reaction. • Photosynthesis is a way to get CO_2 out of the atmosphere, but the rate of photosynthesis is not enough to take up CO_2 from combustion of fossil fuels and cellular respiration combined. • Combustion of fossil fuels is creating a carbon imbalance in the atmosphere. • Changes in the carbon system have an effect on Earth's water system. • We can use our scientific understanding to clarify claims about the connection between fossil fuel use, the changing carbon system, and Earth's water system. • Our carbon imbalance in our atmosphere is mostly due to human combustion of fossil fuels. • We release an estimated 10.5 gigatons of CO_2 per year from human combustion. • Simply cutting emissions in half will not halve the temperature increase. • To reach CO_2 emissions equilibrium, emissions would need to be cut by 9 gigatons per year. • Any reduction in emissions helps to slow the global temperature increase. • Changes to daily activities and behaviors can reduce CO_2 entering the atmosphere. • If more people do these things, we can reduce CO_2 emissions further. • Changes to behaviors are limited by other constraints, so each person may have different options available to them. • There are many different solutions that can be implemented to reduce the amount	atmosphere to the rate for photosynthesis taking CO_2 out of the atmosphere leading to an imbalance in the system. • Develop a model to describe how fossil fuel use causes changes to the climate, which affects community water resources. • Construct an argument supported by science ideas to refute and clarify claims through an explanation of the causal chain of events between the changing climate and water resources. • Use the carbon dioxide model simulation to generate data and test ideas about different emissions rates scenarios to determine how to reach carbon dioxide equilibrium in the atmosphere. • Apply mathematical concepts to calculate an average carbon impact and possible carbon reduction solutions and scale those reductions to see what would happen if more people were to change their behaviors. • Evaluate competing solutions using a systematic process and jointly develop agreed upon criteria to determine how small changes in behaviors and technologies can add up to larger impacts on reducing CO_2 in the atmosphere. • Critically read scientific texts adapted for classroom use to obtain information on how communities are implementing new activities at different scales to mitigate the flow of carbon into and out of the atmosphere and/or adapt to changes in the community. • Apply scientific principles to design a process/system that the school can undertake to reduce the vulnerability to climate change impacts (e.g., high heat, changing water resources) in the short-term and contribute to rebalancing carbon in the long-term. • Ask questions to challenge the proposed resilience plan to evaluate whether the solutions meet the class' agreed criteria

of CO2 being emitted into the atmosphere. • There are some solutions that help take CO_2 out of the atmosphere and solutions that reduce carbon emissions. • Implementing only one solution will not lead to a decrease of CO_2 in the air. Multiple solutions need to be done together in order for any reduction to occur to help rebalance CO_2 in the air. • Communities develop plans to rebalance CO_2 levels in the atmosphere while also building a more resilient community by adapting to changes already occurring within the community. • Plans include many solutions across different parts of the community and at different scales, from individual and family options to large-scale community solutions. • Communities can design plans to help rebalance carbon dioxide which will take awhile, but they can also do things to make the community resilient to changes happening now. • Communities design plans based on community member needs and characteristics of the community itself. • Some places and people may be more at risk for impacts in the community. • Solutions adopted at home and school can make the whole community more resilient. • Science learning is about asking questions and gathering evidence to answer those questions. • As some questions get answered, new questions come up.	checklist and will reduce vulnerabilities to climate impacts in the short-term and rebalance carbon in the long-term. • Construct an argument grounded in evidence and scientific reasoning to recommend a design solution that will prepare a community for predicted changes to temperature and/or precipitation (effect). • Communicate information in writing and/or oral presentation about how adopting individual, family, or school solutions (subsystems) to reduce vulnerabilities to climate change and/or rebalance carbon can contribute to broader community resilience (larger system) (optional). • Communicate scientific information orally about the patterns of class questions that have been explained with sufficient evidence about the impact of a changing climate and community solutions, and ask additional questions that require appropriate and sufficient evidence to answer.

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-ESS3-1, 3-2,) RST.6-8.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (MS-ESS3-2) RST.6-8.9 Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic. (MS-ETS1-2) WHST.6-8.1 Write arguments focused on discipline content. (MS-ESS3-4) 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-ESS3-1) 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-ESS3-3; MS-EST1-2) WHST.6-8.8 Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation. (MS-ESS3-3) WHST.6-8.9 Draw evidence from informational texts to support analysis, reflection, and research. (MS-ESS3-1; MS-EST1-2) **New Jersey Student Learning Standards-Mathematics (2016)** MP.2 Reason abstractly and quantitatively. (MS-ESS3-2) 6.EE.B.6 Use variables to represent numbers and write expressions when solving a real-world or mathematical problem; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set. (MS-ESS3-1) 6.RP.A.1 Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities. (MS-ESS3-3),(MS-ESS3-4) 7.RP.A.2 Recognize and represent proportional relationships between quantities. (MS-ESS3-3),(MS-ESS3-4) 7.EE.B.4 Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities. (MS-ESS3-1) 7.EE.3 Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form (whole numbers, fractions, and decimals), using tools strategically. Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies. (MS-ETS1-2) **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 ● 7.6 Earth's Resources & Human Impact Student Edition Secondary Source Readings ● Achieve3000 articles ○ It's Raining Plastic ○ Can Nature Be Saved? ○ UN Issues Dire Climate Warning ○ Problems Heating Up for Pikas Supporting Text pages ● Handouts - All student handouts are within the lesson folders Technology

Teacher Resources
Texts: ● 7.6 Earth's Resources & Human Impact Teacher Edition **Supplemental Workbooks:** **Technology** **Websites:** **Videos:** ● **Unit 7.6 Earth's Resources & Human Impact - Video Links** ● *The Day After Tomorrow*

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. The initial models developed in this lesson are an opportunity to pre-assess student understanding of how small changes in temperature could affect Earth's water system, as well as what leads to those changes. Additionally, it is an opportunity to pre-assess relevant weather-related ideas from previous OpenSciEd units. Look at the individual models developed on day 2 and the class consensus model developed on days 2 and 3.

For the first part of the model regarding how warmer temperatures could lead to both floods and droughts, look for students to use the following:
Water cycling processes, such as evaporation and precipitation, in their initial causal accounts of floods and droughts. See if students are connecting temperature change to a change in these processes.

Look at how students' individual models accounted for these changes in temperature and water cycling processes compared to the model co-constructed by the class. This will give you insight as to where each individual student is in their initial understanding of the phenomenon and their modeling practice to explain it.

Look at students' causal accounts to see if they use single words, like "evaporation," as a "sufficient" causal explanation or if they elaborate on a mechanism for how temperature change could affect a water cycle process.

For the second part of the model regarding what is causing warmer temperatures, look for students to explain what is causing temperatures to rise, using language or images that link the cause (e.g., greenhouse gases, pollution, carbon dioxide, etc.) to the effect (rising temperatures).
If students focus on mechanisms like the Sun's temperature or distance to Earth or the ozone hole, there is a modification you can make at the start of Lesson 6.
If students focus on gases in the atmosphere as a cause of temperature rise, probe deeper to see what they know about how gases, temperature, and energy of molecules/particles relate to each other.

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" and "why" questions. Listen for questions that address both parts of our 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.

Formative Assessments:
Students will individually construct an explanation, using evidence, about how changes in temperature are having impacts on the water stories in our case site communities. Students synthesize key model ideas from Lessons 2-4 to construct an explanation for how water is changing in one community that they choose to explain. After developing an initial explanation,

they give written feedback to two other students using the guiding questions on the Peer Feedback Instructions and Peer Feedback Guidelines. They will then revise their explanations, reflect on changes made, and can self-assess their comfort with explanation using slide H. Students can choose the modality for communicating their thinking. They can explain the phenomenon through written explanation or using a diagrammatic explanatory model or infographic.

This explanation provides formative information and practice before students transfer their understanding to a new case in Lesson 6. If your students have not developed a written scientific explanation, there is a Building Prerequisite Understanding option for you to model and co-construct an explanation together before they write their own individually.

Scoring Guidance for Case Site Explanations can be used to assess student progress and includes samples of initial explanations, sample feedback, and the revised explanation. It is recommended that you provide feedback to students' explanations prior to their transfer task (Lesson 6) and that students be able to use their written explanations with feedback from you (and peers) to help them craft their explanation in Lesson 6

Summative Assessments:
On days 2 and 3 of Lesson 6, students construct another explanation for an Alaskan community experiencing related changes to the other case sites. This is a transfer task that asks students to draw upon ideas developed in Lessons 2-5 but with the addition of new climate impacts: sea ice decline and wildfires.

On day 2, students revisit the Alaskan headline and learn about different claims made by an Alaskan elder regarding their changing environment. Students identify the data needed to determine if these cases are similar or different and if they have the same causes. In small groups, students analyze data to look for similarities and differences in the Alaskan claim data. They determine that, while they may have differences, the claims are similar in their cause.

Students then compare the Alaskan claims to the previous work done on the Alaska Wildfire and Sea Ice Transfer Task to determine the similarities and differences between the Alaskan claims and their case site claims. Students determine that all cases are impacted by increasing temperatures. The Alaska Wildfires and Sea Ice Key can be used to assess student progress.

There is an individual assessment task on day 2 of Lesson 12, which marks the end of Lesson Set 2. To set students up for this task, on day 1, the class examines a sample social media post to identify claims being made, which of those claims match our science ideas (supporting), and which claims are in need of clarification or explanation (refuting). Then, on day 2, students individually complete the Social Media Post Assessment. Version 1 of this assessment is intended for use by the broader classroom and is considered to be the assessment on level with current student understanding, while Version 2 offers an additional challenge.

Performance Task(s):

Lesson 17 includes instructionally-embedded tasks within the context of students designing a climate resilience plan for their school or community. The 4-day design task and optional extension build towards:

MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

To monitor group progress, use the following assessment opportunities:

Day 1 (formative): listening to students share ideas for the Criteria Checklist and their rationale for including it.

Day 2 (formative): circulate among groups listening in and probing their ideas as they complete the Community Resilience Plan: Project Planning Sheet handout.

Day 3 (formative): you will provide feedback on groups' plans before they begin their final projects using Designing a Community Resilience Plan: Teacher Feedback.

Day 4 (summative): you will evaluate groups' final resilience plans using Community Resilience Plan: Project Planning Sheet.

Extension (summative or formative): using Rubric: Communicating Our Community Resilience Plans to provide feedback for groups on their communication plan and implementation.

To monitor individual progress using the following assessment opportunities:

Anytime (formative): as a student shares ideas in whole group and small group discussion.

Day 2 (formative): individual exit ticket, see slide O.

Day 3 (formative and/or summative): using Rubric: Evaluating Solutions by Asking Questions, provide students feedback on their progress toward providing evaluative feedback to other students.

Day 4 (summative): using Argue for the Best Solution to Solve a Problem in Your Community and Rubric: Argue for the Best Solution to Solve a Problem in Your Community to assess individual progress and provide feedback.

Feedback opportunities include:

Teacher feedback is critical between days 2 and 3 using Designing a Community Resilience Plan: Teacher Feedback.

Peer feedback is critical at the start of day 3 using Part 5 of Community Resilience Plan: Project Planning Sheet. Self-assessment is encouraged at the end of day 2 using slide 0. Using the exit ticket early during students' project work to have students reflect on their comfort with their progress will also give you additional information about whether students need more support.

Stage 3 – Learning Plan
LESSON 1 (3 days) Why are floods and droughts happening more often? We observe two news clips of extreme flood and drought events and share our own water stories. We examine headlines that show a "new normal" of increased floods and droughts and notice a pattern of rising temperatures. We develop an initial model explaining what could be causing warmer temperatures and how warmer temperatures could lead to both droughts and floods. We develop a Driving Question Board (DQB) and brainstorm investigations and sources of data that could help us figure out answers to our questions. **LESSON 2 (3 days) What would we normally expect for these places and how do we know it's really changing?** We develop a systems model to describe Earth's water system. We analyze data to determine what is normal and not normal about temperature and precipitation as it relates to floods and droughts. We do this with our community and six case sites in the United States **LESSON 3 (2 days) How would increased temperatures affect evaporation?** We create bottle setups to test how increased temperatures affect evaporation rates. We also view visualizations of water vapor movement across the US and ocean temperatures in an open system. **LESSON 4 (1 day) Are rising temperatures affecting anything else in Earth's water system?** We obtain additional scientific and technical information about other components of Earth's water system and how those components are changing as temperatures increase. We conclude that all components and processes in the system have been affected by a temperature rise. We update our model and add an entry to our Progress Tracker **LESSON 5 (2 days) How are rising temperatures changing water stories in these communities?** We use our key model ideas from previous lessons to construct explanations, using evidence, about how changes in temperature are having impacts on the water stories in our case site communities. We peer review our explanations and revise them using the feedback from our peers. **LESSON 6 (2 days) How are rising temperatures connected to two seemingly different phenomena?**

We revisit our Alaskan headlines about wildfires and also learn about another community in Alaska that is experiencing multi-year sea ice loss. We apply our key model ideas in a transfer task to explain how an increase in temperatures is causing both phenomena to occur.

LESSON 7 (1 day) Are there any changes in the air that could be related to rising temperatures?
We wonder if changes in the air are related to the rise in temperatures. By looking at data, we build our understanding of the meaning of parts per million and figure out how to find the percent change in the quantity of these gases over time. We notice that, while some gases have not changed at all, some have changed very little, and other gases show an unusual increase over the 100-year period.

LESSON 8 (2 days) Are changes in carbon dioxide and methane related to or causing temperatures to increase?
We use molecular models to investigate the way molecules move in response to energy transfer. We investigate this idea further using an interactive showing how molecules move when energy is absorbed. Using these ideas and the ideas from a reading, we figure out that because greenhouse gases absorb, vibrate, and release energy, they keep our atmosphere warm. We apply these ideas to what we learned about GHGs increasing in our atmosphere to figure out that increasing GHGs are why temperatures are currently increasing.

LESSON 9 (1 day) Are the changes in the amount of CO2 in the atmosphere part of normal cycles that Earth goes through?
We carry out an investigation to determine if gas can be trapped in ice. When we figure out it can, we find out more about how scientists use ice core samples from locations on Earth that have very old ice to determine the amounts of carbon dioxide in the air over time. We focus on carbon dioxide because we know that recently it has been rising the most.

LESSON 10 (2 days) What is happening in the world to cause the sharp rise in CO_2?
We zoom into the last 200 years of Earth's history to understand what led to a rapid increase in CO_2 emissions. We watch a visualization and read about key innovations in human history that transformed the types of energy used to power our communities.

LESSON 11 (1 day) Why could burning fossil fuels create a problem for CO_2 in the atmosphere?
We modify an Earth's Carbon System model to represent the locations of carbon and processes that move carbon around. We simulate these processes using a kinesthetic activity. We figure out that photosynthesis cannot take up CO_2 at the same rate that burning fuels puts CO_2 in the atmosphere and that this is creating a buildup of CO_2 in the atmosphere.

LESSON 12 (2 days) How are changes to Earth's carbon system impacting Earth's water system?
We model the causal relationship between fossil fuel use and changing water resources. We review a tweet regarding climate change and its impacts, break the tweet down into claims, and clarify the information as a class. We take an assessment identifying claims made in another

tweet and refute any inaccurate claims by providing an explanation of the causal relationships between human activities and climate change

LESSON 13 (1 day) Why is solving the climate change problem so challenging?
We determine that the problem of increasing temperatures is due to the CO imbalance in the atmosphere caused by human combustion. We use a simulation to determine what cuts are needed to emissions rates to reach equilibrium.

LESSON 14 (1 day) What things can people do to reduce carbon dioxide going into the atmosphere?
We calculate our daily carbon footprint and create a class Carbon Scoreboard. We calculate the average carbon footprint for someone in our class and compare it to the average American's footprint. We revisit our footprint and choose carbon reduction activities and behaviors we are willing to make that would reduce our carbon emissions and would benefit our family in other ways. We compound the effects of these changes if everyone in our classroom, school, and community are willing to make changes.

LESSON 15 (3 days) How can large-scale solutions work to reduce carbon in the atmosphere?
We use a Design Matrix to organize the different solutions for reducing CO in the atmosphere that we evaluated last class. From our evaluations we determine our constraints for the solutions in trying to meet the criteria of reducing the imbalance of carbon in the air. We reevaluate each solution using our constraints and decide that multiple solutions would need to be implemented to meet our criteria.

LESSON 16 (1 day) How are these solutions working in our communities?
In this lesson, we obtain information from community plans to determine how the solutions are being used in the communities and how they rebalance carbon and/or help the community to become more resilient to changes already occurring in the community. We use these plans as examples to help motivate the need to evaluate and/or develop a plan for their own community.

LESSON 17 (4 days) What solutions work best for our school or community?
We create a checklist for what a resilience plan for our school and local community should include. We work in groups to design resilience plans that contribute to the long-term rebalancing of carbon and also prepare the community for change. We provide feedback to other groups and evaluate the plans by asking questions. We brainstorm how to communicate our plans to other audiences. We argue for the one best for our community

LESSON 18 (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

NEPTUNE CITY SCHOOL DISTRICT
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2025