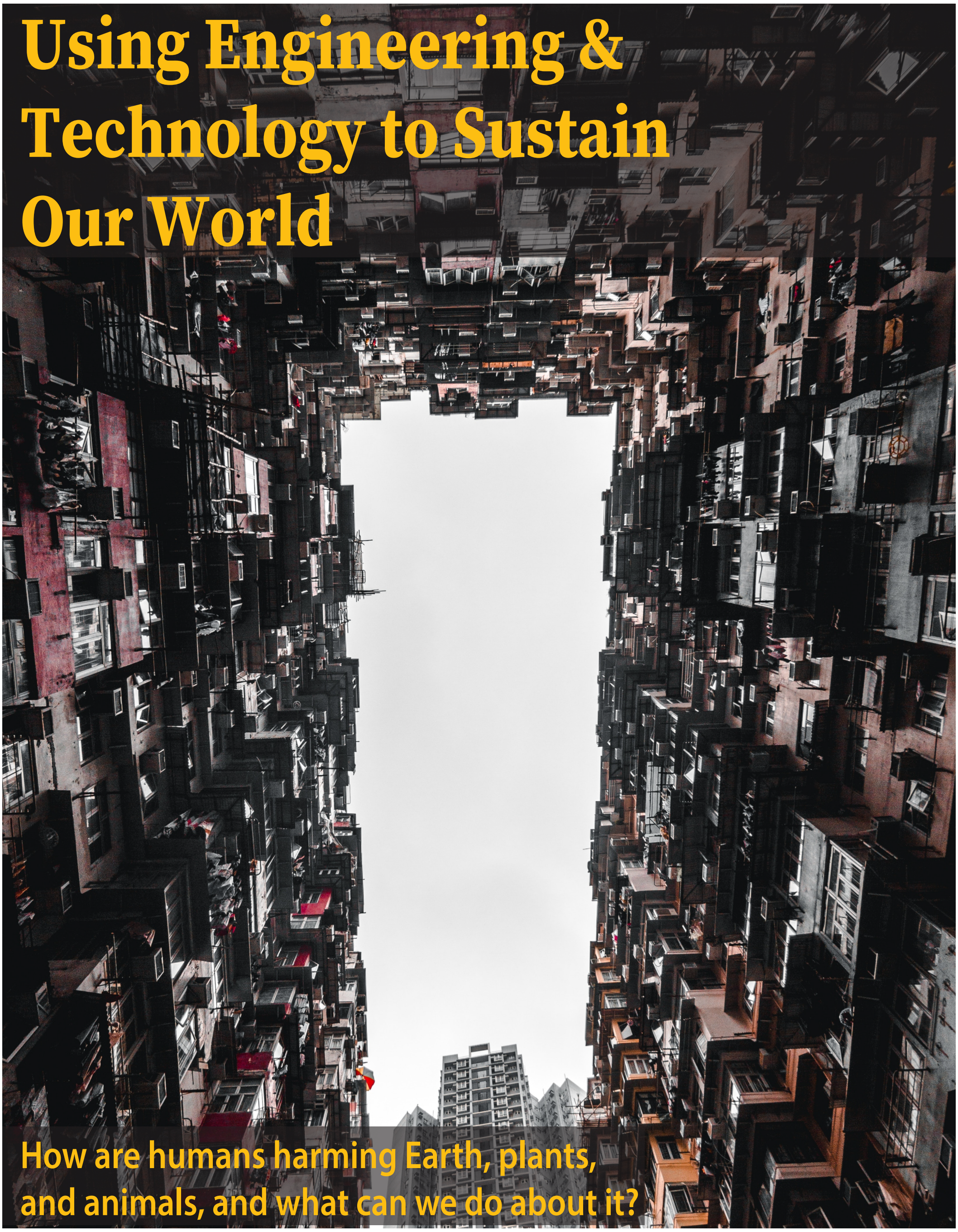
Stanford NGSS Integrated Curriculum
An Exploration of a Multidimensional World

UNIT 4



Using Engineering & Technology to Sustain Our World

How are humans harming Earth, plants, and animals, and what can we do about it?

SCALE
Stanford Center for Assessment, Learning & Equity

Leland Stanford Junior University
Die Luft der Freiheit weht
1891

Stanford NGSS Integrated Curriculum: An Exploration of a Multidimensional World
Unit 4: Using Engineering and Technology to Sustain Our World

Essential Question: How are humans harming Earth, plants, and animals, and what can we do about it?

Total Number of Instructional Days: 37.5 – 41.5

Lift-Off Task: Growing Human Impact

Task 1: Human Population and Resource Consumption

Task 2: Effects of Environmental Change on Biodiversity

Task 3: Waves and Energy

Task 4: Wave Interactions

Task 5: Using Waves to Communicate Information

Connect to the Culminating Project using the Project Organizer

Group Culminating Project:
Present a Scientific Poster at a Resource Conservation Conference

Individual Culminating Project:
Write a Letter to an Environmental Non-Profit Organization Recommending a Solution

Unit 4 Pop-Out
Environmental Injustice
(*Implement any time after Task 2*)

8th Grade Science Unit 4: Using Engineering and Technology to Sustain Our World
Unit Overview

Storyline for Unit 4

In previous science classes, students have likely learned that every ecosystem has a carrying capacity. The Earth, as a whole, is no different—despite what we think, it cannot support an infinite number of human beings. At present, human overpopulation is one of the most pressing environmental issues Earth faces, and thus serves as the anchoring phenomenon for this unit. It is the underlying force that is driving global warming, environmental pollution, habitat loss, the extinction of thousands of plants and animals, and the depletion of crucial natural resources.

For this unit's project, students will ask themselves: What can we do to help lessen the effects of human overpopulation on our planet? In order to do this, they first need to learn deeply about the problem and what solutions are available to them. In the lift-off task, students begin by drawing off their prior knowledge to generate questions around the phenomenon of human overpopulation, which will guide their learning throughout this unit.

In Task 1, students explore this phenomenon in more depth by looking not just at evidence that there are impacts, but also why there are these impacts. Through multiple tools and sources, students will find that human overpopulation and excess per-capita consumption are both wreaking havoc on Earth. This allows them to begin to define the problem at hand—that human activities lead to massive resource extraction and consumption, which are having a negative impact on Earth systems.

While in Task 1, students are introduced to general effects on Earth's systems, Task 2 allows students to dig more deeply into this chain of effects. Using what they learned in Unit 3 about natural selection, they examine how different populations of organisms are affected by human activity, explaining what is happening in terms of natural selection. This will allow them to revisit the problem from Task 1 and define it even more specifically.

At this point in the unit, students switch gears from focusing on the problem to thinking about potential solutions. Here they begin to transition towards the question: What if we could get our energy from other sources, such as waves? To understand if waves could be an alternative energy source, students need to first learn more about waves.

In Task 3, students are introduced to types of waves that are able to travel through a medium, like water waves and sound waves. As they explore the characteristics of these waves, they begin to consider how this knowledge helps them to discern the amount of energy different waves have—a concept that will be essential if they want to consider waves as a potential energy source for their culminating project.

Once students have this basic understanding of waves, they are able to move on to exploring different wave interactions. In Task 4, students use the contexts of sound waves and light waves to explore how they behave when confronted with different materials. By the end of this task, students should have a solid understanding of how waves are reflected, absorbed, or transmitted through various materials—concepts they can use to explain another form of alternative energy, solar energy.

The technologies explored in Tasks 3 and 4 are not the only wave solutions that can be considered in light of the problem students have been examining across this unit. In Task 5, students are introduced to satellite images that monitor Earth's changing landscape due to human activity; this technology uses waves to communicate this information around the world. Students explore digital and analog waves in order to decide which would be better to communicate information, like these satellite images.

After completing all tasks, student groups then choose one of the three solutions (solar energy, ocean wave energy, or satellite image monitoring) and create a scientific poster to present arguments and counterarguments for their choice at a Resource Conservation Conference. After evaluating each other's ideas, they then individually write a letter to a non-profit organization, recommending which solution they should put their funding toward and why.

Three-Dimensional Breakdown of the Performance Expectations

This unit was developed to align with, teach, and assess students' understanding and skills related to these Performance Expectations. Below, we have mapped out the disciplinary core ideas, crosscutting concepts, and science and engineering practices addressed in this unit. Aspects of the dimensions that are not explicitly addressed in this unit are crossed out.

Performance Expectations	Scientific and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
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. [Clarification Statement: Examples of evidence include grade-appropriate databases on human populations and the rates of consumption of food and natural resources (such as freshwater, mineral, and energy). Examples of impacts can include changes to the appearance, composition, and structure of Earth's systems as well as the rates at which they change. The consequences of increases in human populations and consumption of natural resources are described by science, but science does not make the decisions for the actions society takes.]	**Engaging in Argument From Evidence** • Construct an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.	**ESS3.C: Human Impacts on Earth Systems** • Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise.	**Cause and Effect** • Cause and effect relationships may be used to predict phenomena in natural or designed systems.
MS-LS4-4. Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment. [Clarification Statement: Emphasis is on using simple probability statements and proportional reasoning to construct explanations.]	**Constructing Explanations** • Construct an explanation that includes qualitative or quantitative relationships between variables that describe phenomena.	**LS4.B: Natural Selection** • Natural selection leads to the predominance of certain traits in a population, and the suppression of others.	**Cause and Effect** • Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.
MS-PS4-1. Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a	**Using Mathematics and Computational Thinking** • Use mathematical representations to describe and/or	**PS4.A: Wave Properties** • A simple wave has a repeating pattern with a specific wavelength, frequency, and	**Patterns** • Graphs and charts can be used to identify patterns in data.

wave. [Clarification Statement: Emphasis is on describing waves with both qualitative and quantitative thinking.] [*Assessment Boundary: Assessment does not include electromagnetic waves and is limited to standard repeating waves.*]	support scientific conclusions and design solutions.	amplitude.	**Energy and Matter (*Supplementary)** • The transfer of energy can be tracked as energy flows through a natural system.
MS-PS4-2. Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials. [Clarification Statement: Emphasis is on both light and mechanical waves. Examples of models could include drawings, simulations, and written descriptions.] [*Assessment Boundary: Assessment is limited to qualitative applications pertaining to light and mechanical waves.*]	**Developing and Using Models** • Develop and use a model to describe phenomena	**PS4.A: Wave Properties** • A sound wave needs a medium through which it is transmitted. **PS4.B: Electromagnetic Radiation** • When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material ~~and the frequency (color) of the light.~~ • The path that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and water, air and glass) where the light path bends. • ~~A wave model of light is useful for explaining brightness, color, and the frequency-dependent bending of light at a surface between media.~~ • However, because light can travel through space, it cannot be a matter wave, like sound or water waves.	**Structure and Function** • Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used.
MS-PS4-3. Integrate qualitative scientific and technical information to support the claim that digitized signals are a more reliable way to encode and transmit information than analog	**Obtaining, Evaluating, and Communicating Information** • Integrate qualitative scientific and technical information	**PS4.C: Information Technologies and Instrumentation** • Digitized signals (sent as wave pulses) are a more reliable way to encode	**Structure and Function** • Structures can be designed to serve particular functions.

signals. [Clarification Statement: Emphasis is on a basic understanding that waves can be used for communication purposes. Examples could include using fiber optic cable to transmit light pulses, radio wave pulses in wifi devices, and conversion of stored binary patterns to make sound or text on a computer screen.] [*Assessment Boundary: Assessment does not include binary counting. Assessment does not include the specific mechanism of any given device.*]	in written text with that contained in media and visual displays to clarify claims and findings.	and transmit information.	
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.	**Asking Questions and Defining Problems** • Define a design problem that can be solved through the development of an object, tool, process or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions.	**ETS1.A: Defining and Delimiting Engineering Problems** • The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions.	N/A
MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.	**Engaging in Argument from Evidence** • Evaluate competing design solutions based on jointly developed and agreed-upon design criteria.	**ETS1.B: Developing Possible Solutions** • There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem.	N/A

8th Grade Science Unit 4: Using Engineering and Technology to Sustain Our World
Unit Overview

Connections to Common Core Math and ELA Standards:

Over the course of this unit, students will gain knowledge and skills in science, as well as in math and English-language arts. Below we list the Common Core ELA and Math standards for middle school and 8th grade that are relevant to the curriculum tasks in this unit. Within the curriculum, there are opportunities to incorporate components of the following ELA and Math standards:

Middle School Common Core ELA Standards		Unit Task
Key Ideas and Details	CCSS.ELA-Literacy.RST.6-8.1: Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.	Task 1 Task 2 Task 5
	CCSS.ELA-Literacy.RST.6-8.2: Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions.	Task 1 Task 2 Task 5
Integration of Knowledge and Ideas	CCSS.ELA-Literacy.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.	Task 1 Task 3 Task 4 Task 5
Text Types and Purposes	CCSS.ELA-Literacy.WHST.6-8.1: Write arguments focused on discipline content.	Task 1 Task 5
Research to Build and Present Knowledge	CCSS.ELA-Literacy.WHST.6-8.8: Gather relevant information from multiple print and digital sources, using search terms effectively; asses 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.	Task 2 Task 5
	CCSS.ELA-Literacy.WHST.6-8.9: Draw evidence from informational texts to support analysis, reflection, and research.	Task 1 Task 2 Task 4 Task 5
Comprehension and Collaboration	CCSS.ELA-Literacy.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.	All Tasks Culminating Project
Presentation of Knowledge and Ideas	CCSS.ELA-Literacy.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.	Task 4 Culminating Project
	CCSS.ELA-Literacy.SL.8.5: Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest.	Task 4 Culminating Project

8th Grade Science Unit 4: Using Engineering and Technology to Sustain Our World

Unit Overview

Middle School and 8th Grade Common Core Math Standards		Unit Task
Mathematical Practice	CCSS.MATH.MP.2: Reason abstractly and quantitatively.	Task 1
	CCSS.MATH.MP.4: Model with mathematics.	Task 1 Task 3 Task 4 Task 5

Connections to English Language Development (ELD) Standards:

We acknowledge that language development is a key component of disciplinary understanding and helps to support more rigorous and equitable outcomes for diverse students. This curriculum thus takes into account both the receptive and productive language demands of the culminating projects and strives to increase accessibility by including scaffolds for language development and pedagogical strategies throughout learning tasks. We aim to support language acquisition through the development of concept maps; utilizing sentence frames; implementing the Critique, Clarify, Correct technique; employing the Stronger Clearer strategy; and fostering large and small group discussions.

The California ELD Standards are comprised of two sections: the standards and a rubric. Outlined below are the standards from Section One that are met within this curriculum. For additional information, please refer to: https://www.pausd.org/sites/default/files/pdf-faqs/attachments/SS_ELD_8.pdf.

Eighth Grade ELD Standards		
Part I: Interacting in Meaningful Ways	A: Collaborative	1.Exchanging information and ideas with others through oral collaborative discussions on a range of social and academic topics
		2. Interacting with others in written English in various communicative forms (print, communicative technology, and multimedia)
		3. Offering and justifying options, negotiating with and persuading others in communicative exchanges
		4. Adapting language choices to various contexts (based on task, purpose, audience, and text type)
	B: Interpretive	5. Listening actively to spoken English in a range of social and academic contexts
		6. Reading closely literary and informational texts and viewing multimedia to determine how meaning is conveyed explicitly and implicitly through language
		7. Evaluating how well writers and speakers use language to support ideas and arguments with details or evidence depending on modality, text type, purpose, audience, topic, and content area
		8. Analyze how writers and speakers use vocabulary and other language resources for specific purposes (to explain, persuade, entertain, etc.) depending on modality, text type, purpose, audience, topic, and content area

	C: Productive	9. Expressing information and ideas in formal oral presentations on academic topics
		10. Writing literary and informational texts to present, describe, and explain ideas and information, using appropriate technology
		11. Justifying own arguments and evaluating others' arguments in writing
		12. Selecting and applying varied and precise vocabulary and other language resources to effectively convey ideas
Part II: Learning About How English Works	A: Structuring Cohesive Texts	1. Understanding text structure
		2. Understanding cohesion
	B: Expanding and Enriching Ideas	3. Using verbs and verb phrases
		4. Using nouns and noun phrases
		5. Modifying to add details
	C: Connecting and Condensing Ideas	6. Connecting ideas
		7. Condensing ideas

Connections to Environmental Awareness:

Over the course of this curriculum, students will explore content related to various environmental principles and concepts that examine the interactions and interdependence of human societies and natural systems. In accordance with the *Education and the Environment Initiative (EEI),* tasks throughout this curriculum explore many of *California's Approved Environmental Principles and Concepts.* The principles relevant to this unit are outlined in the chart below:

Unit Task	**EEI Principle**	**EEI Concept**
Culminating Project Task 1: Human Population and Resource Consumption	Principle I: The continuation and health of individual human lives and of human communities and societies depend on the health of the natural systems that provide essential goods and ecosystem services.	Concept A: Students need to know that the goods produced by natural systems are essential to human life and to the functioning of our economies and cultures.
Culminating Project Lift-Off Task: Growing Human Impact Task 1: Human Population and Resource Consumption Task 2: Effect of	Principle II: The long-term functioning and health of terrestrial, freshwater, coastal and marine ecosystems are influenced by their relationships with human societies	Concept A: Students need to know that direct and indirect changes to natural systems due to the growth of human populations and their consumption rates influence the geographic extent, composition, biological diversity, and viability of natural systems.
		Concept B: Students need to know that methods used to extract, harvest, transport and consume natural resources influence the geographic extent, composition, biological diversity, and viability of natural systems.
		Concept C: Students need to know that the expansion and operation of human communities

Environment on Biodiversity		influences the geographic extent, composition, biological diversity, and viability of natural systems.
Culminating Project Lift-Off Task: Growing Human Impact Task 1: Human Population and Resource Consumption	Principle IV. The exchange of matter between natural systems and human societies affects the long-term functioning of both.	Concept A: Students need to know that the effects of human activities on natural systems are directly related to the quantities of resources consumed and to the quantity and characteristics of the resulting byproducts.
Culminating Project Task 1: Human Population and Resource Consumption Task 2: Effect of Environment on Biodiversity		Concept B: Students need to know that the byproducts of human activity are not readily prevented from entering natural systems and may be beneficial, neutral, or detrimental in their effect.
Culminating Project Task 2: Effect of Environment on Biodiversity		Concept C: Students need to know that the capacity of natural systems to adjust to human-caused alterations depends on the nature of the system as well as the scope, scale, and duration of the activity and the nature of its byproducts.

8th Grade Science Unit 4: Using Engineering and Technology to Sustain Our World
Teacher Materials List

Unit Essential Question: *How are humans harming Earth, plants, and animals, and what can we do about it?*

Overall Unit – All Tasks
- Unit 4, Task Cards Student Version, Lift-Off and Tasks 1 through 5
- Culminating Project Student Task Card
- Project Organizer
- Projector with Audio (for video or images, whenever needed)

Lift-Off Task (2 days)
Per Student
- Task Card Student Version: Lift-Off
- Post-Its (Optional)
- Task Card Student Version: Culminating Project
- Project Organizer

Per Group
- Poster paper and markers

Whole Class
- Poster paper and markers
- *See Instructions in task for other optional materials to use for the class concept map

Task 1 (4-5 days)
Per Student
- Task Card Student Version: Task 1
- Project Organizer
- Computers or tablets
- Calculators (Optional)
- Colored pencils
- Task 1 article (Option: class set in sheet protectors or PDFs on tablets/computers)

Task 2 (5 days)
Per Student
- Task Card Student Version: Task 2
- Project Organizer

Per Station
- Station Cards, laminated or in sheet protectors (2 Per Station)
- Video capabilities for Station 2 and Station 6 (ie. tablets or computers)

Whole Class
- Projector and Speaker (for video)

Task 3 (5-6 Days)
Per Student
- Task Card Student Version: Task 3
- Project Organizer

- Slinky (Optional: could just have one for whole class)

Per Group

- Plastic Basin
- Water
- Several Different Sized Blocks
- Cork or other floating materials
- Computer or tablet
- Slinky
- Handheld device or tablet (with Oscilloscope app downloaded)

Task 4 (6-7 days)

Per Student

- Task Card Student Version: Task 4
- Project Organizer
- Light Waves and Sound Waves articles

Per Pair

- 2 paper cups
- Pencil
- 10 foot string

Per Group

- String Telephone from the Engage
- Pieces of foam (or other absorbent materials)
- Plastic cups
- Different types of string (twine, floss, yarn, etc)
- Device with Oscilloscope app downloaded (same as used in Task 3)
- glass jar/flask (to fill with water)
- small mirror
- small patch of aluminum foil
- small patch of plastic wrap
- small patch of wax paper
- sheet of notebook paper
- small piece of cardboard
- small piece of dark colored tissue paper
- small piece of light colored tissue paper
- LED flashlight
- Poster Paper
- Markers or Colored Pencils

Task 5 (4-5 days)

Per Student

- Task Card Student Version: Task 5
- Project Organizer

- Analog and Digital Waves Article
- Critique Clarify Correct Graphic Organizer (Optional)

Per Pair

- Device with Oscilloscope app downloaded (same as used in Task 3 and 4)

For Whole Class

- Computer and Projector
- Explore Photos
- LP Record and CD or Radio and handheld device
- Speakers

Culminating Project (9 days)

Per Group: Scientific Poster

- Poster Paper
- Color pencils/markers or printed computer graphics
- Computers with internet capabilities

Per Student: Letter

- Blank Paper or Computer with Word Processing Software
- Pencils/pens

Unit 4 Pop-Out (2.5 days)

Per Student

- Student Version: Unit 4 Pop-Out
- Case Studies 1-6 (Assigned By Group)

Per Group

- Computers
- Poster materials (posters and markers)

8th Grade Science Unit 4: Using Engineering and Technology to Sustain Our World
Building on Prior Knowledge

While Unit 3 focused more heavily on life science concepts, this unit emphasizes more physical science and engineering knowledge and skills. In this unit, students engage in an earth science context—the impact of human overpopulation on natural resource consumption and Earth systems. Within this context, students continue to explore one of the life science concepts of the last unit, but focus much more heavily on physical science—obtaining information about waves and energy and how these scientific concepts might offer solutions to our resource consumption problem.

The integrated model requires students to access and use a wide range of ideas from prior grades. This content knowledge spans seven different Disciplinary Core Ideas: ESS3.C. Human Impacts on Earth Systems, LS4.B. Natural Selection, PS4.A. Wave Properties, PS4.B. Electromagnetic Radiation, PS4.C. Information Technologies, ETS1.A. Defining and Delimiting Engineering Problems, and ETS1.B. Developing Possible Solutions.

As students explore these core ideas, they build on their skills in the following science and engineering practices: Asking Questions and Defining Problems; Developing and Using Models; Using Mathematics and Computational Thinking; Constructing Explanations; Engaging in Arguments From Evidence; and Obtaining, Evaluating, and Communicating Information. In addition to science and engineering practices, students also continue to build on their knowledge of the following crosscutting concepts: Patterns, Cause and Effect, Energy and Matter, and Structure and Function.

*This summary is based on information found in the NGSS Framework.

K-8 Progression of Disciplinary Core Ideas, Science and Engineering Practices, and Crosscutting Concepts for Unit 4

Disciplinary Core Ideas	K-2	3-5	6-8
ESS3.C **Human Impacts on Earth Systems**	Things people do can affect the environment but they can make choices to reduce their impacts.	Societal activities have had major effects on the land, ocean, atmosphere, and even outer space. Societal activities can also help protect Earth's resources and environments.	Human activities have altered the biosphere, sometimes damaging it, although changes to environments can have different impacts for different living things. Activities and technologies can be engineered to reduce people's impacts on Earth.
LS4.B **Natural Selection**	N/A	Sometimes the differences in characteristics between individuals of the same species provide advantages in surviving, finding mates, and reproducing.	Natural selection leads to the predominance of certain traits in a population, and the suppression of others. In artificial selection, humans have the capacity to influence certain characteristics of organisms by selective breeding. One can choose desired parental traits determined by genes, which are then passed on to offspring.
PS4.A **Wave Properties**	Sounds can make matter vibrate, and vibrating matter can make sound.	Waves are regular patterns of motion, which can be made in water by disturbing the surface. Waves of the same type can differ in amplitude and wavelength. Waves can make objects move.	A simple wave model has a repeating pattern with a specific wavelength, frequency, and amplitude, and mechanical waves need a medium through which they are transmitted. This model can explain many phenomena including

			sound and light. Waves can transmit energy.
PS4.B Electromagnetic Radiation	Objects can be seen only when light is available to illuminate them.	Object can be seen when light reflected from their surface enters our eyes.	The construct of a wave is used to model how light interacts with objects.
PS4.C Information Technologies	People use devices to send and receive information	Patterns can encode, send, receive, and decode information.	Waves can be used to transmit digital information. Digitized information is comprised of a pattern of 1s and 0s.
ETS1.A Defining and Delimiting Engineering Problems	A situation that people want to change or create can be approached as a problem to be solved through engineering. Such problems may have many acceptable solutions. Asking questions, making observations, and gathering information are helpful in thinking about problems. Before beginning to design a solution, it is important to clearly understand the problem.	Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account.	The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions.
ETS1.B Developing Possible Solutions	Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem's solutions to other people.	Research on a problem should be carried out before beginning to design a solution. Testing a solution involves investigating how well it performs under a range of likely conditions. At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs. Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved.	A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. Models of all kinds are important for testing solutions.

8th Grade Science Unit 4: Using Engineering and Technology to Sustain Our World
Building on Prior Knowledge

Science and Engineering Practices	K-2	3-5	6-8
Asking Questions and Defining Problems*	Asking questions and defining problems in K-2 builds on prior experiences and progresses to simple descriptive questions that can be tested. • Define a simple problem that can be solved through or development of a new or improved object or tool.	Asking questions and defining problems in 3-5 builds on prior experiences and progresses to specifying qualitative relationships. • Use prior knowledge to describe problems that can be solved. • Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost.	Asking questions and defining problems in 6-8 builds on prior experiences and progresses to specifying relationships between variables, and clarifying arguments and models. • Define a design problem that can be solved through the development of an object, tool, process, or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions.
Developing and Using Models*	Modeling in K-2 builds on prior experiences and progresses to include using and developing models (i.e., diagram, drawing, physical replica, diorama, dramatization, or storyboard) that represent concrete events or design solutions. • Develop and/or use a model to represent amounts, relationships, relative scales (bigger/smaller), and/or patterns in the natural and designed world(s).	Modeling in 3-5 builds on prior experiences and progresses to building and revising simple models and using models to represent events and design solutions. • Develop and/or use models to describe and/or predict phenomena.	Modeling in 6-8 builds on prior experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. • Develop and use a model to describe phenomena.
Using Mathematics and Computational Thinking*	Using mathematics and computational thinking in K-2 builds on prior experience and progresses to recognizing that mathematics can be used to describe the natural and designed world(s). • Describe, measure, and/or compare quantitative attributes of different objects and display the data using simple graphs.	Using mathematics and computational thinking in 3-5 builds on prior experience and progresses to extending quantitative measurements to a variety of physical properties and using computation and mathematics to analyze data and compare alternative design solutions. • Describe, measure, estimate, and/or graph quantities such as area,	Using mathematics and computational thinking in 6-8 builds on prior experience and progresses to identifying patterns in large data sets and using mathematical concepts to support explanations and arguments. • Use mathematical representations to describe and/or support scientific conclusions and design solutions.

		volume, weight, and time to address scientific and engineering questions and problems.	
Constructing Explanations*	Constructing Explanations in K-2 builds on prior experiences and progresses to the use of evidence and ideas in constructing evidence-based accounts of natural phenomena. • Use information from observations (firsthand and from media) to construct an evidence-based account for natural phenomena.	Constructing Explanations in 3-5 builds on prior experiences and progresses to the use of evidence and ideas in constructing explanations that specify variables that describe and predict phenomena. • Construct an explanation of observe relationships (e.g. the distribution of plants in the backyard).	Constructing Explanations in 6-8 builds on prior experiences and progresses to include constructing explanations supported by multiple sources of evidence consistent with scientific ideas, principles, and theories. • Construct an explanation that includes qualitative or quantitative relationships between variables that describe phenomena.
Engaging in Argument from Evidence*	Engaging in argument from evidence in K-2 builds on prior experiences and progresses to comparing ideas and representations about the natural and designed world(s). • Construct an argument with evidence to support a claim. • Make a claim about the effectiveness of an object, tool, or solution that is supported by relevant evidence.	Engaging in argument from evidence in 3-5 builds on prior experiences and progresses to critiquing the scientific explanations or solutions proposed by peers by citing relevant evidence about the natural and designed world(s). • Construct and/or support an argument with evidence, data, and/or a model. • Use data to evaluate claims about cause and effect. • Make a claim about the merit of a solution to a problem by citing relevant evidence about how it meets the criteria and constraints of the problem.	Engaging in argument from evidence in 6-8 builds on prior experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s). • Construct an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. • Evaluate competing design solutions based on jointly developed and agreed-upon criteria.
Obtaining, Evaluating, and Communicating Information*	Obtaining, evaluating, and communicating Information in K-2 builds on prior experiences and uses observations and texts to communicate new information. • Describe how specific images (e.g., a diagram showing how a machine	Obtaining, evaluating, and communicating Information in 3-5 builds on prior experiences and progresses to evaluating the merit and accuracy of ideas and methods. • Combine information in written text with that contained in corresponding tables,	Obtaining, evaluating, and communicating Information in 6-8 builds on prior experiences and progresses to evaluating the merit and validity of ideas and methods. • Integrate qualitative scientific technical information in written text with that contained in media and visual displays to clarify claims and findings.

	works) support a scientific or engineering idea.	diagrams, and/or charts to support the engagement in other scientific and/or engineering practices.	

*These SEPs are summatively assessed using the Culminating Project.

Crosscutting Concepts	K-2	3-5	6-8
Patterns	Students recognize that patterns in the natural and human designed world can be observed, used to describe phenomena, and used as evidence. • Patterns in the natural and human designed world can be observed, used to describe phenomena, and used as evidence.	Students identify similarities and differences in order to sort and classify natural objects and designed products. They identify patterns related to time, including simple rates of change and cycles, and to use these patterns to make predictions. • Similarities and differences in patterns can be used to sort, classify, communicate and analyze simple rates of change for natural phenomena and designed products.	Students recognize that macroscopic patterns are related to the nature of microscopic and atomic-level structure. They identify patterns in rates of change and other numerical relationships that provide information about natural and human designed systems. They use patterns to identify cause and effect relationships, and use graphs and charts to identify patterns in data. • Graphs and charts can be used to identify patterns in data.
Cause and Effect*	Students learn that events have causes that generate observable patterns. They design simple tests to gather evidence to support or refute their own ideas about causes. • Events have causes that generate observable patterns.	Students routinely identify and test causal relationships and use these relationships to explain change. They understand events that occur together with regularity might or might not signify a cause and effect relationship. • Cause and effect relationships are routinely identified, tested, and used to explain change.	Students classify relationships as causal or correlational, and recognize that correlation does not necessarily imply causation. They use cause and effect relationships to predict phenomena in natural or designed systems. They also understand that phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability. • Cause and effect relationships may be used to predict phenomena in natural or designed systems. • Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.

Energy and Matter*	Students observe objects may break into smaller pieces, be put together into larger pieces, or change shapes. • Objects may break into smaller pieces, be put together into larger pieces, or change shapes.	Students learn matter is made of particles and energy can be transferred in various ways and between objects. Students observe the conservation of matter by tracking matter flows and cycles before and after processes and recognizing the total weight of substances does not change. • Matter is made of particles. • Energy can be transferred in various ways and between objects.	Students learn matter is conserved because atoms are conserved in physical and chemical processes. They also learn 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. • The transfer of energy can be tracked as energy flows through a natural system
Structure and Function*	Students observe the shape and stability of structures of natural and designed objects are related to their function(s). • The shape and stability of structures of natural and designed objects are related to their function(s).	Students learn different materials have different substructures, which can sometimes be observed; and substructures have shapes and parts that serve functions. • Substructures have shapes and parts that serve functions.	Students model complex and microscopic structures and systems and visualize how their function depends on the shapes, composition, and relationships among its parts. They analyze many complex natural and designed structures and systems to determine how they function. They design structures to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used. • Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used. • Structures can be designed to serve particular functions.

*These CCCs are summatively assessed using the Culminating Project.

Progression of Knowledge from Kindergarten – 8th grade

ESS3.C. Human Impacts on Earth Systems: In Kindergarten – second grade, students learn that the things people do to live comfortably can affect the world around them. As they learn about human impacts, they also consider solutions to reduce those impacts. This sets the stage for students to explore this in more depth at both the third-fifth grade level and at the middle school level. As students progress through grade levels, they continue to gather more information on human impacts on Earth systems as well as potential solutions. By the time they get to this eighth grade unit, they should have already explored many impacts and solutions. This readies them to delve into the more detailed cause-and-effect relationships and the science behind impacts and solutions. At all grade levels, students are looking at this DCI through the lens of Cause and Effect and using the SEP of Obtaining, Evaluating, and Communicating information in order to learn about this DCI.

The following is the progression of the Performance Expectations for this DCI:

K-ESS3-3 Communicate solutions that will reduce the impact of humans on the land, water, air, and/or other living things in the local environment.

5-ESS3-1 Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and 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.

LS4.B: Natural Selection: This DCI is not introduced in kindergarten – second grade and first appears in the third grade. Before students are ready to understand the mechanism of natural selection, they must first understand the cause-and-effect reasoning behind it by looking at examples. At this level, students are using evidence to conclude that variations in organisms can provide advantages in surviving, finding mates, and reproducing. This set the stage for students to learn the step-by-step mechanism of natural selection in the previous eighth grade unit, Unit 3. Students continued to use Constructing Explanations and Cause and Effect to explain natural selection, but began to incorporate Using Mathematics and Computational Thinking. In this eighth grade unit, students return to the same concept and practices, but merely apply it to new examples.

The following is the progression of the Performance Expectations for this DCI:

3-LS4-2 Use evidence to construct an explanation for how the variations in characteristics among individuals of the same species may provide advantages in surviving, finding mates, and reproducing.

MS-LS4-4 Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment.

PS4.A. Wave Properties: In Kindergarten - second grade, students explore waves only through experience, not through the actual scientific concept. At this point, students are investigating how sound can make matter vibrate and vibrating matter can make sound. This lays the foundation for later grades as they establish a relationship between vibrating matter and sound (waves). In third-fifth grade, students are given the terminology to describe this experience: wave.

Again, exploration of waves is contextualized within an experience that students can observe, which is in this case a water wave. Students experience what a wave looks like and how it moves up and down. Students are also introduced to amplitude and wavelength and how they differ in different waves. Thus, by the time students get to this 8th grade unit, they have a solid foundation in waves and their structure. In this unit, they revisit experiences from kindergarten and add the concept that mechanical waves travel through a medium by vibration of matter. They also begin to think about how wave structure affects function (specifically how amplitude affects energy). While crosscutting concepts vary from Cause and Effect to Patterns to Structure and Function throughout the grade levels, all these can be applied to wave concepts in this eighth grade unit. Aside from at the kindergarten level, students mainly focus on the SEP of Developing and Using Models to explain wave properties.

The following is the progression of the Performance Expectations for this DCI:

1-PS4-1 Plan and conduct investigations to provide evidence that vibrating materials can make sound and that sound can make materials vibrate.

4-PS4-1 Develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move.

MS-PS4-1 Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave.

<u>PS4.B. Electromagnetic Radiation</u>: In Kindergarten – second grade, students lay a solid foundation for electromagnetic radiation by experiencing most of the concepts they will study the science behind in later years. At this level, students experience that objects can only be seen when illuminated and that some materials allow light to pass through, others block all light, and mirrors can be used to redirect light. In third – fifth grade, students develop models of this process in which light reflects from objects and enters the eye, so they can be seen. By the time they reach this eighth grade unit, they have experienced the concepts and engaged in the modeling to prepare them for this PE. In this unit, students develop models to describe not just how waves are reflected, but also absorbed and/or transmitted through various materials. While at the kindergarten – second grade level, students focus on Planning and Carrying Out Investigations, they move to Developing and Using Models at the later levels as they learn about the science behind the experience. Also, as students progress, they move from simple Cause and Effect reasoning, to examining more specifically how Structure affects Function.

The following is the progression of the Performance Expectations for this DCI:

1-PS4-2 Make observations to construct an evidence-based account that objects can be seen only when illuminated.

1-PS4-3 Plan and conduct an investigation to determine the effect of placing objects made with different materials in the path of a beam of light.

4-PS4-2 Develop a model to describe that light reflecting from objects and entering the eye allows objects to be seen.

MS-PS4-2 Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.

PS4.C. Information Technologies: In Kindergarten – second grade, students engage with this DCI through a design activity, creating a device that uses light or sound to communicate over a distance, such as a string telephone or a pattern of drum beats. These are simplified representations of the way modern devices work, which they will explore in this eighth grade unit. In third – fifth grade, they hone in on digital signals and how they can be used to transmit information over long distances without significant degradation. This lays the foundation for students to learn the science behind these technologies in this eighth grade unit—analog and digital waves. In this unit, students gather more information to learn about these two type of signals and figure out that digitized signals are a more reliable way to encode and transmit information. In doing so, they move away from Designing Solutions, Cause and Effect, and Patterns and instead focus on Obtaining, Evaluating, and Communicating Information to learn about the Structure and Function of these two wave types.

The following is the progression of the Performance Expectations for this DCI:

1-PS4-4 Use tools and materials to design and build a device that uses light or sound to solve the problem of communicating over a distance.

4-PS4-3 Generate and compare multiple solutions that use patterns to transfer information.

MS-PS4-3 Integrate qualitative scientific and technical information to support the claim that digitized signals are a more reliable way to encode and transmit information than analog signals.

ETS1.A. Defining and Delimiting Engineering Problems: In Kindergarten - second grade, students first begin to approach situations as problems to be solved through engineering. They learn to ask questions and gather information to clearly understand a problem. In third – fifth grade, students move past identifying the problem to also identifying criteria and constraints surrounding the problem. In this eighth grade unit, students continue their skill-building from Unit 1 of defining criteria and constraints more precisely; this includes consideration of scientific principles and other relevant knowledge. In Kindergarten – second grade, students focused on the science and engineering practice of Asking Questions in order to help them with the practice of Defining Problems; Defining Problems then becomes the main focus in subsequent grades.

The following is the progression of the Performance Expectations for this DCI:

K-2-ETS1-1 Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.

3-5-ETS1-1 Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

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.

ETS1.B. Developing Possible Solutions: In Kindergarten - second grade, students begin communicating multiple designs in the form of diagrams and sketches. By third – fifth grade, students move from mere drawings to actually testing out their designs to see how they perform under different conditions. Students then are able to use this data to make improvements. As in Kindergarten – second grade, the idea that communication of designs with peers is an essential part of the design process. In this eighth grade unit, students continue their work from Unit 1, but instead of evaluating solutions of their own design, they use the same skills to evaluate existing solutions for how well they meet criteria and constraints. At the different grade levels, students engage in a variety of different science and engineering practices: Developing Models in K-2, Designing Solutions (specifically comparing solutions) in 3-5, and Engaging in Argument From Evidence in 6-8.

The following is the progression of the Performance Expectations for this DCI:

K-2-ETS1-2 Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.

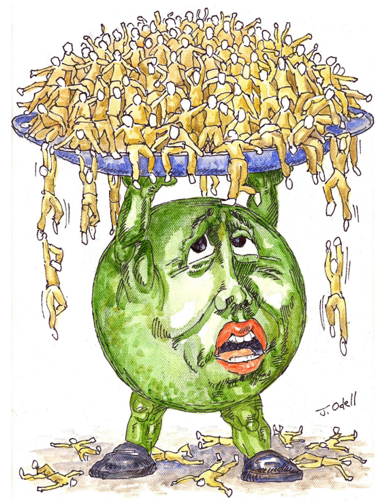
3-5-ETS1-2 Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

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

8th Grade Science Unit 4: Using Engineering and Technology to Sustain Our World
Culminating Project

Unit Essential Question: *How are humans harming Earth, plants, and animals and what can we do about it?*

Introduction



There is no question that human beings are putting a greater strain on our planet than it will be able to sustain. For the first half of the unit, students gather information to define this problem and identify specific criteria and constraints. While this problem at first seems disheartening and overwhelming, there is still hope. In the second half of this unit, students learn about technologies humans might be able to use to help monitor or lessen the effects of human overpopulation and excess resource consumption. For their culminating project, each group will choose one of three solutions to research: solar energy, ocean wave energy, or satellite image monitoring. Based on their research, they will create a scientific poster to present arguments and counterarguments at a Resource Conservation Conference. After evaluating each other's ideas at the conference, students individually write a letter to an environmental non-profit organization, recommending which solution they should put their funding towards and explaining why.

3-Dimensional Assessment

Disciplinary Core Ideas

ESS3.C: Human Impacts on Earth Systems
- As human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth.

LS4.B: Natural Selection
- Natural selection leads to the predominance of certain traits in a population, and the suppression of others.

PS4.A: Wave Properties
- A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude.

PS4.B: Electromagnetic Radiation
- When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the material.

PS4.C: Information Technologies and Instrumentation
- Digitized signals are a more reliable way to encode and transit information.

ETS1.A: Defining and Delimiting Engineering Problems
- The more precisely the criteria and constraints can be defined, the more likely it is the solution will be successful.

ETS1.B: Developing Possible Solutions
- There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints.

Science and Engineering Practices

Asking Questions and Defining Problems
- Define a design problem and include multiple criteria and constraints.

Developing and Using Models
- Develop and use a model to describe phenomena.

Using Mathematics and Computational Thinking
- Use mathematical representations to describe and/or support scientific conclusions and design solutions.

Constructing Explanations
- Construct an explanation that includes qualitative or quantitative relationships between variables that describe phenomena.

Engaging in Argument From Evidence
- Evaluate competing design solutions based on jointly developed and agreed-upon design criteria.

Obtaining, Evaluating, and Communicating Information
- Integrate qualitative scientific and technical information in written text with that contained in media and visual displays to clarify claims and findings.

Crosscutting Concepts

Cause and Effect
- Cause and effect relationships may be used to predict phenomena in natural or designed systems.
- Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.

Energy and Matter
- The transfer of energy can be tracked as energy flows through a natural system.

Structure and Function
- Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used.
- Structures can be designed to serve particular functions.

Time Needed (Based on 45-Minute Periods)

9 days at end of unit

- Group Project: 4 periods (includes 1 presentation day)
- Individual Project: 5 periods
  - First draft: 3 periods
  - Feedback: 1 period
  - Revision: 1 period

Materials

Scientific Poster

- Poster Paper
- Color pencils/markers or printed computer graphics
- Computers with internet capabilities

Letter

- Blank Paper or Computer with Word Processing Software
- Pencils/pens

Instructions for the Culminating Project

1. Introduce the Culminating Project at the end of the Lift-Off task, including both the group and individual components outlined in the Challenge.

2. Read over the Culminating Project Task Card with the students. We recommend only reading the challenge and group criteria for success at this time in order to not overwhelm students with information.
   - Take questions for clarification.
   - Optional: Show the following clip used in the 7th grade integrated curriculum to provide an additional hook to engage students: https://www.youtube.com/watch?v=WfGMYdalClU.

3. Remind students that as they go through the Project Organizer, they will be planning pieces of their scientific poster and recording scientific concepts they will likely need for their individual project. However, there is nothing wrong with going back and changing their ideas over the course of the unit. The students won't fully design their poster until the end of the unit, so change during the processing time is acceptable and often experienced.

4. Make sure the students fill out the Project Organizer after each task, which will help the students think about how human impact on Earth systems and biodiversity is related to wave technologies. This process allows students to both apply and document relevant scientific concepts as they move through the unit. This will inform both their group and individual projects.
   - We recommend that students complete the Project Organizer individually. They might discuss ideas first as a group, but should then respond individually. This allows students time to process concepts on their own and generate their own ideas, which can be used later when it comes to developing their group project.

5. The table below summarizes how the Project Organizer guides the students through developing different components of their scientific poster and individual letter.

Task	Project Organizer	Group and Individual Culminating Project
Lift Off Growing Human Impact	• Why do you think humans are having more of a negative impact over time?	• None
Task 1 Human Population and Resource Consumption	• Diagram the problem as a cause-and-effect flowchart. • What are the criteria of success in solving this problem? • What are the constraints in solving this problem? • Look at the flowchart you created: Where do you think is the most feasible place for humans to intervene in this process?	• Poster describes the multiple cause-and-effect relationships involved in the problem Earth faces • Letter identifies the criteria and constraints of the problem. It also describes the multiple cause-and-effect relationships (overpopulation and excess per-capita resource consumption) that are resulting in harm to Earth.
Task 2 Effects of Environmental Change on Biodiversity	• How can you use cause-and-effect reasoning and the process of natural selection to better define the problem? • Add to the problem you outlined after Task 1. • Are there any other criteria and constraints you would like to add considering what you have learned in this task?	• Poster describes how environment affects biodiversity in the problem Earth faces • Letter convinces reader that the changes to environment will negatively affect biodiversity on Earth, using evidence and the cause-and-effect relationship of natural selection.
Task 3 Waves and Energy	• Based on what you learned today, draw a model of an ocean wave, using labels. • How is the structure of an ocean wave related to the amount of energy it has? • How might these ideas about waves and their energy help us use ocean waves as an energy source?	• If ocean wave energy is the chosen solution, poster presentation will describe and diagram how it works in terms of waves and energy. • Letter uses mathematical wave models showing the characteristics of waves to explain how the characteristics of different ocean waves might affect the energy that can be transferred.
Task 4 Wave Interactions	• Use what you learned about the ways that light waves get **reflected, absorbed, and transmitted** to draw a model of how solar radiation and solar panels work. • What are the properties of clouds, air, and solar cells that cause waves to reflect, transmit, or absorb? • Explain how we can use light waves as a way to reduce our impact on the earth.	• If solar energy is the chosen solution, poster presentation will describe and diagram how it works in terms of waves and energy. • Letter models the different wave interactions involved in solar radiation and solar panel technology. Student also describes the properties of the clouds, air, and solar panels that lead to these interactions.
Task 5 Using Waves to Communicate Information	• What technology did you learn about in this task that can be used to monitor resource consumption or mitigate the effects on Earth?	• If satellite image monitoring is the chosen solution, poster presentation will describe and diagram how it works in terms of waves and energy.

	• Can you think of any other ways that waves can communicate information to help mitigate effects on Earth? • Are analog or digital waves a better option for this solution? Why? Explain using knowledge of their structure and function.	• Letter uses information from texts, videos, and pictures in Task 5 to explain what type of signals have the best structure to communicate these images and why.

6. After all the learning tasks are completed, and all the Project Organizers are completed, the students can choose a solution and start to design their scientific posters. We recommend making sure there is an even distribution of solutions chosen—for this reason, you may choose to assign solutions to groups.
    - As always, we recommend the use of group roles for Culminating Project work time (See "How to Use This Curriculum" document for details). We recommend changing the roles every work day.

7. Students will then create a scientific poster and associated presentation that meets all the criteria in the student handout. The Project Organizers and Group Criteria for Success should be used as reference for the students to remind them of all components of their poster and presentation.
    - You may want to show images or videos of what a scientific poster presentation looks like, so students have an idea of what they are preparing for.

8. Group presentations at the "Resource Conservation Conference" should be done in a gallery-walk format as most scientific poster presentations are done. In order to ensure that everyone can visit the posters and have time to present, you may want to switch up when group members are at their poster presenting and when they are walking around visiting other posters.
    - We recommend that students take notes during this segment, as they will use information from other groups to evaluate all potential solutions and make a recommendation in their individual letter. You may wish to provide a graphic organizer to help them organize their notes, based on the requirements of the individual project. An option is provided at the end of this teacher guide.

9. Once the "Resource Conservation Conference" is complete, students are ready to move on to their individual project. Students will write a letter to an environmental non-profit that makes a recommendation of a solution to fund and meets all the criteria in the student handout.

10. Conduct a peer review of the letters after students have completed a first draft.
    - Copy the Letter Peer Review Feedback form found in the Student Instructions. Another option is to use the Student 3-Dimensional Individual Project Rubric.
    - Assign each student a partner, preferably a partner from a different group.
    - Students switch drafts and assess them using the peer review feedback form or 3-Dimensional Rubric.
        - Remind each student to give one positive comment and one constructive comment for each section on the checklist.
        - Allow students time to present their feedback to their partner, so their partner may ask clarifying questions if needed.

11. After receiving feedback, allow students time to complete a final draft based on the feedback they received.

Assessment

The Project Organizer can be formatively assessed using:

- ❒ *Criteria of your choice.* We recommend using the 3-Dimensional Assessment matrix from the Unit Overview to inform your criteria.

The Group Culminating Project will be summatively assessed using:

- ❒ The *Group Project Criteria for Success* Checklist

The Individual Culminating Project will be summatively assessed using:

- ❒ The *3-Dimensional Individual Project Rubric*.
- ❒ Keep in mind that the Proficient level indicates that the student has successfully demonstrated understanding of the criteria. Because we are in the early stages of NGSS adoption, it may take multiple opportunities throughout the course of the year for students to reach Proficient.
- ❒ If you wish to give students a numeric score, you could take the average score of all of their rubrics or add up rubric scores to give students a summation out of the total. Because of the note above, this scoring may not correlate to traditional grading systems.
- ❒ While we recommend scoring all of the project criteria with the rubrics for each student, we understand the burden of that level of scoring.
    - One option is to select the rubrics that you wish to focus on for this project and use those to assess each student's individual project.
    - Another option is to review the Proficient level of each of the project's rubrics and use the descriptions to generally analyze all student work for trends.

Resource Conservation Conference Notetaker

Instructions: As you visit other groups' posters, take notes in the boxes below. You will be able to use this information in your individual project.

Ocean Waves Energy	
Draw models that show the characteristics of different ocean waves.	Which wave characteristic affects the energy of an ocean wave? How?

Solar Energy	
Draw a model that shows and explains all the different wave interactions involved in solar radiation and solar panel technology.	How do the properties of the clouds, the air, and the solar panels affect how the light wave behaves?

Satellite Image Monitoring	
Take notes on the differences between digital and analog signals:	Which type of signals is best to communicate satellite images? Why?

8th Grade Science Unit 4: Using Engineering and Technology to Sustain Our World

3-Dimensional Individual Project Rubric

Overview: The following rubrics can be used to assess the individual project: a letter to an environmental non-profit organization. Each rubric is aligned to one section of the *Individual Project Criteria for Success*, located on the Culminating Project Student Instructions. *If student provides no assessable evidence (e.g., "I don't know" or leaves answer blank), then that student response cannot be evaluated using the rubric and should be scored as a zero.

Below we provide an alignment table that details the dimensions assessed for each criterion.

	Student Criteria for Success	Disciplinary Core Idea	Science and Engineering Practice	Crosscutting Concept
1	○ Define the problem Earth faces ○ What are the criteria of success in solving the problem? ○ What are the constraints that could limit solutions?	ETS1.A: Defining and Delimiting Engineering Problems • The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions.	Asking Questions and Defining Problems • Define a design problem that can be solved through the development of an object, tool, process or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions.	N/A
2	○ What is harming Earth? ○ Describe the multiple cause-and-effect relationships at work.	ESS3.C: Human Impacts on Earth Systems • Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise.	N/A	Cause and Effect • Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.
3	○ How can you use natural selection to explain and predict why these changes to environment also affect organisms? Support with evidence and reasoning to describe this relationship between environment and traits.	LS4.B: Natural Selection • Natural selection leads to the predominance of certain traits in a population, and the suppression of others	Constructing Explanations • Construct an explanation that includes qualitative or quantitative relationships between variables that describe phenomena	Cause and Effect • Cause and effect relationships may be used to predict phenomena in natural or designed systems.
4	○ Ocean Waves Energy: draw and compare at	PS4.A: Wave Properties	Using Mathematics and	Energy and Matter

	least two mathematical wave models to explain how the characteristics of different ocean waves might affect the energy that can be transferred from the ocean wave to the energy-capture devices.	• A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude.	Computational Thinking • Use mathematical representations to describe and/or support scientific conclusions and design solutions.	• The transfer of energy can be tracked as energy flows through a natural system.
5	○ Solar Energy: draw a model to explain all the different wave interactions involved in solar radiation in order to explain how light waves from the sun can be used for energy in solar panel technology. ○ Use labels to identify the different types of wave interactions. ○ Use captions to describe the properties of the clouds, the air, and the solar panels, which affect how the wave behaves.	PS4.B: Electromagnetic Radiation • When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material. • The path that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and water, air and glass) where the light path bends.	Developing and Using Models • Develop and use a model to describe phenomena	Structure and Function • Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used.
6	○ Satellite Image Monitoring: Make a claim for what type of signals has the best structure to communicate satellite images. Combine information from the texts, videos, and pictures in Task 5 to explain why.	PS4.C: Information Technologies and Instrumentation • Digitized signals (sent as wave pulses) are a more reliable way to encode and transmit information.	Obtaining, Evaluating, and Communicating Information • Integrate qualitative scientific and technical information in written text with that contained in media and visual displays to clarify claims and findings.	Structure and Function • Structures can be designed to serve particular functions.
7	○ Evaluate the three solutions and recommend one solution to be funded. In your evaluation, include: ○ Why the solution you chose should be funded over the others. ○ How well the solution you chose meets the criteria and constraints of the problem.	ETS1.B: Developing Possible Solutions • There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem.	Engaging in Argument from Evidence • Evaluate competing design solutions based on jointly developed and agreed-upon design criteria.	N/A

3-Dimensional Individual Project Rubric

Rubric 1: Student defines the problem Earth faces and identifies criteria and constraints to solving this problem.

- Dimensions Assessed: DCI – ETS1.A: Defining and Delimiting Engineering Problems, SEP – Asking Questions and Defining Problems

Emerging (1)	Developing (2)	Proficient (3)	Advanced (4)
Student **inaccurately or incompletely** defines the problem Earth faces **and/or** identifies **irrelevant** criteria and constraints.	Student **accurately, but generally** defines the problem Earth faces **and** identifies relevant criteria **OR** constraint(s).	Student accurately and **completely** defines the problem Earth faces and identifies **a** relevant criterion and constraint.	Student accurately and completely defines the problem Earth faces and identifies **multiple relevant** criteria and constraints to solving this problem.
Look Fors: ● Student inaccurately or incompletely defines the problem. For example, “Humans are overpopulating Earth” or “Organisms are using up too many resources, creating too much competition” or “humans are using too many resources.” While some of these examples may be correct, they do not completely outline the problem. ● And/or student identifies irrelevant criteria and/or constraints. For example, “One criterion for success is that there will be no more resources consumed and no more impact on Earth.” This is a not a realistic criterion.	**Look Fors:** ● Student accurately defines the problem, but it may be general: human overpopulation and activities are having negative impacts on Earth. ● Student then identifies at least one criterion for success. See potential student responses in Advanced column. OR Student identifies at least one relevant constraint. See potential student responses in Advanced column. Student does not identify both criteria and constraints.	**Look Fors:** ● Student accurately defines the problem: human overpopulation and excess resource consumption are having negative impacts on Earth and its biodiversity. ● Student then identifies one relevant criterion for success. See potential student responses in Advanced column. ● Student also identifies one relevant constraint. See potential student responses in Advanced column.	**Look Fors:** ● Student accurately defines the problem: human overpopulation and excess resource consumption are having negative impacts on Earth and its biodiversity. ● Student then identifies multiple relevant criteria for success, such as “a decreased rate in the destruction and pollution of habits”, “less organisms on the endangered species list”, “less fossil fuels extracted and used”, etc. ● Student also identifies multiple relevant constraints, such as “alternative forms of energy require a higher cost up front, so less likely to be used”, “people like their lifestyle so will be unwilling to change their ways”, “technology barriers in widespread distribution of satellite images”, etc.

8th Grade Science Unit 4: Using Engineering and Technology to Sustain Our World

3-Dimensional Individual Project Rubric

Rubric 2: Student explains what is harming Earth, identifying causes and explaining the chain of cause-and-effect reasoning.

- Dimensions Assessed: DCI – ESS3.C: Human Impacts on Earth Systems, CCC – Cause and Effect

Emerging (1)	Developing (2)	Proficient (3)	Advanced (4)
Student **inaccurately** explains what is harming Earth.	Student **accurately** explains what is harming Earth, identifying **one** cause and explaining a **partial** chain of cause-and-effect reasoning.	Student accurately explains what is harming Earth, identifying **multiple** causes and explaining a **partial** chain of cause-and-effect reasoning.	Student accurately explains what is harming Earth, identifying multiple causes and explaining the **complete** chain of cause-and-effect reasoning.
Look Fors: • Student reasoning is inaccurate or irrelevant to this unit. For example, "Human overpopulation uses up our planet's oxygen at too fast of a rate, thus harming Earth."	**Look Fors:** • Student accurately explains that human overpopulation OR per-capita resource consumption are harming Earth, but not both. It only connects the one identified cause with the effect and thus, does not use the same complex chain of cause and effect reasoning as higher levels. • For example, "Human overpopulation is harming Earth because this destroys and pollutes more environments."	**Look Fors:** • Student accurately explains that human overpopulation and per-capita resource consumption are harming Earth, but does not explain the entire chain of cause and effect reasoning as the Advanced response. • For example, "Humans are already over-consuming and overpopulation causes even more resource consumption. Extracting and using these resources for use causes a lot of pollution, which is bad for the Earth."	**Look Fors:** • Student accurately explains that human overpopulation and per-capita resource consumption are harming Earth, citing some specific effects and using a complex chain of cause and effect reasoning. • For example, "Humans are already over-consuming resources. If human population increases, this resource consumption is only going to increase more. Extracting these resources for use causes a lot of damage to Earth, such as pollution, habitat destruction, and soil degradation. Using them also causes negative impacts, like global warming. More people also means more homes, which destroys natural habitats. Thus humans are indirectly and directly harming Earth."

8th Grade Science Unit 4: Using Engineering and Technology to Sustain Our World

3-Dimensional Individual Project Rubric

Rubric 3: Student explains and predicts why recent environmental changes will affect organisms, using evidence and the cause-and-effect relationship of natural selection to support their explanation.

- Dimensions Assessed: DCI – LS4.B: Natural Selection, CCC – Cause and Effect, SEP – Constructing Explanations

Emerging (1)	Developing (2)	Proficient (3)	Advanced (4)
Student **inaccurately** explains and predicts why recent environmental changes will affect organisms.	Student **generally** explains and predicts why recent environmental changes will affect organisms, using **no** evidence AND/OR **no** cause-and-effect relationship of natural selection to support their explanation.	Student **partially** explains and predicts why recent environmental changes will affect organisms, using evidence and **part of** the cause-and-effect relationship of natural selection to support their explanation.	Student **accurately** explains and predicts why recent environmental changes will affect organisms, using evidence and the **complete** cause-and-effect relationship of natural selection to support their explanation.
Look Fors: ● Student explanation is inaccurate. For example, "Humans are killing all the organisms for food."	**Look Fors:** ● Student offers a technically correct explanation using general reasoning, but the explanation makes no reference to concepts of natural selection AND/OR does not cite any evidence. For example, "As the environment changes because of humans, this causes animals to change and adapt."	**Look Fors:** ● Student's explanation uses the cause-and-effect reasoning involved in some of the principles of natural selection and cites at least one piece of evidence. For example, "As the environment changes because of human activities, this will affect organisms. When an environment changes, some organisms in a species might have traits that are less suited to the new environment, so those ones will die. For example..." This example leaves out the effect on the traits of the whole population.	**Look Fors:** ● Student's explanation uses the cause-and-effect reasoning involved in all the principles of natural selection and cites at least one piece of evidence. For example, "As the environment changes because of human activities, this will affect organisms. When an environment changes, different organisms in a species might have traits that are better suited to the new environment. If a trait helps the organism survive, then it will be more likely to reproduce and pass on that trait, creating a population of organisms with more of the new trait. For example…"

8th Grade Science Unit 4: Using Engineering and Technology to Sustain Our World

3-Dimensional Individual Project Rubric

Rubric 4: Student explains how the characteristic(s) of ocean waves affect the energy that can be transferred, using mathematical wave models.

- Dimensions Assessed: DCI – PS4.A: Wave Properties, CCC – Energy and Matter, SEP – Using Mathematics and Computational Thinking.

Emerging (1)	Developing (2)	Proficient (3)	Advanced (4)
Student **inaccurately** explains how the characteristic(s) of ocean waves affect the energy that can be transferred **and/or uses inaccurate** mathematical wave models.	Student **accurately** explains how the characteristic(s) of ocean waves affect the energy that can be transferred, but **only uses one** mathematical wave model.	Student **accurately** explains how the characteristic(s) of ocean waves affect the energy that can be transferred, using **partial but accurate** mathematical wave models.	Student **accurately** explains how the characteristic(s) of ocean waves affect the energy that can be transferred, using **complete and accurate** mathematical wave models.
Look Fors: • Student explanation is inaccurate. For example, they explain that the higher the frequency of the wave, the more energy it can transfer. • Models are either missing or inaccurate. For example, for the above response, a student might draw two waves with different frequencies and label each as having more and less energy.	**Look Fors:** • Student accurately explains that the larger the amplitude the ocean wave has, the more energy it can transfer to the energy-capture device. • To aid their explanation, student only draws one wave model that accurately labels at least amplitude, if not other characteristics. Because they only draw one wave model, they do not make comparisons of different amplitudes and the effect on energy.	**Look Fors:** • Student accurately explains that the larger the amplitude the ocean wave has, the more energy it can transfer to the energy-capture device. • To aid their explanation, student draws at least two wave models that accurately label amplitude, but not frequency and/or wavelength. The two wave models should show waves of different amplitudes and identify which ocean wave would have more energy.	**Look Fors:** • Student accurately explains that the larger the amplitude the ocean wave has, the more energy it can transfer to the energy-capture device. • To aid their explanation, student draws at least two complete wave models that accurately label characteristics, such as amplitude, frequency, and wavelength. The two wave models should show waves of different amplitudes and identify which ocean wave would have more energy.

Rubric 5: Student develops a model of solar radiation and solar energy harvest to describe how the properties of different matter result in the reflection, absorption, and transmission of light waves.

- Dimensions Assessed: DCI – PS4.B: Electromagnetic Radiation, SEP – Developing and Using Models, CCC – Structure and Function

Emerging (1)	Developing (2)	Proficient (3)	Advanced (4)
Student develops an **inaccurate or irrelevant** model.	Student develops an **incomplete** model of solar radiation and solar energy harvest to **incompletely** describe how the properties of different matter result in the reflection, absorption, and transmission of light waves.	Student develops a **partial** model of solar radiation and solar energy harvest to **partially** describe how the properties of different matter result in the reflection, absorption, and transmission of light waves.	Student develops a **complete** model of solar radiation and solar energy harvest to **accurately** describe how the properties of different matter result in the reflection, absorption, and transmission of light waves.
Look Fors: ● Student model is inaccurate or irrelevant. For example, it shows sun rays hitting solar panels, but makes no mention of any wave interactions or properties of matter affecting behavior.	**Look Fors:** ● Student develops an incomplete model that accurately shows and describes the properties of one of the three materials (clouds, air, solar panels) and its effect on a wave interaction (reflection, absorption, transmission). See Advanced column for correct responses. OR ● Student develops a model that accurately shows and describes most or all of the wave interactions, but does not include any description of the properties of matter that lead to the wave interactions.	**Look Fors:** ● Student develops a partial model that accurately shows and describes the properties of at least two of the three materials (clouds, air, solar panels) and their effect on wave interactions (reflection, absorption, transmission). See Advanced column for correct responses.	**Look Fors:** ● Student develops a complete model that accurately shows and describes how the properties of clouds, air, and solar panels leads to all three wave interactions (reflection, absorption, and transmission). For example, student draws and describes how light rays from the sun reflect off of clouds back into the atmosphere because of the properties of water in the clouds; other rays transmit though air down to Earth because of the transparent properties of air; and some rays reflect but most absorb into solar panels because of the properties of a component called silicon, exciting electrons and creating electric current.

8th Grade Science Unit 4: Using Engineering and Technology to Sustain Our World

3-Dimensional Individual Project Rubric

Rubric 6: Student identifies what type of signals has the best structure to communicate satellite images, explaining why by integrating information from text, media, and visuals.

- Dimensions Assessed: DCI – PS4.C: Information Technologies, SEP – Obtaining, Evaluating, and Communicating Information, CCC – Structure and Function.

Emerging (1)	Developing (2)	Proficient (3)	Advanced (4)
Student **inaccurately** identifies what type of signals has the best structure to communicate satellite images **AND/OR does not** explain why.	Student **accurately** identifies what type of signals has the best structure to communicate satellite images, **generally** explaining why but **using no explicit** information from text, media, and visuals.	Student **accurately** identifies what type of signals has the best structure to communicate satellite images, **partially** explaining why by **using specific** information from text, media, **and/or** visuals.	Student accurately identifies what type of signals has the best structure to communicate satellite images, **completely** explaining why by **integrating specific** information from text, media, **and** visuals.
Look Fors: • Student inaccurately identifies analog signals as best OR • Student accurately identifies digital signals as the best but offers no explanation as to why or explanation is very inaccurate.	**Look Fors:** • Student identifies digital signals as best and generally explains why, but does not touch on structure and its effect on function and does not explicitly use any information from Task 5. • For example, "Digital signals are the best way to communicate satellite images because they are easy to recreate."	**Look Fors:** • Student identifies digital signals as best and explains why, referencing structure and its effect on function, including some information from at least one Task 5 source. • For example, "Digital signals are the best way to communicate satellite images. According to the article, digital signals are sent as patterns of 1s and 0s, while analog signals vary greatly. This makes them easier to recognize and recreate accurately after travelling long distances."	**Look Fors:** • Student identifies digital signals as best and explains why, referencing structure and its effect on function and including lots of specific information from multiple different Task 5 sources. • For example, "Digital signals are the best way to communicate satellite images. In a picture from Task 5, you can see digital signals are sent as patterns of two universal structures (1 or 0), while analog signals vary greatly in structure. The video and article said that because digital signals have two universal structures, even if they pick up interference over long distances, the pattern is still recognizable and can be recreated accurately. Because analog signals varies in structure, it is hard to recognize and recreate after suffering a lot of interference."

3-Dimensional Individual Project Rubric

Rubric 7: Student recommends one solution to be funded and explains why this is a better solution in terms of criteria and constraints.

- Dimensions Assessed: DCI – ETS1.B: Developing Possible Solutions, SEP – Engaging in Argument from Evidence

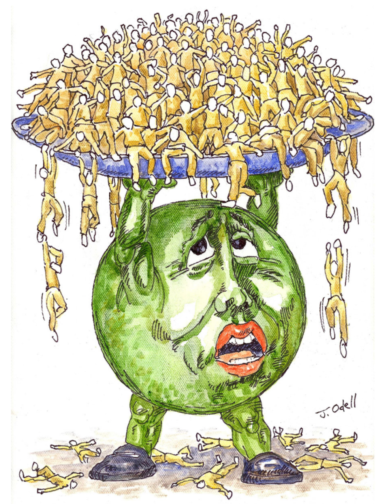
Emerging (1)	Developing (2)	Proficient (3)	Advanced (4)
Student recommends an **irrelevant** solution to be funded.	Student recommends one **relevant** solution to be funded and explains why this is a better solution **but not** in terms of criteria and constraints.	Student recommends one relevant solution to be funded and explains why this is a better solution in terms of criteria **or** constraints.	Student recommends one relevant solution to be funded and explains why this is a better solution in terms of criteria **and** constraints.
Look Fors: • Student recommendation may be accurate but irrelevant to this project. For example, funding a recycling program or instituting a one-child law.	**Look Fors:** • Student recommends ocean energy, solar energy, or satellite image monitoring. It does not matter which is chosen, as long as it is supported with reasoning. • Student explains why but not in terms of criteria and constraints. For example, "I recommend funding ocean energy because waves naturally happen all the time, so they can't be used up."	**Look Fors:** • Student recommends ocean energy, solar energy, or satellite image monitoring. It does not matter which is chosen, as long as it is supported with reasoning. • Student explains why in terms of criteria OR constraints, but not both. For example, "I recommend funding solar energy because people are very unwilling and unlikely to change their lifestyle so this just gives them another way to get the energy they already use."	**Look Fors:** • Student recommends ocean energy, solar energy, or satellite image monitoring. It does not matter which is chosen, as long as it is supported with reasoning. • Student explains why in terms of criteria and constraints. For example, "I recommend funding satellite image monitoring because it will likely have a broader impact globally on people to use less of all kinds of resources. This would mean less extraction of resources and less destruction and pollution of habitats. It also does not cost any money up front, just a change in lifestyle, so more people are able to do it."

8th Grade Science Unit 4: Using Engineering and Technology to Sustain Our World
Lift-Off Task: Growing Human Impact

Unit Essential Question: *How are humans harming Earth, plants, and animals and what can we do about it?*

Introduction

Students may recall the picture to the right from a previous science class. In those science classes, they learned that every ecosystem has a carrying capacity. The Earth, as a whole, is no different—despite what we think, it cannot support an infinite number of human beings. At present, human overpopulation is one of the most pressing environmental issues Earth faces. It is the underlying force that is driving global warming, environmental pollution, habitat loss, the extinction of thousands of plants and animals, and the depletion of crucial natural resources. For this unit's project, students will ask themselves: What can we do to help lessen the effects of human overpopulation on our planet? However, before students can pick a solution, they first need to learn more about the problem and what solutions are available to them. In this Lift-Off task, students draw off their prior knowledge to generate questions around the phenomenon of human overpopulation. These questions will guide their learning throughout this unit.



Alignment Table

Because the Lift-Off tasks focus on student-generated questions, we do not identify specific Disciplinary Core Ideas or Science and Engineering Practices in this table.

Crosscutting Concepts (*Depending upon student-generated questions)
- Patterns
  - Graphs and charts can be used to identify patterns in data.
- Cause and Effect
  - Cause and effect relationships may be used to predict phenomena in natural or designed systems.
  - Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.
- Energy and Matter
  - The transfer of energy can be tracked as energy flows through a natural system.
- Structure and Function
  - Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used.
  - Structures can be designed to serve particular functions.

Equity and Groupwork
- Share and listen to broad and diverse student contributions.
- Make connections between each other's ideas
- Work together to co-construct a concept map.

Language
- Use connector words to link ideas.
- Write and discuss questions about the phenomenon.
- Organize key questions in a concept map.

8th Grade Science Unit 4: Using Engineering and Technology to Sustain Our World
Lift-Off Task: Growing Human Impact

Learning Goals

This learning task introduces students to the phenomenon of human overpopulation and begins generating questions that will guide them through the unit. More specifically, the purpose is to:

- Individually generate a list of questions about human overpopulation.
- Make connections between related questions.
- Draft possible answers using prior knowledge.
- Apply prior knowledge of human overpopulation to predict why humans are having more of a negative impact on Earth in recent years.

Content Background for Teachers

Humans rely on Earth's ecosystems for a variety of different services. The Earth provides the production of food, natural filtration of water, regulation of climate, medicinal properties, fuel sources, resources for all our material goods, and more. Unfortunately, not only are there too many humans populating earth, but they are also not using Earth's resources in a way that is sustainable for long periods of time. There are many sources of evidence that indicate that human activities in agriculture, industry, and other modes of consumption have had major impacts on the land, bodies of water, air, and climate.

While human overpopulation is certainly at play, many of these effects also come down to consumption. Humans are harvesting natural resources at an alarming rate—coal, natural gas, wood, and fossil fuels for fuel, electricity, and heating; excess water for industry and residential purposes; plants and animals for food sources, etc. In addition to destroying habitats to harvest resources, humans are also having the same effect by clearing land for urban developments and agriculture. In addition to habitat and resource loss, humans are also degrading habitats through heavy pollution and excess waste from all of these activities. These impacts on Earth don't even include all the effects of climate change, which are a result of humans burning fossil fuels.

While students won't know all this background in detail, most will come to this unit with some prior knowledge around human overpopulation, resource consumption, carrying capacity, and environmental impacts. In this task, students use any prior knowledge they do have to generate questions that will help them make sense of the phenomenon for this unit—human overpopulation.

Aside from generating questions, students will also be creating a concept map, which is a graphical tool that helps to organize and represent knowledge and questions, and is a successful academic language instruction tool. As students learn more about human overpopulation and related concepts, they will add more questions and ideas to this concept map. If your students have not had previous experience making concept maps, please see the instructions in Part B below for strategies on teaching this skill.

Academic Vocabulary

- Ecosystem
- Environment
- Carrying Capacity
- Human Overpopulation
- Resource Consumption
- Impact

*Additional academic vocabulary will vary by class

Time Needed (Based on 45-Minute Periods)

2 Days

- Introduction, Part A and Part B: 1 period
- Part C, Project Organizer and Reflection: 1 period

Materials

- Unit 4, Lift-Off Task Student Version

Part B

- Poster paper and markers
- Post-Its (Optional)

Part C

- Poster Paper and markers
- *See Instructions below for other optional materials to use for the class concept map

Connecting to the Culminating Project

- Culminating Project Handout
- Project Organizer Handout

Instructions

1. Introduce students to the unit by reading or projecting the Unit Essential Question aloud.

2. Read the short paragraph on page 1 of the student guide aloud, which introduces the phenomenon for the unit: human overpopulation.

Part A

1. In this Lift-Off task, students will be generating questions to help them make sense of the phenomenon.

2. Have students complete this section individually in their student guide.
    - For students who need more support, encourage them to use the cartoon to inspire any questions they may have.
    - Here is a list of some potential questions students might generate: "What is human overpopulation? How many humans can our Earth hold? What are the effects of human overpopulation? Is overpopulation the only problem or are there other problems humans are causing? What will happen to Earth if there are too many humans? What can we do to stop this besides just not having more babies? How am I contributing to the problem?"
    - This should be done independently as students will have time in the next section to share ideas.

Part B:

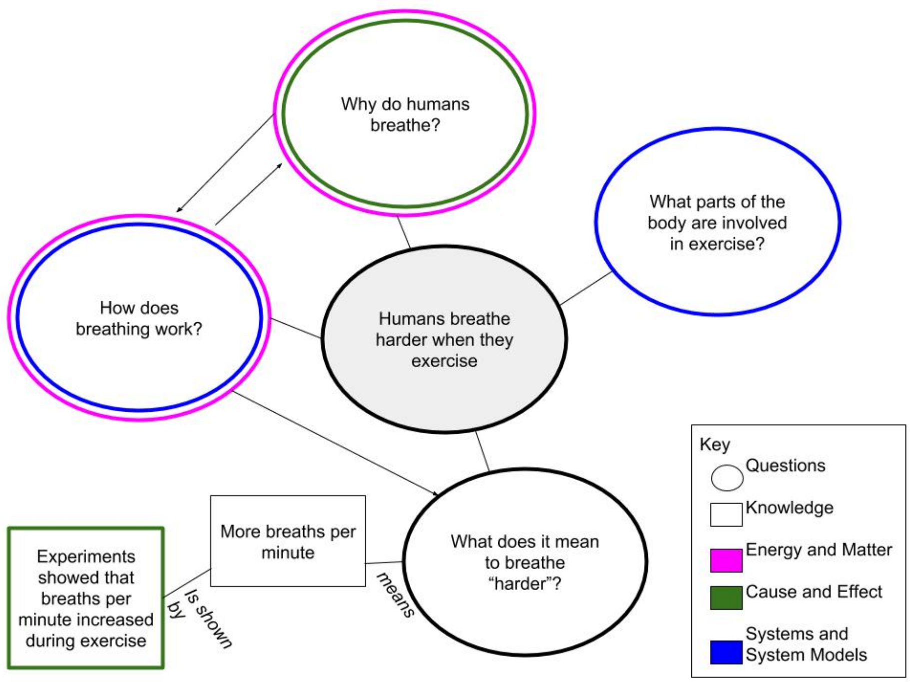
1. In this part of the task, students create a concept map as a group.
    - Remind students to refer to the directions on their student guide to help them make their concept map. First, students should compare each member's list of questions and

record/connect key questions on a piece of poster paper. They will then draft possible answers using prior knowledge.
  - Remind students that there are no right or wrong questions or predictions, so students feel encouraged to contribute any and all questions and ideas that they think of.
  - Because this is a collaborative task, it is recommended that you remind students of group work norms and assign group roles, such as Resource Manager, Facilitator, Recorder, and Harmonizer (See "How to Use this Curriculum" for more details).

2. Students will post their posters on a wall and then walk around and look at each group's ideas. One suggestion for gallery walks is for students to interact with the posters in some way. For example, students are required to initial or leave post-its on three questions that they are also excited about on other posters.

How to Concept Map

For students who have not had a lot of experience making concept maps, we have detailed a strategy below for introducing concept mapping using more familiar content. An example is also provided, but this will vary depending on what your students come up with as you make your own model.



1. Write the phenomenon in the middle of the poster, in this case "Humans breathe harder when they exercise."
2. Ask students to share questions they might ask to make sense of this phenomenon and make a list of these questions on the board.
3. Model the process of reviewing the list and finding similarities amongst the questions.
   - Place these key questions on the concept map poster, modeling how to put similar questions near each other on the poster. Circle these to signify that these are questions, not content knowledge.
4. Ask students to look at the key questions and see if any of the questions are connected: Would answering one question lead to one of the other questions? Model making these connections by drawing arrows

between the circles.

5. In this Lift-Off task, students will only be drafting possible answers to the questions, not actually gathering and recording learned concepts. However, throughout the unit, they will be adding content they have learned. Model this by recording a student's prior knowledge to one of the questions, using boxes to signify that these are pieces of content knowledge rather than questions.
    - Use connector words to identify the relationships between the content boxes (See image above for an example).

6. Optional: To emphasize crosscutting concepts using a concept map, make a key of different colors for the crosscutting concepts emphasized in this unit. Identify questions that clearly show evidence of the different crosscutting concepts and circle them with the corresponding colors. Explain to students how you made that choice by pointing out the language that hints at that crosscutting concept. *Note: not all boxes and circles will necessarily have a crosscutting concept.

Part C

1. Construct a whole-class concept map that begins to help students make sense of the phenomenon of human overpopulation.
    - Start with the phenomenon in the middle.
    - Then ask students to share out the questions that were most common across all the posters in the classroom. As you record questions on the poster, organize them based on connections you see. Draw circles around each question (as you add to the concept map throughout the unit, you'll also be adding concepts learned, which can be written in boxes to distinguish them from the questions).
    - Ask students to identify any connections they see between the questions and record these as lines between the questions.
        - Recommended: Give pairs of students think time to come up with 1-2 connections to add to the class concept map and call on pairs using equity sticks. This encourages more equitable participation in a class-wide activity.
    - The purpose of this concept map is to facilitate generation of student questions, promote language development, and support understanding of the science content throughout the unit. Allowing students to ask their own questions and use their own words to make meaning of the concepts will not only help them make deep connections about science content, but will also help their oral and written language development.
    - This whole class concept map will be revisited at the end of each subunit, asking students questions like: Some facilitating questions to ask students are: What new ideas/concepts do you want to add to the map? What connections do you want to add or change? What is your reason for that addition/revision? What connections can we make between the questions/ideas already on the map? What new questions do you have about the phenomenon?

2. Because this concept map will be added to and revised throughout the unit, here are some practical options for implementation.

- If you have access to white board paper, we encourage you to use these for class posters since it will allow you and your students to make revisions throughout the unit.
- Another option is to use smaller pieces of paper for each class and project using a document camera; this will save space as opposed to doing large class posters.
- We highly recommend students keep their own version of this concept map in their notebooks, adding questions and concepts as they go through the unit.

3. Once the draft concept map is complete, introduce students to the crosscutting concepts for this unit. We recommend posting posters of each crosscutting concept in your classroom (See beginning of teacher guide for templates).
   - The crosscutting concepts for this unit are: Patterns, Cause and Effect, Energy and Matter, and Structure and Function. Assign a color for each crosscutting concept that can be used throughout the unit.
   - Have students analyze the class concept map for as many examples of the crosscutting concepts as they can find. Depending on the questions they have, they may be able to find an example of each of the crosscutting concepts or perhaps just some.
   - We recommend modeling this process by picking a question, identifying the crosscutting concept, and tracing the circle in the corresponding color. Explain the key words that helped you identify the crosscutting concept in this question. Some identifying words that students might look for are:
     - **Patterns**: These could be phrases such as, "is the same as", "has in common with", "is similar to", "shares" etc.
     - **Cause and Effect:** These could be phrases such as, "that results in," "that causes," "that explains why," "is due to," etc.
     - **Energy and Matter:** These could be phrases such as, "is transferred through," "is made by," "is put into," "is added to," "is cycled within," "is taken out by," "is extracted for," "is converted into," "is absorbed by," etc.
     - **Structure and Function**: These could be phrases such as, "its shape affects its function by," "structure causes it to," "functions this way because of," etc.

Connecting to the Culminating Project

1. Hand out the Culminating Project Task Card and read aloud the Challenge and Group Project Criteria for Success as a class.
   - Take questions for clarification.
   - Optional: Show the following clip used in the 7th grade integrated curriculum to provide an additional hook to engage students: https://www.youtube.com/watch?v=WfGMYdalClU.

2. Pass out their Project Organizer and explain that they will complete a section of this after each task in class. Students independently complete the Lift-Off Task section of the Project Organizer in class. Revisions can be done for homework, depending upon student's needs and/or class scheduling.
   - Students have been tasked with presenting a poster at a Resource Conservation Conference that showcases one solution to help monitor or lessen the effects of human overpopulation and excess resource consumption. The student prompt is as follows: Humans are having more of a

negative impact on Earth in recent years. Based on the cartoon and your prior knowledge, why do you think is?

Reflection

1. At the end of the task, ask students to reflect on what they have learned over the course of this task by answering the following three questions in their student guide:
   - At the beginning of this task, you made a list of all the questions you have about human overpopulation. Look back at your list: think about the questions your peers asked that you did not initially write down. How are their questions different from the ones you originally asked?
   - In this unit, we will be focusing on four crosscutting concepts: **Patterns**: by using graphs and charts to identify patterns in data; **Cause and Effect**: by seeing how phenomena may have more than one cause, and using cause-and-effect relationships to predict phenomena; **Energy and Matter**: by observing that the transfer of energy can be tracked as it flows through a system; **Structure and Function**: by noticing how an object's structure can be designed to serve particular functions. Looking at your class concept map, give an example of how one of these crosscutting concepts came up in today's task.
   - Now that you understand what project you'll be working on over the course of this unit, what else do you need to know? What additional questions do you have?

2. There are no right answers, but encourage students to look back at their initial lists and their class concept map. They should not change their initial responses, but rather use this reflection space to add to their questions based on what they have learned through this task. By generating more of their own questions, students continue to engage in sense-making of the phenomenon and the gathering of knowledge and skills for their final project.

8th Grade Science Unit 4: Using Engineering and Technology to Sustain Our World
Task 1: Human Population and Resource Consumption

Unit Essential Question: *How are humans harming Earth, plants, and animals, and what can we do about it?*

Introduction

In the Lift-Off Task, students engaged their prior knowledge of human overpopulation, generating questions that might help them make sense of this phenomenon as they move through this unit. In this task, students explore this phenomenon in more depth by looking not just at evidence that there are impacts, but also why there are these impacts. In doing so, students explore a new scientific tool—carbon footprint—that is used to paint a picture of how many resources individuals and regions are consuming. Throughout this task, students compare per-capita consumption data and consider why global resource consumption has likely increased in recent years. Once they have a clear understanding of the multiple causes, they gather information and construct an argument about the effects on Earth's systems and biodiversity.

Alignment Table

Performance Expectations	Scientific and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
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. [Clarification Statement: Examples of evidence include grade-appropriate databases on human populations and the rates of consumption of food and natural resources (such as freshwater, mineral, and energy). Examples of impacts can include changes to the appearance, composition, and structure of Earth's systems as well as the rates at which they change. The consequences of increases in human populations and consumption of natural resources are described by science, but science does not make the decisions for the actions society takes.]	**Engaging in Argument From Evidence** • Construct an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.	**ESS3.C: Human Impacts on Earth Systems** • Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise.	**Cause and Effect** • Cause and effect relationships may be used to predict phenomena in natural or designed systems. • Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability (*Secondary*)

8th Grade Science Unit 4: Using Engineering and Technology to Sustain Our World

Task 1: Human Population and Resource Consumption

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.	**Asking Questions and Defining Problems** • Define a design problem that can be solved through the development of an object, tool, process or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions.	**ETS1.A: Defining and Delimiting Engineering Problems** • The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions.	N/A
Supplementary Science and Engineering Practices • Using Mathematics and Computational Thinking ○ Apply mathematical concepts and/or processes (such as ratio, rate, percent, basic operations, and simple algebra) to scientific and engineering questions and problems. ○ Use mathematical representations to describe and/or support scientific conclusions and design solutions.			
Supplementary Crosscutting Concepts • Patterns ○ Graphs, charts, and images can be used to identify patterns in data.			
Equity and Groupwork • Come to consensus on how different regions should be shaded according to per-capita emissions • Discuss conclusions about a data set.			
Language • Read an article and organize information into a graphic organizer. • Write an argument. • *Use the "Stronger Clearer" protocol to improve language of argument.			

Learning Goals

This learning task asks students to gather information about human population, resource consumption, and environmental impacts and use the information to construct an argument. More specifically, the purpose is for students to:

- Calculate their own carbon footprint to explore what this measure means.
- Calculate the per-capita emission of carbon dioxide for different regions in the world.
- Create a shaded map to identify patterns in per-capita emissions for different regions.

8th Grade Science Unit 4: Using Engineering and Technology to Sustain Our World
Task 1: Human Population and Resource Consumption

- Obtain information and construct an argument about the causes and effects around resource consumption and impacts to Earth's systems.
- Apply knowledge of resource consumption to define the problem at hand, including criteria and constraints.

Content Background for Teachers

This task introduces students to a lot of new vocabulary and asks them to make a chain of connections using cause-and-effect reasoning. These vocabulary terms and connections will be outlined in this section so you can more easily facilitate this same type of reasoning for students as they work through this task.

https://www.theecoambassador.com/WhatisaCarbonFootprint.html

While human population has been growing steadily over time, this rate has greatly increased in the last two centuries. The first period of dramatic growth came with the industrial revolution during the 18th century because of increased food production, advances in medicine, and better sanitation. Another dramatic increase began around 1950 with the Green Revolution, as industrial farming practices were able to greatly increase food production. While access to medicine, better sanitation, and more food are in themselves good things, it has led to an unsustainable rate in global population growth. This is leading us towards a phenomenon scientists call overpopulation, in which the ecological footprint of the human population exceeds the carrying capacity of Earth.

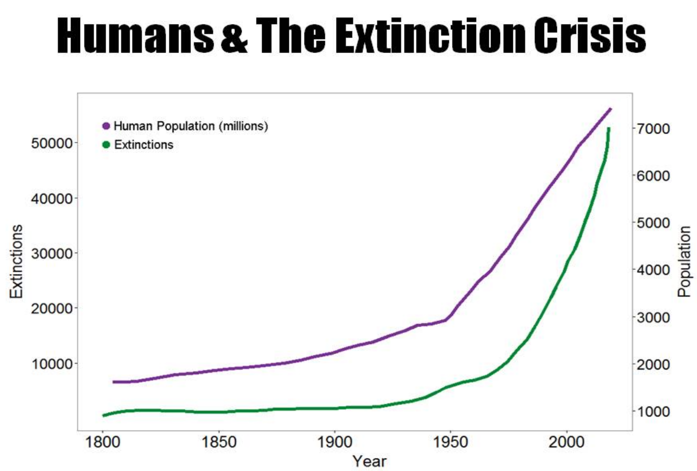
In order to satisfy the growing number of human beings, more and more of Earth's resources are being used. When we talk about natural resources, we are referring to things like wood, natural gas, oil, coal, minerals, freshwater, plants and animals, nutrient-rich soil, and more. This excess consumption of natural resources is not just related to population, however; it also has to do with the fact that in our culture of consumption, many humans are consuming even more than in previous decades.

In this task, students are introduced to one measure scientists use to deduce and compare rates of natural resource consumption—carbon footprint. Carbon footprint refers to the amount of carbon dioxide emitted due to the consumption of fossil fuels through various activities by a particular person or group of people. While this obviously greatly varies by people, students will also find in this task that the average per-capita consumption can also vary by region.

The problem with excess resource consumption is two-fold. From a human-centric perspective, this is problematic because these resources are being depleted faster than nature can replenish them, so they will not be available for people in the near future. From an eco-centric perspective, this is problematic for the degradation to the environment and the effect this has on plants and animals right now.

8th Grade Science Unit 4: Using Engineering and Technology to Sustain Our World
Task 1: Human Population and Resource Consumption

In this task, students are focusing on the effects to natural systems. Increasing human population and excess per-capita consumption is the driving force behind all kinds of negative environmental impacts. Overall, the extraction of resources as well as the resulting climate change is leading to destruction and degradation of key habitats. By harming the environments themselves, we are also putting countless species at risk for extinction, if they have not gone extinct already. For more information, read the Task 1 Article provided with this task.



Data source: Scott, J.M. 2008. *Threats to Biological Diversity: Global, Continental, Local.* U.S. Geological Survey, Idaho Cooperative Fish and Wildlife, Research Unit, University Of Idaho.

Academic Vocabulary

- Human Consumption
- Natural Resource
- Fossil Fuel
- Carbon Footprint
- Per-Capita
- Carbon Dioxide Emissions
- Consume

Time Needed (Based on 45-Minute Periods)

4-5 Days

- Engage and Explore: 1 period
- Explain: 1 period
- Elaborate: 1-2 periods
- Evaluate and Reflection: 1 period

Materials

- Unit 4, Task 1 Student Version

Engage

- Computers or tablets

Explore

- Calculators (Optional)

Explain

- Colored pencils

Elaborate

- Copies of Task 1 article (class set in sheet protectors or PDFs on tablets/computers)

Evaluate

- Project Organizer Handout

8th Grade Science Unit 4: Using Engineering and Technology to Sustain Our World
Task 1: Human Population and Resource Consumption

Instructions

Engage

1. Introduce to Task 1: In the Lift-Off task, you generated questions about human overpopulation and made a hypothesis of why this might be happening more and more in recent years. Think about what you were still wondering about at the end of the last task (look back if you need to). What questions do you still have?
    - Before you pass out their student guide, give students time to reflect individually or with a partner about the questions they recorded at the end of the last task. Share a few of these out as a class, using facilitating questions to guide students toward questions that relate to this task.

2. Transition to Task 1: Today, you will dig into the question of how and why humans are having such a negative effect on Earth.
    - Now pass out their Task 1 student guide. We recommend reading the introductory material on the student guide. This introductory material introduces them to the term, **carbon footprint**, and explains why it is a useful tool in comparing resource consumption patterns in different people and groups.

3. Students then calculate their own carbon footprint, using the Trees for Life Kids Carbon Calculator" (link provided on student guide, if needed).
    - If students do not have access to computers or tablets, we recommend going through the calculator on your own computer and projecting it so students can see what measures are used. It may also be helpful to run through it twice with two different scenarios—for example, someone who drives a car to commute far to school and takes lots of vacations by plane vs. someone who rides their bike to school and takes lots of vacations by car within the state. This way students can compare the different carbon emissions between scenarios.

4. Optional: Conduct a class-wide discussion to share insights.
    - Some facilitating questions you may want to ask students:
        - How did your carbon footprint compare to the average adult? Why do you think yours was less (or greater)?
        - What activity added the most to your carbon footprint?
        - What could you do to reduce your carbon footprint?
        - Did any of the questions surprise you?
        - Did anything surprise you in your results?
    - The use of equity sticks is encouraged for more equitable participation in class-wide discussions (See "How To Use This Curriculum" for more details).

Explore

1. Now that students have a personal understanding of what a carbon footprint is and what it means to consume resources, they can start to create a bigger picture of how resource consumption compares on a global scale.
    - As you transition to this section of the task, take time to explicitly introduce the new vocabulary word, **per-capita**, as it will be used again and again throughout this task.

2. Assign roles to each group. You may use whatever roles you prefer. We recommend the use of the Materials Manager, Facilitator, Reporter, Harmonizer.
   - Ask Facilitator to read the directions and to make sure everyone understands the task.
   - Ask the Materials Manager to handle any resources needed to complete the task (calculator optional).
   - Ask the Harmonizer to make sure that everyone contributes their ideas and that everyone's voice is heard.
   - Ask the Recorder to make sure the group is recording their calculations in their student guides.

3. In this activity, students are given data about the populations of different regions in 2012 as well as their corresponding amounts of carbon dioxide emissions. From this data, they must calculate the average per-capita emission of carbon dioxide for each region. This gives students practice at the supplementary SEP of **Using Mathematics and Computational Thinking;** later in this task, they will be able to apply this per-capita rate to a scientific question.
   - We recommend modeling the math process using the first row, Africa, in their data table.
   - We also recommend providing calculators, but the math can also be done on paper without calculators.

4. Optional: Have groups swap data tables and compare the math to make sure they have the same calculations.

Explain

1. Now that students have the calculated data, they need to make comparisons and draw conclusions. This process of shading a world map gives them an image to use to identify **Patterns** in the data, a supplementary crosscutting concept for this task.

2. Here students will shade a key to create a gradient of color that represents low to high rates of consumption (ie. carbon dioxide emissions). Then they will come to consensus on what region should be assigned each color gradient before they begin to shade their own maps.
   - You may want to show them what a gradient is, using an unrelated map.
   - You may also want to show students a map that indicates where each of the regions are or write the name of the regions directly on their map for them.

3. When students are just looking at the original data, it is clear that for the most part human population size is what correlates with amount of carbon dioxide emitted. By shading on a map, however, they will come to notice that this is not always the case. This example helps to emphasize the crosscutting concept of **Cause and Effect** as students realize that phenomena may have more than one cause. To help them analyze the data and map for these patterns and draw conclusions, they will discuss and answer the questions in their student guide with their group. Sample responses are provided below:
   - 1 and 1a: North America has the largest per-capita emissions at 17 tons, likely due to their culture of consumption. Europe is also high up between 8 and 9 tons, likely for similar reasons and burning of fossil fuels. Interestingly, the Middle East also has a high amount of emissions for its size, perhaps for similar reasons or because there are so many fossil fuels available there.

- 2 and 2a: In general, the more people in a region, the greater amount of carbon dioxide emitted. This is the case in Asia, for example. This means that since our global population is increasing, so will carbon dioxide emissions and natural resource consumption.
    - This question directly addresses the crosscutting concept of **Cause and Effect**, as students use the relationship between population and carbon emissions to predict how an increase in population will affect carbon emissions and resource consumption.
- 3: I think that per-capita emissions have increased. This is because the culture of consumption has gotten even worse due to the obsession with material goods.

Elaborate

1. At this point in the task, students understand that human consumption of natural resources is a problem that is exacerbated by an increasing human population. This section of the task allows students to collect concrete evidence of the effects of this on Earth and its biodiversity.

2. Distribute the article provided with this task to students. To save resources, you may wish to create a class set and put them in sheet protectors or distribute to students digitally if tablets or computers are available. Students read the article and organize the information they learn using the table in their student guides. This helps students focus on the crosscutting concept of **Cause and Effect**, as it relates to the effects of human activities on natural systems. Sample responses to the information chart is provided below:

Cause: What are humans doing and why?	**Effect**: What is the effect on natural systems?
Extracting natural resources to use for daily activities	This destroys or pollutes ecosystems.
Cutting down rainforest trees for timber and land	This completely removes habitats.
Doing activities that emit carbon dioxide, like driving cars or using electricity.	Ocean temperature and global temperature gets warmer which kills coral reefs and melts Arctic ice.
Destroying habitats through climate change, pollution, extraction of resources, overfishing, etc.	Habitats are lost or degraded, resulting in 1/3 of species threatened with extinction.

3. Using this information as well as the data in the Explore, students then construct an argument to support or refute a mock news story claim that human overpopulation is the only thing having an impact on Earth and the impact is minor. By refuting a false claim, students will be engaging in more complex sense-making related to the phenomenon of human overpopulation.
    - This activity requires students to practice **Engaging in Argument From Evidence**, by using both evidence and scientific reasoning to refute this claim. Students are also using the crosscutting concept of **Cause and Effect** as they argue that this impact to Earth has more than one cause, in

this case human overpopulation and increase in per-capita resource consumption. To support their argument with evidence, students will not only use evidence from the article, but also the mathematical representations they calculated (per-capita emission data), thus giving them more practice at **Using Mathematics and Computational Thinking.**

- Optional Sentence Stems to Provide:

Original Claim (The News Story)	The news story says…
Your Claim	However, evidence shows that…
Evidence and Cause-And-Effect Reasoning	In the data, I observed that… This made me hypothesize that… In general, I noticed that the greater the population size,… However, in the data, I also saw that… This means that… In the article, I learned that This leads to…, which is…. For example…. This causes… In conclusion…

- Sample Argument

Original Claim (The News Story)	The news story says that human overpopulation is the only thing having an impact on Earth and the impact is minor.
Your Claim	However, evidence shows that it is not just human overpopulation, but also excess per-capita consumption of natural resources that is impacting Earth, and these effects are very damaging to Earth's systems.
Evidence and Cause-And-Effect Reasoning	In general, the data showed that the larger the population was, the greater the carbon emissions, which supports the news story's claim. Since this data was collected in 2012, human population has increased by 0.5 billion people, so that means even more natural resources are likely being consumed. However, In the data, I also saw that per-capita emissions varied by region and some were extremely high. I hypothesize that this is because the countries with the higher emissions are engaging in more damaging activities, like using lots of fossil fuels for industry, using more energy in homes, and buying more things. In the article, I learned that with more humans consuming more natural resources, there is more extraction of these natural resources. This leads to more habitat loss or degradation of ecosystems, which is threatening many species with extinction. For example, we are cutting down rainforests for timber and land to accommodate an increasing population, but this destroys habitats and thus the animals and plants with it. In conclusion, it is both human overpopulation and excess per-capita resource consumption that is causing very negative effects like habitat loss and species extinction on Earth.

4. Optional: You may want to use the academic language tool introduced in Unit 1—"Stronger and Clearer"—to help students strengthen and clarify language and ideas in their argument. As they talk to peers, they can build from others' ideas and borrow language from their partners.
    - This activity can be set up in different ways, but we recommend having students form two concentric circles, so that partners are facing each other.
    - A potential guide for students is provided in the box below. As in Unit 1, walk students through the process using the instructions provided on the guide below.
    - This revised argument is a great option for formative assessment. Collect student work to identify trends in students' ability to accurately identify more than one cause for the phenomenon (**Cause and Effect).** See "How to Use This Curriculum" for strategies on utilizing formative assessment data to provide feedback to students and inform classroom instruction.

Stronger and Clearer: The following activity is to help you and your peers strengthen and clarify the argument you wrote. Each time you talk to a new partner, you can build from their ideas and borrow the language of previous partners.

Instructions:
1. Record ideas and language you liked from your own argument in the chart below to help you think about what you will say to your partner (1 minute)
2. Stand in front of your assigned partner. Turn your papers upside down, so that you are not looking at it while speaking. Take turns sharing your argument aloud (1 minute per person).
    a. After each partner shares, the listener may ask clarifying questions. Have a discussion about strengths and suggestions (1 minute per person).
3. You will then have time to record any ideas or language that will make your argument stronger and clearer (1 minute).
4. When your teacher calls time, each of you in the inner circle will move one space to the right, so you have a new partner. Repeat Steps 2 and 3.

	Ideas and Language I like from the argument
Me	
Partner 1	
Partner 2	

Use the space below to write a revised version of your argument, borrowing from the ideas and language of your peers. Remember that while it is encouraged to learn from others, it is not okay to copy directly!

5. Return to the whole-class concept map from the Lift-Off Task.
    - In small groups, have students brainstorm new concepts and new connections that they have learned in this task, as well as any new questions that have come up for them. Then have groups share these aloud in a class-wide discussion and add to the class concept map. The use of equity sticks is encouraged for more equitable participation in class-wide discussions (See "How To Use This Curriculum" for more details).
        - Some facilitating questions to ask students are: What new ideas/concepts do you want to add to the map? What connections do you want to add or change? What is your reason for that addition/revision? What connections can we make between the questions/ideas already on the map? What new questions do you have about the phenomenon?
        - Draw circles around each question and boxes around each concept.
        - Write connector words to describe connections between the concept boxes.
        - For this task, students may begin to connect some of their previous question circles to concept boxes about the following: the relationship between human overpopulation and resource consumption, variations in per-capita resource consumption, and specific impacts on Earth systems (such as habitat degradation, habitat loss, and species extinction).
    - Have students analyze the additions to the class concept map for as many examples of this task's crosscutting concepts as they can find. Once a student has identified the crosscutting concept, you can trace the circle in the corresponding color (decided on in the Lift-Off task). We recommend asking students to share key words that helped them identify the crosscutting concept for that concept or question. Some identifying words students might look for are:
        - **Patterns**: These could be phrases such as, "is the same as", "has in common with", "is similar to", "shares" etc.
        - **Cause and Effect:** These could be phrases such as, "which results in," "which causes," "that explains why," "is due to," etc.
    - Once again, the purpose of this concept map is to facilitate generation of student questions, promote language development, and support understanding of the science content throughout the unit. Allowing students to ask their own questions and use their own words to make meaning of the concepts will not only help them make deep connections about science content, but will also help their oral and written language development.

Evaluate: Connecting to the Culminating Project

1. Students independently complete the Task 1 section of the Project Organizer in class. Revisions can be done for homework, depending upon student's needs and/or class scheduling.

2. Students have been tasked with presenting a poster at a Resource Conservation Conference that showcases one solution to help monitor or lessen the effects of human overpopulation and excess resource consumption. Their prompt is as follows: **Defining Problems:** Now that you have a better idea of the problem we are facing, answer the following questions:
   - Diagram the problem as a cause-and-effect flowchart.
   - What are the criteria of success in solving this problem?
   - What are the constraints in solving this problem?
   - Look at the flowchart you created: Where do you think is the most feasible place for humans to intervene in this process?

3. In completing this section of the Project Organizer, students begin to engage with one of the Engineering and Design Performance Expectations of this unit, MS-ETS1-1. Here they define the design problem by drawing it out as a flowchart and then identifying multiple criteria and constraints, using both scientific principles as well as their own experiential knowledge.

Reflection

1. At the end of the task, ask students to reflect on what they have learned over the course of this task by answering the following three questions in their student guide:
   - At the beginning of this task, you were asked to calculate your own carbon footprint. After learning what you have today, what kinds of impacts do you think your carbon footprint is having on Earth?
   - In this task, we focused on two crosscutting concepts: **Cause and Effect**: by seeing how phenomena may have more than one cause, and using cause-and-effect relationships to predict phenomena and **Patterns**: by using graphs and charts to identify patterns in data. Where did you see examples of **Cause and Effect** or **Patterns** in this task?
   - Now that you have learned more about human overpopulation, what questions do you still have?

2. There are no right answers, but encourage students to look back at their Engage and their class concept map. They should not change their initial responses, but rather use this reflection space to add their ideas and questions based on what they have learned throughout this task. By generating more of their own questions, students continue to engage in sense-making of the phenomenon and the gathering of knowledge and skills for their final project.

Assessment

1. You may collect the Project Organizer and assess using:
    - *Criteria of your choice.* We recommend using the Alignment Table at the beginning of this document to inform your criteria.
    - This can be a formative tool to periodically look for trends in student understanding after the completion of a task. You can then use this formative data to inform any re-teaching, as necessary.

2. You may also give students time to make revisions with one of the two options:
    - Students may make changes to their Project Organizer according to your comments OR
    - Ask students to exchange Project Organizers with a partner and give partners 5 minutes to give written feedback. Then allow students time to make changes to their work according to the feedback.

Effects of Overpopulation and Resource Consumption

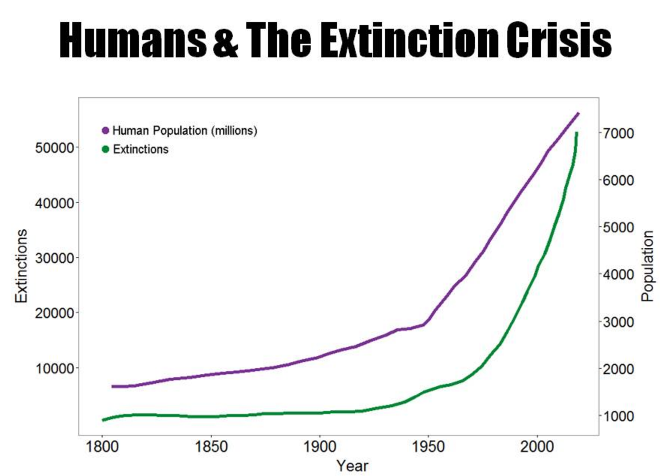
(Adapted from "Effects of Human Overpopulation" Article on *everythingconnects.org*)

Human overpopulation is among the most pressing environmental issues, silently aggravating the forces behind global warming, environmental pollution, habitat loss, the sixth mass extinction, intensive farming practices, and the consumption of finite natural resources, such as freshwater, farmable land and fossil fuels, at speeds faster than their rate of regeneration.

Depletion of Natural Resources – Humans rely on many natural resources to survive, such as fossil fuels (oil, coal, natural gas), freshwater, minerals (iron, copper, gold), nutrient-rich soil, and plants and animals. Unfortunately, humans are using up these resources at a much faster rate than they can be replenished by nature. By doing so, humans are not only hurting themselves as they run out of resources, they are also harming natural systems. The way humans remove these resources either pollutes the ecosystems or destroys them entirely. The following sections will reveal more specific effects of these human activities.

Habitat Loss – Human overpopulation is a major driving force behind the loss of ecosystems, such as rainforests, coral reefs, wetlands, and Arctic Ice. Rainforests, for example, once covered 14%of the Earth's land surface and now cover a bare 6%. As human population increases, there is a greater demand for timber (wood from trees) and land to grow food and build houses for more people. More human beings also means more carbon emissions. Increased carbon dioxide emissions are making oceans warmer and more acidic, which is killing the coral reefs. These same carbon dioxide emissions are also making the global temperature warmer, which is melting Arctic Ice, thus removing another key habitat on Earth.

Species Extinction: As habitats are lost, so are the plants and animals that once lived there. Humans are currently causing the greatest mass extinction of species since the extinction of the dinosaurs 65 million years ago. The 2012 IUCN Red List of Threatened Species showed that nearly a third of the total species examined are threatened with extinction. This is a result of the habitat loss and degradation described above. Climate change, pollution, acidification of oceans (from carbon dioxide emissions), extraction of natural resources (like fossil fuels and timber), overfishing, and hunting are all human factors driving this process. Look at the graph to the right: How is human population related to species extinctions?



Data source: Scott, J.M. 2008. *Threats to Biological Diversity: Global, Continental, Local.* U.S. Geological Survey, Idaho Cooperative Fish and Wildlife, Research Unit, University Of Idaho.

8th Grade Science Unit 4: Using Engineering and Technology to Sustain Our World

Task 2: Effects of Environmental Change on Biodiversity

Unit Essential Question: *How are humans harming Earth, plants, and animals, and what can we do about it?*

Introduction

So far, students have begun to define the problem at hand—human activities lead to massive resource extraction and consumption, which are having a negative impact on Earth systems. In the last task, students explored general concepts of how changes to the environment are affecting species and putting them at risk of extinction. In this task, students dig more deeply into this part of the problem. Using what they learned in Unit 3 about natural selection, they examine how this is guided by the familiar mechanism of natural selection. For each example of an organism affected by human activity, students learn to explain what is happening in terms of natural selection. By digging into a process involved in this chain of effects created by overpopulation, students are continuing to make sense of the phenomenon for this unit. By the end of this task, they will be able to make the problem they defined after Task 1 even more specific, outlining the role that natural selection plays in the resource consumption problem they are facing in their project.

Alignment Table

Performance Expectations	Scientific and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
MS-LS4-4. Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment. [Clarification Statement: Emphasis is on using simple probability statements and proportional reasoning to construct explanations.]	**Constructing Explanations** • Construct an explanation that includes qualitative or quantitative relationships between variables that describe phenomena.	**LS4.B: Natural Selection** • Natural selection leads to the predominance of certain traits in a population, and the suppression of others.	**Cause and Effect** • Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability. • Cause and effect relationships may be used to predict phenomena in natural or designed systems *(Secondary)*.
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.	**Asking Questions and Defining Problems** • Define a design problem that can be solved through the development of an object, tool, process or system and includes multiple criteria and constraints, including	**ETS1.A: Defining and Delimiting Engineering Problems** • The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful.	N/A

	scientific knowledge that may limit possible solutions.	Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions.	

Equity and Groupwork

- Discuss information using guiding questions.

Language

- Discuss and come to consensus on a definition for natural selection.
- Read scientific text and watch videos to gather information.
- Write an explanation.

Learning Goals

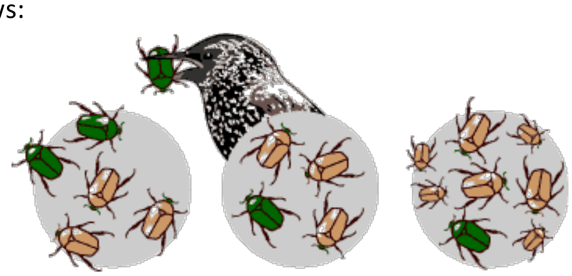
This learning task explores examples of organisms affected by human-caused environmental changes and asks students to explain this in terms of natural selection. More specifically, the purpose is to:

- Use prior knowledge of natural selection to make a prediction about how resource consumption might affect biodiversity (different plants and animals) on Earth.
- Gather evidence of organisms affected by human actions.
- Write a paragraph explaining how human-caused changes to environments are affecting organisms, using evidence and the concept of natural selection.
- Apply knowledge of past and present extinctions to predict future impacts.
- Apply knowledge of natural selection to better define the problem at hand.

Content Background for Teachers

As stated in the introduction, this task takes the context of the problem and digs into the mechanism behind how humans are affecting plants and animals, especially since it is often indirectly. This can be explained through the process of natural selection, a concept that students should be familiar with from last unit. To provide a quick review of natural selection, natural selection is the process whereby organisms better adapted to their environment tend to survive and produce more offspring, leading to a population with more of that trait. Charles Darwin's four principles of natural selection are as follows:

1. There is variation in traits. New variations happen all the time due to mutation and recombination of genes.
2. There is differential reproduction. Populations tend to overproduce, and the environment cannot support unlimited population growth. This means that not all individuals will survive and reproduce.
3. There is heredity. Those with the traits suited to that specific environment will survive and reproduce, passing on their genes. And vice versa.


evolution.berkeley.edu

4. Populations change over time. Over time, there will be more organisms with the best-suited trait to that environment in a population.

Because natural selection completely depends on the core tenet of environment, it makes sense that if humans are changing the environment, then traits will also be affected through natural selection. Let's look at it through Darwin's four principles above. In every population, there is a variation in traits. Because of carrying capacity, not all individuals in a population will survive and reproduce. If the environment changes (for example, snow to dirt surroundings), then the traits that are best suited to their environment also change (ex: white fur vs. brown fur). Those organisms with the new best-suited trait (ex: brown fur) survive to reproduce and create more offspring with that trait. Over time, there will be more organisms with the best-suited trait to the new environment in the population (ex: population with more brown fur organisms).

The steps in this process of natural selection can thus be used to explain most of the examples provided to students in the Explore of this task. This helps us understand why human overpopulation and excess consumption of natural resources is also affecting plants and animals, not just the Earth itself. Thus, students are able to form a more complete and complex picture of this link in the chain of cause-and-effect reasoning that they have been developing so far this unit.

This mechanism, however, relies on the fact that there are indeed trait variations in a population of organisms that are best suited to these new environments humans are creating. If these variations do not exist, then plants and animals cannot survive and reproduce, ultimately leading to the extinction of that species. Because of the rate at which environments are changing or being destroyed entirely by humans, this will be the fate of many organisms across our planet. In this task, students are given multiple examples of such organisms, so they begin to understand that while adaptation is an important natural process, it is often not possible. This creates an even greater motivation to address the problem set forth in this unit.

Academic Vocabulary

- Natural Selection
- Biodiversity
- Habitat Loss
- Poaching
- Habitat Degradation
- Climate Change
- Extinction

Time Needed (Based on 45-Minute Periods)

5 Days

- Engage: 0.5 period
- Explore: 2 periods
- Explain: 1 period
- Elaborate: 0.5 period
- Evaluate and Reflection: 1 period

8th Grade Science Unit 4: Using Engineering and Technology to Sustain Our World

Task 2: Effects of Environmental Change on Biodiversity

Materials

- Unit 4, Task 2 Student Version

Explore

- Station Cards, laminated or in sheet protectors (2 Per Station)
- Video capabilities for Station 2 and Station 6 (ie. tablets or computers)

Elaborate

- Projector and Speaker (for video)

Evaluate

- Project Organizer Handout

Instructions

Engage

1. Introduce to Task 2: In the Lift-Off task, you looked at your own carbon footprint, as well as the carbon footprints of many different regions of the world. In doing so, you learned that human beings are consuming way too many natural resources and it is only getting worse as global population grows! Think about what you were still wondering about at the end of the last task (look back if you need to). What questions do you still have?
    - Before you pass out their student guide, give students time to reflect individually or with a partner about the questions they recorded at the end of the last task. Share a few of these out as a class, using facilitating questions to guide students toward questions that relate to this task.

2. Transition to Task 2: You've collected evidence that humans are changing many environments around the world, but how does environmental change affect plants and animals? Today you will revisit a familiar concept from Unit 3 to think about how humans consuming natural resources is not just affecting environments, but also the plants and animals living in those environments. Before we explore this in depth, let's see what you already know.
    - Now pass out their Task 2 student guide.

3. In pairs, have students discuss the term *natural selection*, using prior knowledge from Unit 3.
    - If students are having difficulty remembering what natural selection means, you may want to project a picture from last unit or another picture you like that shows the process of natural selection. This should help jog their memory.
    - Once students have discussed the term and agree on what natural selection is, ask them to write down a definition or draw a flowchart of the process, whichever makes more sense to them. Then have them describe an example from Unit 3.
        i. Sample student response: "Organisms have variation in traits > some traits are better suited for that environment > the ones with the best suited traits survive and reproduce, while the others might die before reproducing > this leads to more organisms with that best suited trait in the population over time. One example of this is the rabbits whose environment changed from snow to dirt, so eventually there were more brown rabbits because they could camouflage better."

4. We highly recommend sharing out definitions/flowcharts and coming to consensus on a definition for natural selection as a class, which can be posted on the board or a poster for the remainder of this task. This serves as the core concept for the rest of this task, so it is important all students are on the same page.
   - The use of equity sticks is encouraged for more equitable participation (See "How To Use This Curriculum" for more details).

5. Question #2 connects students' prior knowledge to the task at hand, asking them to make a prediction about how resource consumption might affect biodiversity on Earth.
   - Students will likely use information from the previous task to make their prediction (ie. resource consumption is causing species extinctions), but encourage students to consider other possible effects and how natural selection might be at play in other effects. This emphasizes the crosscutting concept of **Cause and Effect,** as students use cause-and-effect relationships they already know to predict phenomena, in this case the effect on biodiversity.

Explore

1. In Unit 3, students have already seen an example of natural selection at work due to a human-caused environmental change. In this Explore, students learn that this is just one of many examples in which human consumption of natural resources is affecting plants and animals around the world.
   - In groups, students visit 6 research stations to learn more about these examples.

2. Set up 6 stations around the room with the station cards associated with this task. We recommend putting at least two copies of the station card at each station, laminated or in sheet protectors. Another option is to set up tablets or computers at each station depicting a PDF of that station card. For Stations 2 and 6, students do need computers (headphones optional) to watch short videos.
   - Optional: To spread students out at more stations, you can set up duplicates of each station.

3. Assign roles to each group. You may use whatever roles you prefer. We recommend the use of the Materials Manager, Facilitator, Reporter, Harmonizer.
   - Ask Facilitator to read the directions and to make sure everyone understands the task, as well as facilitate the discussion using the guiding questions.
   - Ask the Materials Manager to be responsible for the materials needed to complete the task, by reading information from the station cards aloud.
   - Ask the Harmonizer to make sure that everyone contributes their ideas and that everyone's voice is heard.
   - Ask the Recorder to make sure everyone is recording their data.

4. In groups, students visit the stations around the room, analyzing different examples through pictures, text, and videos and recording information in the chart on their student guides. We recommend you encourage them to use the guiding questions on the station cards. This will help them to interpret the information through the lens of natural selection.
   - The content of this performance expectation and the information in the station cards heavily emphasizes the crosscutting of **Cause and Effect**, as students explore various ways humans are negatively affecting organisms. By exploring multiple examples, students specifically engage with

the aspect of this CCC that asks students to notice how phenomena may have more than one cause. For example, species extinctions can happen because of deforestation for agriculture, habitat degradation due to pollution, hunting, climate change, etc.

- A sample chart is shown below:

Station	Use **Cause and Effect** to describe how humans are negatively affecting the organism(s)	Explain the why using your knowledge of **natural selection**.
1: Effect of Habitat Loss on Forest Species	*Humans are removing forest in Sumatra and Borneo for timber and to clear space for plantations of palm oil. This is removing the habitat for many organisms, like the orangutan, elephant, and tiger.*	*When humans change or remove the habitat, those with traits that are best suited to the new environment survive. However, for many species there are no trait variations that help some survive, so the whole species can go extinct.*
2: Effect of Hunting On Elephants	*Humans were hunting elephants with tusks for their ivory, which was killing all the elephants with tusks.*	*Because humans wanted the tusks for ivory, those with tusks did not survive long enough to reproduce. Tuskless elephants then had the best suited trait, so they survived to reproduce and there are now more tuskless elephants in the population.*
3.Effect of Habitat Degradation on Hudson River Fish	*Humans use electricity and the company that made electricity in the mid-1900s put lots of pollution into the Hudson River, killing or deforming many fish, while the tomcod with the right genetic variation survived.*	*Some tomcod fish had a genetic variation that made it difficult for the toxic chemical to attach to the fish's proteins, creating a sort of shield. These fish survived in the toxic river to reproduce and pass on more of that gene. The other fish died because of the toxic chemicals, so now most tomcod fish have this genetic variation.*
4: Effect of Habitat Change on Kit Fox	*Humans are growing in population and converting lots of San Joaquin Valley's grasslands into farmland and housing, and using lots of Rodenticides. This is destroying the kit fox's habitat and killing all its prey.*	*When humans destroy or change the habitat so much (ie. killing most of the prey), the kit foxes with traits that are best suited to the new environment survive, and the others die out. However, in this case, kit foxes do not seem to have any trait variations that will help them survive this, so if it continues, they may go extinct.*
5: Effect of Climate Change on The California Pika	*Humans are burning fossil fuels, which releases carbon dioxide and increases temperature. This makes it so that pika must stay underground to avoid overheating and can't forage for food, so they may die. Many pika are moving to higher elevations if they can.*	*Because of the warming temperatures, if there are pika with lower metabolic rates and thinner fur, they would survive longer to reproduce because they could be out foraging for food. The ones with thicker fur would die. Thus, there would be more pika with thinner fur in future populations. However, if this trait doesn't exist, then pika*

		will likely go extinct over time.
6: Effect of Climate Change on Many Organisms	*Humans are burning fossil fuels, which releases carbon dioxide and increases temperature. This is affecting the environments of many different plants and animals, which is leading to changes in traits in all of the example organisms.*	*One example is the Tawny Owl. There is a brown and white color variation in these owls. Because warmer temperatures are melting the snow, the brown owls are less visible by prey, so they get more food, survive, and reproduce to make more brown owls. This makes brown the more common trait now.*

Explain

1. Using the evidence they have collected in the stations, students will now individually write a paragraph to answer the following question: What is the relationship between human-caused changes to the environment and populations of organisms in those environments? Students should write a claim supported with evidence from the stations and scientific reasoning related to natural selection.
   - This asks students to use the science and engineering practice of **Constructing Explanations**, as they explain the qualitative relationship between environments and populations of organisms.
   - Optional scaffold: Model the process by collectively constructing a claim together as a class and identify one example of evidence that can be used to back up that claim.
   - Optional Sentence Stems to Provide:

When ___ changes, ___ changes because of…. Natural selection is… Thus, it mades sense that… For example, in station __... When ___, this resulted in… This led to a population of organisms with a lot of the trait of… Another example is… Because the environment change to ___, this led to… If there isn't a trait variation in the population that works in the new environment, this means that… This is likely the case for…

   - Sample Paragraph

Human-caused changes to an environment can greatly alter the traits in a population of organisms because of a process called natural selection. Natural selection is the process whereby organisms better adapted to their environment tend to survive and produce more offspring with that trait. Thus, it makes sense that if humans change the environment, then the traits in populations or organisms may also change over time. For example, in Station 3, I learned about a fish called the tomcod. When humans polluted the Hudson River with toxic chemicals, most fish died, except for tomcod fish with a genetic variation that made them immune to the chemicals. This means that this part of the river now has a population of tomcod fish that mostly all have this genetic variation. Another example is the Tawny Owl. There is a brown and white color variation in these owls. Because human-caused warmer temperatures

are melting the snow, the brown owls are less visible by prey, so they get more food, survive, and reproduce to make more brown owls. This makes brown the more common trait now, instead of white. If there isn't a trait variation in the population that works with the new environment, then the organisms might die out altogether. This is the likely case for the California pika, the kit fox, and the animals in the Borneo forest.

2. Optional peer review: Have table partners switch paragraphs and make suggestions for revisions.
   - This can be used as a formative assessment. Collect student work to identify trends in students' ability to accurately explain how natural selection leads to the predominance of certain traits in a population. See "How to Use This Curriculum" for strategies on utilizing formative assessment data to provide feedback to students and inform classroom instruction.

Elaborate

1. In the stations, students observed some clear examples of natural selection leading to new adaptations in our recent changing environments. They also saw examples in which the environment may be changing too much for many organisms to adapt. This Elaborate takes what they learned in the Explore and focuses on this second aspect: What happens when organisms can't adapt quickly enough?
   - First, have students make their own prediction to this question based on their understanding of the relationship between environment and populations. While all the questions in this segment heavily focus on the crosscutting concept of **Cause and Effect** in general as students look at reasons why animals and plants go extinct, this first question allows students to specifically use cause and effect relationships to predict this phenomenon of extinction.

2. As a class, project the following video: https://www.youtube.com/watch?v=2mlT0HeVLv4
   - In pairs, have students discuss the video and answer the questions in their student guide.
   - Sample student responses:
     - 1: When organisms can't adapt quickly enough to environmental changes, they go extinct. For example, the Wooly Mammoth died out because it did not have traits suited for the warmer climate and the competition for food supply.
     - 2: The three major human-driven causes for animals going extinct named were hunting, habitat destruction for land use, and pollution. Another one we could add from the station card on the kit fox is use of rodenticides to kill an animal's food source. We could also add burning fossil fuels, which increases global temperature, from the last two stations.
     - 3: Because environments are changing so quickly, it is likely that many plants and animals will go extinct in the future.

3. Optional: Share out a few responses to the questions class-wide. Again, the use of equity sticks is encouraged.

4. Return to the whole-class concept map from the Lift-Off Task.
   - In small groups, have students brainstorm new concepts and new connections that they have learned in this task, as well as any new questions that have come up for them. Then have groups share these aloud in a class-wide discussion and add to the class concept map. The use of equity

sticks is encouraged for more equitable participation in class-wide discussions (See "How To Use This Curriculum" for more details).
  - Some facilitating questions to ask students are: What new ideas/concepts do you want to add to the map? What connections do you want to add or change? What is your reason for that addition/revision? What connections can we make between the questions/ideas already on the map? What new questions do you have about the phenomenon?
  - Draw circles around each question and boxes around each concept.
  - Write connector words to describe connections between the concept boxes.
  - For this task, students may begin to connect some of their previous boxes or circles to concept boxes about the following: specific examples of biodiversity impacts and the mechanism of natural selection.
- Have students analyze the additions to the class concept map for as many examples of this task's crosscutting concept as they can find. Once a student has identified a box or circle with the crosscutting concept, you can trace the circle in the corresponding color (decided on in the Lift-Off task). We recommend asking students to share key words that helped them identify the crosscutting concept for that concept or question. Some identifying words students might look for are:
  - **Cause and Effect:** These could be phrases such as, "which results in," "which causes," "that explains why," "is due to," etc.
- Once again, the purpose of this concept map is to facilitate generation of student questions, promote language development, and support understanding of the science content throughout the unit. Allowing students to ask their own questions and use their own words to make meaning of the concepts will not only help them make deep connections about science content, but will also help their oral and written language development.

Evaluate: Connecting to the Culminating Project

1. Students independently complete the Task 2 section of the Unit Project Organizer in class. Revisions can be done for homework, depending upon student's needs and/or class scheduling.

2. Students have been tasked with presenting a poster at a Resource Conservation Conference to show one solution to help monitor or lessen the effects of human overpopulation and excess resource consumption. Their prompt is as follows: Today we learned that not only is Earth being harmed, these changes to Earth's environment are also affecting organisms. Now that you know how this is happening:
   - How can you use cause-and-effect and the process of natural selection to better define the problem?
     - **Defining Problems:** Add to the problem you outlined after Task 1.
   - Are there any other criteria and constraints you would like to add considering what you have learned in this task?

3. In completing this section of the Project Organizer, students continue to engage with one of the Engineering and Design Performance Expectations of this unit, MS-ETS1-1. By using new knowledge to clarify the problem and define the criteria and constraints more precisely, students make it more likely that the solution they choose will be most successful.

Reflection

1. At the end of the task, ask students to reflect on what they have learned over the course of this task by answering the following three questions in their student guide:
    - At the beginning of this task, you were asked to use your knowledge of natural selection to make a prediction about how resource consumption might affect biodiversity on Earth. Look back at your prediction: after collecting all the evidence today, how would you change your prediction or add to your reasoning? Use evidence from the task to justify your response and record below.
    - In this task, we focused on one crosscutting concept: **Cause and Effect**: by seeing how phenomena may have more than one cause, and using cause-and-effect relationships to predict phenomena. Where did you see examples of **Cause and Effect** in this task?
    - Now that you have learned more specifics about impacts to Earth's systems, what questions do you still have?

2. There are no right answers, but encourage students to look back at their Engage and their class concept map. They should not change their initial responses, but rather use this reflection space to add their ideas and questions based on what they have learned throughout this task. By generating more of their own questions, students continue to engage in sense-making of the phenomenon and the gathering of knowledge and skills for their final project.

Assessment

1. You may collect the Project Organizer and assess using:
    - *Criteria of your choice.* We recommend using the Alignment Table at the beginning of this document to inform your criteria.
    - This can be a formative tool to periodically look for trends in student understanding after the completion of a task. You can then use this formative data to inform any re-teaching, as necessary.

2. You may also give students time to make revisions with one of the two options:
    - Students may make changes to their Project Organizer according to your comments OR
    - Ask students to exchange Project Organizers with a partner and give partners 5 minutes to give written feedback. Then allow students time to make changes to their work according to the feedback.

Station 1: Effect of Habitat Loss on Forest Species


(a)


(b)

(c)


(d)


(e)

Human destruction of habitats has accelerated greatly in the latter half of the twentieth century. Natural habitats are often destroyed through human activity for the purpose of harvesting natural resources for industry production and urbanization. Clearing habitats for agriculture, for example, is the principal cause of habitat destruction. Other important causes of habitat destruction include mining, logging, and urban sprawl. Habitat destruction is currently ranked as the primary cause of species extinction worldwide.

Consider the exceptional biodiversity of Indonesia and Malaysia. The island of Sumatra (Figure C) is home to one sub-species of orangutan (Figure A), a species of critically endangered elephant (Figure D), and the Sumatran tiger (Figure B); however half of Sumatra's forest is now gone. The neighboring island of Borneo (Figure C), home to the other sub-species of orangutan, has lost a similar area of forest, and forest loss continues in protected areas. The orangutan in Borneo is listed as endangered by the International Union for Conservation of Nature (IUCN), but it is simply the most visible of thousands of species that will not survive the disappearance of the forests of Borneo. The forests are being removed for their timber, and to clear space for plantations of palm oil (Figure E), an oil used in Europe for many items including food products, cosmetics, and biodiesel.

Guiding Questions

1. What human activities are affecting the environment in this example?
2. What is the effect on the environment in Sumatra and Borneo?
3. How is this change in environment affecting the orangutan, elephant, and tiger (as well as other species)?
4. Is there a trait variation you could see helping any of these animals adapt to their new environment? If there isn't one, what happens to them?
5. Explain this entire process in terms of natural selection.

Sources

- https://courses.lumenlearning.com/boundless-biology/chapter/threats-to-biodiversity/

Station 2: Effect of Hunting on Elephants

When we think of natural resources that humans consume, we often think of water, fossil fuels, minerals, etc. However, animals and plants are natural resources as well.

In Zambia, the proportion of tuskless female elephants went from 10% to 40% in 20 years. In Sri Lanka, fewer than 5% of male elephants now have tusks. This is all due to poaching (hunting)—elephant tusks are made of ivory, which is very valuable, so elephants with tusks were more likely to be killed.

Watch the following video to learn more about the effect of hunting on elephants. Visit https://www.youtube.com/watch?v=IxJDUrDH9v4, or search YouTube for “Selection for Tuskless Elephants, HHMI Biointeractive Video” (**Start video at 3:55**).

Guiding Questions

1. What human activity is affecting elephants?
2. Explain this entire process in terms of natural selection.

Sources

- https://grist.org/article/2011-05-05-how-humans-are-forcing-other-species-to-evolve/
- http://www.freestockphotos.biz/stockphoto/10006

Station 3: Effect of Habitat Degradation on Hudson River Fish

Ever seen a raccoon unlatch a garbage can in search of leftovers? Or shimmy across power lines to get from one rooftop to another? If so, you've witnessed an animal adapting its behavior to city life. That's been going on since people started building cities thousands of years ago.

Now, biologists are seeing signs that animals and plants are also adapting in a more basic way to survive in cities. Their genes are changing. Urban *pollution,* traffic and shrinking wild spaces have been causing changes in these genetic instructions.

One example is a fish that lives in a very polluted segment of the Hudson River, called the **tomcod**. A company called General Electric was the main electricity company in the region. In their process of electricity production in the mid-1900s, the General Electric plants spewed lots of toxic chemical pollution into the river, killing some fish and causing severe deformations in many others.

But some of the tomcod fish had a genetic variant that allowed them to survive. Here's how the gene adaptation works: The normal form of the gene gives instructions for building a certain protein in the fish. To do damage, the toxic chemical must attach to this protein. But the variant gene gives slightly different protein-building instructions. This change makes it hard for the toxic chemical to latch on, so this adaptation acts as a sort of shield. Today, nearly all tomcod fish in this part of the Hudson carry the protective form of this gene.

Guiding Questions

1. What human activities are affecting the environment in this example?
2. What is the effect on the environment in the Hudson River?
3. How is this change in environment affecting fish in the river, especially the tomcod fish?
4. Explain this entire process in terms of natural selection.

Sources

- https://www.sciencenewsforstudents.org/article/cities-drive-animals-and-plants-evolve

Station 4: Effect of Habitat Change on The Kit Fox

The San Joaquin kit fox was relatively common until the 1930s, when people began to convert grasslands to farms, orchards and cities. By 1958, 50 percent of its habitat in California's Central Valley had been lost, due to extensive land conversions for agriculture/homes and use of rodenticides (kills small rodents). By 1979, less than 7 percent of the San Joaquin Valley's original grasslands remained undeveloped.

The kit fox was listed as endangered in 1967. Today there are fewer than 7,000 scattered among fragmented populations. In these regions, human population has grown by 60 percent — or 1.5 million people — since 1983.

Besides habitat loss, the San Joaquin kit fox is threatened by the rodenticides humans use in agriculture, industry, and homes in the Central Valley. Kit foxes eat small rodents, so as rodenticides kill much of their prey, there is not enough food for the foxes. Kit foxes had already adapted to get their water from the prey they eat, making them even more dependent on their food source. If this process continues, the kit fox will likely become extinct in the near future.

Guiding Questions

1. What human activities are affecting the environment in this example?
2. What is the effect on the environment in San Joaquin Valley?
3. How is this change in environment affecting the kit fox?
4. Is there a trait variation you could see helping the kit fox adapt to this new environment? If there isn't one, what happens to the kit fox?
5. Explain this entire process in terms of natural selection.

Sources

- https://www.biologicaldiversity.org/programs/population_and_sustainability/species.html

Station 5: Effect of Climate Change on The California Pika

These cute creatures have demonstrated their incredible resilience in the face of danger, but even pikas may not be able to adapt to the increasingly warming world, caused by human activities like burning fossil fuels. As temperatures rise, pikas are abandoning their low-elevation habitat and moving to higher ground to escape the heat.

Researchers at the University of California, Santa Cruz surveyed 67 locations with historical records of pikas and found that the animals have disappeared from 10 of them - that's 15 percent of the surveyed sites.

These poor pikas are struggling, and especially with 2014 confirmed as the hottest year on record, these animals are at risk of local extinction. When summer temperatures are too high (like this past summer), pikas are forced to stay underground to avoid overheating. Less time spent foraging for food means less to eat, which increases the likelihood of local extinction.

Moving up the mountain is an option for these pikas. With high metabolic rates and thick fur, they are well adapted to the cold temperatures at high elevations. However, this could be just as harmful as it is helpful. "They are uniquely adapted to cold temperatures, but these same adaptations make the species vulnerable to global warming," Stewart said.

Researchers have found that by 2070, pikas will be gone from much of their historical range in California - that's 39 to 88 percent of sites. And this isn't just bad news for pikas, but for other local wildlife as well - they are prey to many species and alter vegetation and soil composition by foraging.

"Pikas are a model organism for studying climate change, and their decline at low-elevation sites suggests that the future for other species is not great either," Stewart added. "The problem is that the climate is changing faster than species can adapt or disperse to new sites."

Guiding Questions

1. What human activities are affecting the environment in this example?
2. What is the effect on the Pika's environments throughout California?
3. How is this change in environment affecting pikas?
4. What trait variation could you see helping the pikas adapt to this new environment? What happens if this genetic variation never appears in the population?
5. Explain this entire process in terms of natural selection.

Sources

- http://www.natureworldnews.com/articles/12476/20150203/poor-pikas-losing-their-california-habitat-to-climate-change.htm
- http://sacramento.cbslocal.com/2016/09/13/protections-rejected-for-american-pika-other-species/

Station 6: Effect of Climate Change on Many Organisms

Watch the following video that shows some examples of organisms changing in response to climate-related environmental changes. Visit https://www.youtube.com/watch?v=ZCKRjP_DMII, or search YouTube for "Can wildlife adapt to climate change? – Erin Eastwood".

Guiding Questions

1. What human activities are affecting environments in these examples?
2. Give one example from the video of how climate change affects the environment.
3. In the example you chose, how is this change in environment affecting the plant or animal?
4. Explain your example in terms of natural selection.

8th Grade Science Unit 4: Using Engineering and Technology to Sustain Our World

Task 3: Waves and Energy

Unit Essential Question: *How are humans harming Earth, plants, and animals, and what can we do about it?*

Introduction

Thus far in this unit, students have been focused on the problem—that human overpopulation and excess consumption of resources is placing an unsustainable strain on our planet. Now that students have gathered all this background, they are ready to begin thinking about solutions. Students know that human needs for energy are what is causing a lot of the environmental degradation, so here they begin to transition towards the question: What if we could get our energy from other sources, such as waves? To understand if waves could be an alternative energy source, students need to first learn more about waves. In this task, students are introduced to types of waves that are able to travel through a medium, like water waves and sound waves. As they explore the characteristics of these waves, they begin to consider how this knowledge helps them to discern the amount of energy different waves have—a concept that will be essential if they want to consider waves as a potential energy source for their culminating project.

Alignment Table

Performance Expectations	Scientific and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
MS-PS4-1. Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave. [Clarification Statement: Emphasis is on describing waves with both qualitative and quantitative thinking.] [*Assessment Boundary: Assessment does not include electromagnetic waves and is limited to standard repeating waves.*]	**Using Mathematics and Computational Thinking** • Use mathematical representations to describe and/or support scientific conclusions and design solutions.	**PS4.A: Wave Properties** • A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude.	**Patterns** • Graphs and charts can be used to identify patterns in data.
Supplementary Science and Engineering Practices • Developing and Using Models ○ Develop and use a model to describe phenomena.			
Supplementary Crosscutting Concepts • Energy and Matter ○ The transfer of energy can be tracked as energy flows through a natural system.			
Equity and Groupwork • Work as a group to generate and observe water waves. • Participate in group roles to utilize a simulation. • Develop a model in partners and share within a group.			

8th Grade Science Unit 4: Using Engineering and Technology to Sustain Our World

Task 3: Waves and Energy

Language
- Come to consensus on a definition for "wave"
- Learn and model new vocabulary terms related to waves

Learning Goals

This learning task explores how waves have certain characteristics that relate to their energy. More specifically, the purpose is to:
- Explore water waves to identify characteristics of waves and formulate a definition.
- Use a computer simulation to relate amplitude to energy in various waves.
- Create a model of a wave and compare different amplitudes of waves.
- Analyze characteristics of sound waves, using an app-based oscilloscope.
- Apply knowledge of waves and energy to explain a potential alternative energy source.

Content Background for Teachers

In this task, students begin their study of waves with what is likely the most familiar example—a water wave.
When students think of waves, one of the first things they may think about is an ocean wave crashing on the beach. Water waves are a great example of wave to explore because unlike sound or light waves, they are visible.


https://pixabay.com/en/wave-atlantic-pacific-ocean-huge-1913559/

A wave is a disturbance that travels through space and matter, transferring energy from one place to another. One of the most important things for students to notice and remember is that waves transfer energy, not matter. Students will be able to observe this early on, when they see that a cork floating in water will move up and down, but not from one side of the bin to the other with the wave.

Water waves are classified as mechanical waves, meaning they require a medium or some sort of matter to travel through. These waves travel when molecules in the medium collide with each other and pass along the energy. In the case of water waves, this medium is water. Students also explore sound waves in this task, which is another example of a mechanical wave. Sound can travel through air, water, or solids, but it can't travel through a vacuum. Students mainly explore air as the medium in this task.

There are a few main characteristics, or properties, that scientists use to describe waves. The ones studied in this task are amplitude, frequency, and wavelength. Wavelength is the distance between identical points on consecutive waves. Frequency is the number of full wavelengths that pass a point in a given time interval. The amplitude refers to the distance between the starting height and highest (or lowest) point of a wave. You can see graphs with these characteristics labeled on the student guide. The effect we experience is different depending on how these characteristics vary in the wave. A sound wave with high frequency and short wavelength, for example, will result in a high-pitched sound. Meanwhile, a sound wave with large amplitude will have a loud sound. In this task, students focus heavily on the relationship between amplitude and energy. Through multiple activities, they will find that the higher the amplitude of the wave, the more energy it has.

8th Grade Science Unit 4: Using Engineering and Technology to Sustain Our World

Task 3: Waves and Energy

Academic Vocabulary

- Water Wave
- Amplitude
- Wavelength
- Frequency
- Energy
- Matter
- Molecules
- Sound Wave

Time Needed (Based on 45-Minute Periods)

5-6 Days

- Engage: 1 period
- Explore: 1 period
- Explain: 1-2 periods
- Elaborate: 1 period
- Evaluate and Reflection: 1 period

Materials

- Unit 4, Task 3 Student Version

Engage (Per Group)

- Plastic Basin
- Water
- Several Different Sized Blocks
- Cork or other floating materials

Explore (Per Group)

- Computer or tablet (See Explore section for a non-tech option)
- Slinky

Elaborate (Per Group)

- Handheld device or tablet (with Oscilloscope app downloaded)

Evaluate

- Project Organizer Handout

Instructions

Engage

1. Introduce to Task 3: In the last task, you got a clear and comprehensive picture of the problem Earth is facing. Think about what you were still wondering about at the end of the last task (look back if you need to). What questions do you still have?
    a. Before you pass out their student guide, give students time to reflect individually or with a partner about the questions they recorded at the end of the last task. Share a few of these out as a class, using facilitating questions to guide students toward questions that relate to this task.

2. Transition to Task 3: Now it's time to move towards the question of potential solutions.
   a. Now pass out their Task 3 student guide. We recommend reading the introductory material on the student guide. This introductory material reviews concepts around energy and resource consumption from seventh grade, so students understand why we are focusing on energy when we consider some solutions to the problem.

3. Distribute the materials to each group (noted in the Materials section above).
   - Optional: Instead of making waves with objects, you may wish to put a lid on the bin and ask kids to lightly slosh the bin to make waves. This may make less of a mess.

4. Assign roles to each group. You may use whatever roles you prefer. We recommend the use of the Materials Manager, Facilitator, Reporter, Harmonizer.
   - Ask Facilitator to read the directions and to make sure everyone understands the task, as well as facilitate the discussion about observations of the waves.
   - Ask the Materials Manager to be responsible for the materials needed to complete the task.
   - Ask the Harmonizer to make sure that everyone contributes their ideas and that everyone's voice is heard.
   - Ask the Recorder to make sure everyone is recording their observations and conclusions.

5. As a group, students will generate different sizes and shapes of waves, so they can make observations.
   - On their student guides, they should record observations of wave characteristics as well as come to consensus about a definition for the term "wave."
   - The first portion of this exploration is for them to merely make general observations about waves. The purpose of adding the floating object is to help students notice that the water isn't actually being moved all the way through the bin, but rather energy is being passed from one water molecule to the next. While not explicit, this is students' first experience with the crosscutting concept of **Energy and Matter** in this task, as they track energy transfer by observing the movement of the wave.

6. Once students have completed the exploration and cleaned up their materials, conduct a class-wide discussion about characteristics of waves in order to come to a consensus on a definition for the term "wave".
   - We recommend asking students to share out multiple characteristics they noticed about waves and grouping them together in a list on the board or a poster. This will help students to notice trends that all groups are observing about waves. It will also help to come up with a class definition for "wave".
   - Use these shared characteristics to transition to a discussion about a definition for "wave". You may want to ask a few student groups to share out the definition that they came up with and build consensus from there. We highly recommend leaving up this class definition throughout the remainder of the unit, revising throughout the rest of the tasks as needed.
   - The use of equity sticks may be used to get the discussion started (See "How To Use This Curriculum" for more details).

8th Grade Science Unit 4: Using Engineering and Technology to Sustain Our World

Task 3: Waves and Energy

Explore

1. Now that students have experienced waves and identified characteristics in their own words, they can learn the words that scientists used to describe the same things they have seen.

2. Before students explore waves again, they need to know the terms amplitude, wavelength, and frequency. Review these terms with students, using the written vocabulary and diagrams on their student guides. This will be the type of mathematic wave model they will utilize throughout the unit.
   - These terms are extremely important for the remainder of this unit, so you may wish to review these terms with a PowerPoint presentation or some other means.

3. Once students understand the terms, they are ready to practice applying them within the PhET simulation, Wave on a String (http://phet.colorado.edu/sims/html/wave-on-a-string/latest/wave-on-a-string_en.html).
   - In this simulation, students will explore the question: Do you think a small wave or a large wave has more energy? This question is especially critical as it relates to their culminating project context—finding alternative forms of energy.
   - By using a computer simulation that takes real-life data and allows them to manipulate it in a simulated environment, students are engaging with the science and engineering practice of **Using Mathematical and Computational Reasoning.** Students are applying the simple mathematical wave model they have just learned (pictured on their student guide) to identify how the wave model characteristics correspond with physical observations in the simulation.
   - *For a non-tech option of a wave simulation, a similar setup can be achieved using string, meter sticks, a metal ring that is large enough to fit around the meter stick. The string can be tied to the ring that fits over the meter stick. A person holds the other end of the string and generates a wave. The displacement of the person's hand and the amplitude of the waves generated can be measured by using the meter stick(s). A small slinky could also be used in place of the string for a more dramatic effect.

4. This activity should be done in groups, so we recommend assigning roles to each group, but switching up the roles assigned in the previous activity. You may use whatever roles you prefer, but we recommend the use of the Materials Manager, Facilitator, Reporter, Harmonizer (see descriptions within Engage activity above).
   - Students then follow the procedure on their student guides, recording data in the table that follows. As they compare amplitudes and energy of different waves in the simulation, they are engaging with the crosscutting concept of **Energy and Matter**, as they can track the energy of the wave based on its amplitude.

5. After students complete the simulation, the graph on their student guide allows them to confirm what they learned through the simulation, that the energy of waves is proportional to their amplitude. Guiding questions are provided on their student guide to support them with their graph analysis.

6. At the end of this activity, conduct a quick wrap-up activity that checks for understanding using a slinky.
   - Take a vote to answer the question: Do large amplitude or small amplitude waves have more energy?

- Then ask for a student volunteer to demonstrate this concept with a slinky wave: student generates a low amplitude wave and then a high amplitude wave.
  - Ask the student volunteer which wave they felt more, or which one was trying to "move" their arm more? Student should notice that the larger the amplitude, the more the receiving arm will want to move. This means that more energy is being transferred through the wave.
  - Give other students the opportunity to come up and feel if for themselves.
  - Optional: Using a slinky to demonstrate the relationship between amplitude and energy is not only a clear visual, but the students can actually *feel* the difference in energy when changing the amplitude of a wave. They will be more likely to remember this relationship. Therefore, you might consider finding a class set of slinky's so more students can try this.
- Conclude as a class: Large wrench distance = large amplitude = more energy. Small wrench distance = small amplitude = less energy
- Again, students are **Using Mathematical and Computational Reasoning** by applying the simple mathematical wave model to identify how the amplitude corresponds with the physical observations of energy in the slinky.

Explain

1. Now that students have learned and applied these new concepts around the characteristics of waves, they will explain everything they know by creating a model.
   - This gives students practice at the supplementary SEP **Developing and Using Models** in order to describe the phenomena of waves, specifically amplitude, frequency, wavelength and the effect on energy.

2. Students return to the context of the Engage, creating a model of a cross-section of one of the water waves they generated in the Engage.
   - You may wish to model what you mean by cross-section before students begin.
   - In their models, students are following directions on their student guide to explain what is happening to their water wave and other objects, labeling the new terms they have learned (amplitude, frequency, and wavelength), and comparing their wave to other water waves in terms of amplitude and energy.
   - The latter criterion helps students continue to engage with the crosscutting concept of **Energy and Matter**, as students consider how they can track the energy of the wave in terms of its amplitude.

3. We recommend this activity be done in pairs. That way, students have a thought partner to process ideas they have learned as they create the model.
   - This also means that they will have another pair within the same group to share their model with. This allows them to discuss comparisons between their two models based on their mutual experience during the Engage. Once students complete their models in partners, ask them to share with the other pair from their group. Students should them make any changes/revisions necessary so both of their models accurately include all the criteria specified in their student guide.

4. Optional: Conduct a mini gallery walk so students can see other representations of waves. This also allows you to do a quick scan of where students are at conceptually with their understanding of waves.

Elaborate

1. The Engage and the Explain dealt specifically with water waves. However, these concepts can be applied to another type of wave that needs matter to travel—sound waves. In this activity, students use an app called "Oscillo" or "Oscilloscope" to help them visualize sound waves.

2. We highly recommend reviewing the introductory paragraphs and associated diagram as a class before beginning this activity. These paragraphs introduce sound waves and identify how sound waves are similar to and different from water waves, which students are already familiar with.
    - You may wish to project the image of the sound wave on the board to prompt a discussion of how water waves and sound waves travel. Emphasize to students that both water and sound waves require a medium, or matter, to travel. The way these waves travel is by molecules colliding and passing along their energy. With water waves, these are water molecules. With sound waves, it could be any matter, but students will most often experience them with air molecules in this task.
        - Because most students have already learned about thermal energy transfer in previous years, you might consider using the same conceptualization of molecule motion and energy transfer as a familiar starting point for students.

3. We also recommend modeling the process of using the oscilloscope before beginning the activity. Project the oscilloscope, either on your computer or using a document camera. You may create sounds of different pitches and at different volumes any way you like: inviting up a student volunteer, playing different songs, or making the sounds yourself. As you do so, point out the characteristics they should be looking for (amplitude, wavelength, and frequency). This not only models the use of new technology, but is also a great review of wave characteristics.

4. Distribute the devices on which you have downloaded an oscilloscope app (test out before to make sure it works on the type of device you are using). An alternative option is for one student in each pair to download the app on their phone.
    - If students feel uncomfortable installing the app on their device or you do not have access to other devices they can use, you can display the oscilloscope from your own device. Then you can walk the class through the questions, asking volunteers to use your device in front of the class to help explain the difference between graphs.

5. In pairs, students will experiment with the device, attempting to use their voices to make waves with different characteristics. They will record these actions in the table in their student guide.

6. Once students have experimented with the oscilloscope, they use data they collected and their knowledge of wave characteristics to interpret four different graphs on their student guides.
    - This exercise allows them to show what they know about wave characteristics, practice making comparisons, and reinforce the relationships between wave amplitude and energy.

- Possible sentence frames:
  - Graph __ and __ have the same _____.
  - Graph __ has a (greater/lower) _____ than Graph __.
  - Graph __ has a (louder/quieter) sound than Graph __.
  - Graph __ has a (higher/lower) pitched sound than Graph __.
- Possible student responses:
  - 2a and 2b: Graph 1 and 2 have the same frequency and wavelength. Graph 2 has a much larger amplitude, meaning it has more energy. Graph 2 has a louder sound.
  - 3a and 3b. Graph 3 and 4 have the same amplitude, but Graph 3 has a much greater frequency and much shorter wavelength than Graph 4. Graph 3 has a higher pitched sound.

7. You may do this activity in a variety of ways, but we recommend students analyze the first set of graphs in a Think-Pair-Share format. This gives them time to review before doing the second set of graphs individually, which can then be used as a formative assessment. Otherwise, this may be done in pairs or groups, depending on the needs of your students.
   - Collect student work to identify trends in students' ability to accurately analyze the graphs for amplitude, frequency, and wavelength**.** Or you may specifically wish to focus on if students are making the connection between amplitude and energy. See "How to Use This Curriculum" for strategies on utilizing formative assessment data to provide feedback to students and inform classroom instruction.

8. Return to the whole-class concept map from the Lift-Off Task.
   - In small groups, have students brainstorm new concepts and new connections that they have learned in this task, as well as any new questions that have come up for them. Then have groups share these aloud in a class-wide discussion and add to the class concept map. The use of equity sticks is encouraged for more equitable participation in class-wide discussions (See "How To Use This Curriculum" for more details).
     - Some facilitating questions to ask students are: What new ideas/concepts do you want to add to the map? What connections do you want to add or change? What is your reason for that addition/revision? What connections can we make between the questions/ideas already on the map? What new questions do you have about the phenomenon?
     - Draw circles around each question and boxes around each concept.
     - Write connector words to describe connections between the concept boxes.
     - For this task, students may begin to connect some of their previous question circles to concept boxes about the following: how alternative energy might be a solution to the problem, how waves are related to energy, the characteristics of waves, and the types of waves.
   - Have students analyze the additions to the class concept map for as many examples of this task's crosscutting concepts as they can find. Once a student has identified the crosscutting concept, you can trace the circle in the corresponding color (decided on in the Lift-Off task). We recommend asking students to share key words that helped them identify the crosscutting concept for that concept or question. Some identifying words students might look for are:

    - **Patterns**: These could be phrases such as, "is the same as", "has in common with", "is similar to", "shares" etc.
    - **Energy and Matter:** These could be phrases such as, "is transferred through," "is made by," "is put into," "is added to," "is cycled within," "is taken out by," "is extracted for," "is converted into," "is absorbed by," etc.
  - Once again, the purpose of this concept map is to facilitate generation of student questions, promote language development, and support understanding of the science content throughout the unit. Allowing students to ask their own questions and use their own words to make meaning of the concepts will not only help them make deep connections about science content, but will also help their oral and written language development.

Evaluate: Connecting to the Culminating Project

1. Students independently complete the Task 3 section of the Unit Project Organizer in class. Revisions can be done for homework, depending upon student's needs and/or class scheduling.

2. Students have been tasked with presenting a poster at a Resource Conservation Conference that showcases one solution to help monitor or lessen the effects of human overpopulation and excess resource consumption. Their prompt is as follows: One way we might mitigate (reduce) the effects of resource consumption on Earth is to use sources of energy that are more plentiful and cause less environmental degradation. For example, electricity can be generated from ocean waves.
    - Based on what you learned today, draw a model of an ocean wave, using labels.
    - How is the structure of an ocean wave related to the amount of energy it has?
    - How might these ideas about waves and their energy help how us use ocean waves as an energy source?

Reflection

1. At the end of the task, ask students to reflect on what they have learned over the course of this task by answering the following three questions in their student guide:
    - At the beginning of this task, you were asked to define a wave and identify characteristics of waves. Look back at your definition and characteristics: after collecting all the evidence today, how could you add to these or revise these?
    - In this task, we focused on two crosscutting concepts: **Patterns**: by using graphs and charts to identify patterns in data, and **Energy and Matter**: by observing that the transfer of energy can be tracked as it flows through a system. Where did you see examples of **Patterns** and **Energy and Matter** in this task?
    - Now that you've learned that waves can generate energy without as much impact on the environment, what questions do you still have?

2. There are no right answers, but encourage students to look back at their Engage and their class concept map. They should not change their initial responses, but rather use this reflection space to add their ideas and questions based on what they have learned throughout this task. By generating more of their own questions, students continue to engage in sense-making of the phenomenon and the gathering of knowledge and skills for their final project.

Assessment

1. You may collect the Project Organizer and assess using:
   - *Criteria of your choice.* We recommend using the Alignment Table at the beginning of this document to inform your criteria.
   - This can be a formative tool to periodically look for trends in student understanding after the completion of a task. You can then use this formative data to inform any re-teaching, as necessary.

2. You may also give students time to make revisions with one of the two options:
   - Students may make changes to their Project Organizer according to your comments OR
   - Ask students to exchange Project Organizers with a partner and give partners 5 minutes to give written feedback. Then allow students time to make changes to their work according to the feedback.

8th Grade Science Unit 4: Using Engineering and Technology to Sustain Our World

Task 4: Wave Interactions

Unit Essential Question: *How are humans harming Earth, plants, and animals, and what can we do about it?*

Introduction

Students have already begun their study of waves in order to seek potential solutions for monitoring or mitigating the effects of human consumption of natural resources. In the last task, the focus was to lay a foundation for what waves are, what characteristics they have, and how these characteristics relate to their energy. Now that students have this basic understanding of waves, they are able to move on to exploring different wave interactions. In this task, students use the contexts of sound waves and light waves to explore how they behave when confronted with different materials. By the end of this task, students should have a solid understanding of how waves are reflected, absorbed, or transmitted through various materials. This will aid them with their culminating project as they seek to use these concepts to explain another form of alternative energy, solar energy.

Alignment Table

Performance Expectations	Scientific and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
MS-PS4-2. Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials. [Clarification Statement: Emphasis is on both light and mechanical waves. Examples of models could include drawings, simulations, and written descriptions.] [*Assessment Boundary: Assessment is limited to qualitative applications pertaining to light and mechanical waves.*]	**Developing and Using Models** • Develop and use a model to describe phenomena	**PS4.A: Wave Properties** • A sound wave needs a medium through which it is transmitted. **PS4.B: Electromagnetic Radiation** • When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material. • The path that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and water, air and glass) where the light path bends. • However, because light can travel	**Structure and Function** • Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used.

		through space, it cannot be a matter wave, like sound or water waves.	

Supplementary Crosscutting Concepts

- Energy and Matter
  - The transfer of energy can be tracked as energy flows through a natural system.

Equity and Groupwork

- Work with a partner to construct a string telephone.
- Participate in group roles to experiment with waves and different materials.
- Participate in group roles to develop a poster model.
- Learn from others in a gallery walk.

Language

- Use compare-and-contrast language to describe observations.
- Read and annotate articles.
- Use words and drawings to model a wave interaction.
- Learn and apply new vocabulary terms related to wave interactions.

Learning Goals

This learning task explores how sound waves and light waves behave when interacting with objects. More specifically, the purpose is to:

- Use a string telephone to explore whether sound travels better through air or through string.
- Experiment with how different materials affect light and sound waves.
- Read and annotate articles about sound and light waves.
- Create models of different wave interactions.
- Apply knowledge of wave interactions to new scenarios.
- Apply knowledge of wave interactions to explain how solar energy works.

Content Background for Teachers

In this task, students continue their study of waves by focusing on how sound and light waves behave when interacting with different objects and materials. The background section of Task 3 provides detailed background on the basics of waves and their characteristics. For background specific to how sound and light waves can be reflected, absorbed, or transmitted, please see the corresponding resource card articles for this task.

Academic Vocabulary

- Light wave
- Reflection
- Absorption
- Transmission

Time Needed (Based on 45-Minute Periods)

6-7 Days

8th Grade Science Unit 4: Using Engineering and Technology to Sustain Our World

Task 4: Wave Interactions

- Engage: 1 period
- Explore: 1-2 periods
- Explain: 2 periods
- Elaborate: 1 period
- Evaluate and Reflection: 1 period

Materials

- Unit 4, Task 4 Student Version

Engage (Per Pair)

- 2 paper cups
- Pencil
- 10 foot string

Explore (Per Group)

- Part 1
    - String Telephone from the Engage
    - Pieces of foam (or other absorbent materials)
    - Plastic cups
    - Different types of string (twine, floss, yarn, etc)
    - Masking tape to hold string
    - Device with Oscilloscope app downloaded (same as used in Task 3)
- Part 2 (Per Group, as options)
    - glass jar/flask (to fill with water)
    - small mirror
    - small patch of aluminum foil
    - small patch of plastic wrap
    - small patch of wax paper
    - sheet of notebook paper
    - small piece of cardboard
    - small piece of dark colored tissue paper
    - small piece of light colored tissue paper
    - LED flashlight or laser pointers

Explain

- Light Waves and Sound Waves articles (Per person)
- Poster Paper (Per group)
- Markers or Colored Pencils (Per group)

Evaluate

- Project Organizer Handout

Instructions

Engage

1. Introduction to Task 4: In the last task, you observed water and sound waves. Think about what you were still wondering about at the end of the last task (look back if you need to). What questions do you still have?

- Before you pass out their student guide, give students time to reflect individually or with a partner about the questions they recorded at the end of the last task. Share a few of these out as a class, using facilitating questions to guide students toward questions that relate to this task.

2. Transition to Task 4: The water and sound waves you observed in the last task are known as mechanical waves. Mechanical waves require matter to travel through, such as water or air. However, there is another type of wave that is able to travel in vacuum, or not through any matter. These are light waves, also known as electromagnetic waves. If water waves carry energy that we can use, perhaps light waves also have energy that we can use. Using what we already know about waves, we will now investigate the question of what are light waves.
   - Now pass out their Task 4 student guide. We recommend reading the introductory material on the student guide. This introductory material helps students make connections between sound waves, which they are familiar with, and light waves. It also transitions them to the activity.

3. Distribute the materials to each pair of students (noted in the Materials section above) and ask students to follow the instructions on their student guide.
   - Once students construct their string telephones, they should test them out with a partner, standing about 10 feet apart with the string taut. One person should place the oscilloscope near their ear. They should then record their responses to the questions in their student guide.
   - Students should notice that sound travels better through the string than through air. This is because air molecules are spread farther out than the molecules in solid string, allowing sound waves to move faster and farther in string.
     i. While this activity does not focus on the same aspect of the crosscutting concept of **Energy and Matter** as the rest of the unit, it does help students focus on how matter does not move but rather vibrates to transfer the energy along.

4. Optional: Discuss the final question as a class, using the picture from the Task 3 Elaborate as visual stimulus to prompt discussion.
   - Possible facilitating questions: As a sound wave travels through air, what kinds of things does it "hit"? What happens when it hits these things? How do these things in air appear different from these things in a string?
   - The use of equity sticks is encouraged for more equitable participation in classwide discussions (See "How To Use This Curriculum" for more details).

Explore

1. The Engage served to lay the foundation for students to experiment with more ways that different materials affect how both sound waves and light waves behave.
   - In this activity, students explore sound waves in Part 1 and light waves in Part 2.

2. First, students will need to use the oscilloscope app from Task 3 to observe the sound wave that travels through their original string telephone that they made in the Engage. This will serve as the baseline, so they can compare this wave to the sound waves that interact with different materials. This should be recorded in their student guide to reference throughout the activity.

3. Pass out materials (specified in Materials section) and assign roles to each group. You may use whatever roles you prefer, but we recommend the use of the Materials Manager, Facilitator, Reporter, Harmonizer. We also recommend switching up these rolls between Part 1 and Part 2, so students have a varied experience.
    - Ask the Facilitator to read the directions and to make sure everyone understands the task, as well as facilitate the discussion about observations made.
    - Ask the Materials Manager to be responsible for the materials needed to complete the task.
    - Ask the Harmonizer to make sure that everyone contributes their ideas and that everyone's voice is heard.
    - Ask the Recorder to make sure everyone is recording their observations and conclusions.

4. Part 1: Student groups use different materials to re-construct their telephone so it can minimize, maximize, or even change the sound. They can use the same oscilloscope app to measure the sound waves and record all data in their student guide.
    - Once students finish their investigation, they should discuss and respond to the questions that follow in their student guide.
    - We highly recommend conducting a class-wide discussion centered around these questions. Some facilitation options are listed below:
        i. Ask a few groups to share their findings and record on the board. Then ask the class what patterns they notice about the findings and record these as well.
        ii. Ask what happens to the sound wave when it goes through materials that make the sound quieter or louder. Specifically, how do students think amplitude is affected?
            1. Potential sentences stems to provide:
                a. "We found that using ______ and ______ made the sound louder/quieter."
                b. "The materials that make sound louder are different from the materials that make sound quieter because the louder ones look/feel like _____ and _____, while the quieter ones look/feel like _____ and _____."
        iii. The use of equity sticks is encouraged for more equitable participation in classwide discussions (See "How To Use This Curriculum" for more details).
    - These questions will begin students' exploration of the crosscutting concept of **Structure and Function** in this task, as they consider how the properties of different materials and how the materials are shaped and used affect the function of the telephone (experience of sound). These questions also return to the crosscutting concept of **Energy and Matter,** as students are able to use the oscilloscope to track the energy flow of a wave as it interacts with different materials. For example, the oscilloscope will show that when a sound wave interacts with a material that makes the sound quieter, the amplitude of the wave is decreasing.

5. Part 2: Student groups now engage in a similar exploration using light. Here, students select four materials to test from the lists in their student guides, so these materials should be made available in the classroom (see Materials section). Each group then tests how a light beam from a flash light interacts with the different materials they chose, recording observations in their student guide. This activity is best done with the lights off.

- During this investigation, students are introduced to the new vocabulary for this task: reflected, absorbed, and transmitted. This gives them an opportunity to learn these words in a hands-on context, but they will explore these in more detail in the Explain.
- As with Part 1, once students finish their investigation, they should discuss and respond to the questions that follow in their student guide.
- Again, we highly recommend conducting a class-wide discussion centered around these questions. Some facilitation options are listed below:
  i. Ask the class what three/four things can happen when a light wave interacts with a material
  ii. Ask the class how they think the shape or size of the light wave changes when interacting in the above ways.
  iii. Ask the class what kinds of materials cause these different behaviors
  iv. The use of equity sticks is encouraged for more equitable participation in classwide discussions (See "How To Use This Curriculum" for more details).
- These questions will continue students' exploration of the crosscutting concept of **Structure and Function**, as they consider how the properties of different materials affect the way light behaves. These questions also return to the crosscutting concept of **Energy and Matter,** as students use what they learned about the structure and energy of sound waves to predict the energy flow of light waves during transmission and reflection. For example, because sound going through materials seemed to decrease the amplitude of the sound wave, they could predict that light transmitting through a material might also decrease the amplitude of the light wave, diminishing its brightness.

Explain

1. Now that students have done their own investigations, they can gather some extra detail that they may then use in their models.
   - This activity allows students to practice key reading strategies as well as the SEP of **Developing and Using Models,** as students develop a visual model to describe the phenomenon of a wave interaction.
   - It also continues their development of **Structure and Function** as they explain why the properties, shape, or use of the material causes the wave to behave in that way.

2. Distribute the Light Waves and Sound Waves articles. We recommend providing students their own copy so they can annotate, but if you are short on resources, you could print a class copy and put them in sheet protectors.
   - Students should annotate with whatever strategy they are most comfortable using in your classroom.

3. Once students have finished the reading, we highly recommend doing a review of key points in the articles via a class discussion or powerpoint presentation.
   - In this discussion, ask students to voice any questions they have about the reading.
   - Here are some frames you may want to pose to students as Think-Pair-Shares at the end of this discussion (See "How to Use This Curriculum" for details on use of Think-Pair-Shares and equity sticks):

- When the light or sound bounces back off the material, the wave is ___________________ (absorbed, reflected, or transmitted).
- When the light or sound does not go through to the other side of the material, the wave is ___________________ (absorbed, reflected, or transmitted).
- When the light or sound goes through the material, the wave is ___________________(absorbed, reflected, or transmitted).

4. Assign each group one type of wave interaction to develop a poster model for. These could be: a sound wave travelling through only air between the sound source and an oscilloscope, a sound wave with a wall between the sound source and an oscilloscope, a light wave bounding off a mirror, a light wave hitting a thick piece of cardboard, and a light wave shining through a window.
    - As usual, assign roles to each group (see Explore section above).
    - Students then construct their models on posters, following the criteria in their student guides.
    - *Note: The light wave interactions should really be focused on absorption, reflection, and transmission, less on the structure of the wave. However, students may draw a light wave that has a change in structure (smaller amplitude) when transmitted through a material.

5. Conduct a gallery walk where students can view each others' models. As they view others' models, they will be recording their observations in both drawings and words, so that every student will have a model of each type of wave interaction for reference.
    - Optional: We recommend having 1-2 students from each group stay at their poster so they are there to explain their wave interaction and answer any questions. You can rotate these students every 5 minutes, so everyone has a chance to both present and gather information.
        - If students have questions or potential revisions to models they see, encourage them to ask the group or respectfully make suggestions.
    - We recommend doing a short debrief after the gallery walk to emphasize key concepts. If you notice some errors in models, use this time to offer revised perspectives.

Elaborate

1. Lastly, students can wrap up everything they have learned in this task by applying it to some new situations.
    - This section is identified as an individual activity so you might use it as a formative assessment to see where students are conceptually. However, depending on the needs of your students, you may choose to do this in pairs or groups.
    - If used as a formative assessment, collect student work to identify trends in students' ability to identify how different materials affect the behavior of waves (**Structure and Function)** and how the changing energy of the wave can be tracked as it flows through a system (**Energy and Matter).** See "How to Use This Curriculum" for strategies on utilizing formative assessment data to provide feedback to students and inform classroom instruction.

2. The first question deals with sound waves in the context of dolphins use of echolocation.
    - Possible sentence frame to provide: I think the dolphin's reflected signal will be _____ (quieter/louder/unchanged) because _____.

   - Sample student response: I think the dolphin's reflected signal will be quieter because when a sound wave is reflected, some is absorbed by the kelp. Also as the sound wave passes through the water, it loses energy transferring it from water molecule to water molecule. This makes the amplitude of the sound wave decrease.

3. The second question is more complex, but scaffolds the response using multiple facilitating questions.
   - Optional: model the diagram using actual objects. Change the third object between a glass and metal bottle so students can see how this affects the result.
   - Sample student responses: a) The light wave is reflected by the mirror, b) The light wave is mostly transmitted by the glass bottle and mostly reflected by the metal bottle, c) the observer can see the light from the torch only if it is shiny metal because it reflect, d) It will not be as bright because the amplitude decreases as it interacts with different materials.

4. Return to the whole-class concept map from the Lift-Off Task.
   - In small groups, have students brainstorm new concepts and new connections that they have learned in this task, as well as any new questions that have come up for them. Then have groups share these aloud in a class-wide discussion and add to the class concept map. The use of equity sticks is encouraged for more equitable participation in class-wide discussions (See "How To Use This Curriculum" for more details).
     - Some facilitating questions to ask students are: What new ideas/concepts do you want to add to the map? What connections do you want to add or change? What is your reason for that addition/revision? What connections can we make between the questions/ideas already on the map? What new questions do you have about the phenomenon?
     - Draw circles around each question and boxes around each concept.
     - Write connector words to describe connections between the concept boxes.
     - For this task, students may begin to connect some of their previous question circles to concept boxes about the following: how both sound waves and light waves interact with different materials, how the energy of a wave can change as it interacts with different materials, a new alternative energy solution—solar energy.
   - Have students analyze the additions to the class concept map for as many examples of this task's crosscutting concepts as they can find. Once a student has identified the crosscutting concept, you can trace the circle in the corresponding color (decided on in the Lift-Off task). We recommend asking students to share key words that helped them identify the crosscutting concept for that concept or question. Some identifying words students might look for are:
     - **Structure and Function**: These could be phrases such as, "its shape affects its function by," "structure causes it to," "functions this way because of," etc.
     - **Energy and Matter:** These could be phrases such as, "is transferred through," "is made by," "is put into," "is added to," "is cycled within," "is taken out by," "is extracted for," "is converted into," "is absorbed by," etc.
   - Once again, the purpose of this concept map is to facilitate generation of student questions, promote language development, and support understanding of the science content throughout the unit. Allowing students to ask their own questions and use their own words to make meaning of the concepts will not only help them make deep connections about science content, but will also help their oral and written language development.

Evaluate: Connecting to the Culminating Project

1. Students independently complete the Task 4 section of the Unit 4 Project Organizer in class. Revisions can be done for homework, depending upon student's needs and/or class scheduling.
2. Students have been tasked with presenting a poster at a Resource Conservation Conference that showcases one solution to help monitor or lessen the effects of human overpopulation and excess resource consumption. Their prompt is as follows: Another way we can conserve resources is to use solar (sun) energy for electricity. When light rays from the sun shine down on Earth, some of the light is reflected by the atmosphere and clouds, while others transmit down to Earth to be reflected or absorbed. Solar panels can absorb these light waves and the energy from the light waves creates electricity.
    - Use what you learned about the ways that light waves get **reflected, absorbed, and transmitted** to draw a model of how solar radiation and solar panels work.
    - What are the properties of clouds, air, and solar cells that cause waves to reflect, transmit or absorb?
    - Explain how we can use light waves as a way to reduce our impact on the earth.

Reflection

1. At the end of the task, ask students to reflect on what they have learned over the course of this task by answering the following three questions in their student guide:
    - At the beginning of this task, you experimented with a string telephone. Look back at your explanation of why sound travels better through the string than the air: after learning everything you have through this task, how could you add to or revise this explanation?
    - In this task, we focused on two crosscutting concepts: **Structure and Function**: by noticing how an object's structure can be designed to serve particular functions and **Energy and Matter**: by observing that the transfer of energy can be tracked as it flows through a system. Where did you see examples of **Structure and Function** and **Energy and Matter** in this task?
    - Now that you have learned about how different materials can affect waves and their energy, what questions do you still have?

2. There are no right answers, but encourage students to look back at their Engage and their class concept map. They should not change their initial responses, but rather use this reflection space to add their ideas and questions based on what they have learned throughout this task. By generating more of their own questions, students continue to engage in sense-making of the phenomenon and the gathering of knowledge and skills for their final project.

Assessment

1. You may collect the Project Organizer and assess using:
    - *Criteria of your choice.* We recommend using the Alignment Table at the beginning of this document to inform your criteria.
    - This can be a formative tool to periodically look for trends in student understanding after the completion of a task. You can then use this formative data to inform any re-teaching, as necessary.

2. You may also give students time to make revisions with one of the two options:

- Students may make changes to their Project Organizer according to your comments OR
- Ask students to exchange Project Organizers with a partner and give partners 5 minutes to give written feedback. Then allow students time to make changes to their work according to the feedback.

Sound Waves
Reflection, Absorption, and Transmission

(Adapted from "How Obstacles Affect Sound Waves" by Ron Kurtus - 2007)

When a sound wave meets an obstacle, some of the sound is reflected back from the front surface and some of the sound passes into the obstacle material, where it is absorbed or transmitted through the material. Reflection and absorption are dependent on the wavelength of the sound. The percentage of the sound transmitted through an obstacle depends on how much sound is reflected and how much is absorbed.

Reflection

When a sound wave in air reaches the surface of another material, some of the sound is reflected off the surface. For example, when sound hits a wall, some is reflected and some passes into the wall.

- **Smooth surfaces are best:** If the surface that the sound wave hits is relatively smooth, more sound will be reflected than if the surface is rough. For example, more sound will be reflected from a smooth wall made of mud than a pile of dirt. The reason is that the rough or porous surface allows for many internal reflections, resulting in more absorption and less reflection.
- **Echoes:** When sound reflects off a smooth flat surface, an echo or reproduction of the sound can be heard. Echoes are more noticeable if the surface is far enough away to allow for a time-lag between when the sound is made and when it is heard.

Absorption

As sound travels through any material, there is some loss due to absorption. Since sound is a regular vibration of the atoms or particles in a material, some of the energy of the sound wave is lost due to particles colliding with each other. That lost sound energy is turned into heat energy.

- **Absorption in air:** The amplitude of a sound wave traveling through air not only becomes less as it spreads out, but some of its energy is lost due to absorption. The amount of energy lost to heat is related to the frequency of the sound wave. For example, if you yelled as loud as you could, someone 1 mile (1.6km) away probably could not hear you, even under the best of conditions. On the other hand, an elephant can make a low frequency rumbling sound that can be heard by other elephants more than 5 miles (8km) away!
- **Absorption in different materials:** Some materials absorb sound more than others. Often, in music recording studios, you will see lots of sound absorbing materials on the walls to eliminate any undesired or outside sounds when recording a song.

Stop and think - If you are next to a car with the radio playing very loud music, why do you usually hear the low thumping bass more clearly than the singing?

Transmission

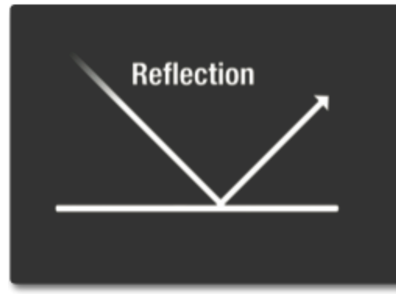
Transmission of sound occurs as a sound wave enters another material. A sound wave in air can be transmitted through a wall of a house. Similarly, sound can enter water and be transmitted through the liquid. However, the amount of sound transmitted depends on the material. For example, if someone shouts underwater, it is difficult to understand the words being spoken, but the sound can travel much further and faster underwater than it would in the air.

Stop and think - Under normal conditions air is a gas, and water is a liquid. Why do you think sound travels faster through water than through air?

Light Waves
Reflection, Absorption, and Transmission

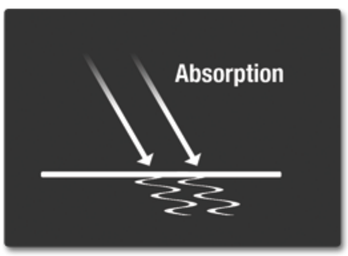
When a light wave encounters an object, they are either reflected, absorbed, or transmitted depending on the composition of the object and the wavelength of the light.

Reflection



Reflection is when incident light (incoming light) hits an object and bounces off. Very smooth, or shiny surfaces such as mirror, reflect almost all incident light. When light is reflected, none of the incident light matches the vibrating frequency of particles making up the material it hits.

You can see this when normal sunlight, light made up of a rainbow of colors, bounces off a plant leaf. If a plant leaf is green, then all the colors of the rainbow will be absorbed by the plant leaf except for green light. Plants have cells that contain particles whose vibrating frequency matches the blue/violet and red/orange parts of the rainbow. Since the green part of the rainbow does not match the vibrating frequency of the particles in the green plant leaf, it will bounce off the leaf and reach your eyes. This is why many plant leaves appear green to our eyes.



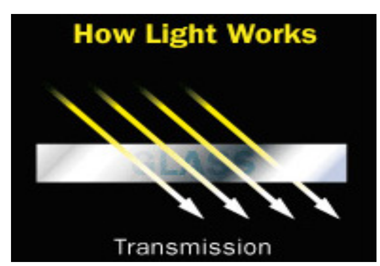
Absorption

Absorption occurs when the frequency of the incident light closely matches the vibrating frequency of the particles in a material. When light hits these particles, they absorb the energy of the light and gein to collide with neighboring particles more quickly. With enough light, the material begins to feel warm to the touch and can release heat. This is why non-shiny objects tend to feel warm when left in the Sun.

Stop and think - Why do you think a shiny object will not feel as warm when left in the Sun?

Some objects, such as darker colored objects, absorb more incident light energy than others. For example, black pavement absorbs more visible light and ultraviolet light energy and reflects very little, as compared to a light-colored concrete sidewalk. This is why the black pavement is hotter than the sidewalk on a hot summer day.

Transmission



Transmission occurs when light passes through an object or material, without being absorbed or reflected. The amount of light that passes through depends on the material it is passing through. Darker, thicker materials tend to let less light pass through, while clear, thin materials let more light pass through. Very clear materials, like glass, let nearly 100% of the incident light through. However, if you make the glass darker, like with sunglasses, some of the light can be absorbed by the glass, thus letting less light through.

Stop and think - Why do you think some sunglasses use both dark and shiny glass material?

Image Sources: https://science.nasa.gov/ems/03_behaviors,
https://science.howstuffworks.com/question4041.htm

8th Grade Science Unit 4: Using Engineering and Technology to Sustain Our World

Task 5: Using Waves to Communicate Information

Unit Essential Question: *How are humans harming Earth, plants, and animals, and what can we do about it?*

Introduction

In the last two tasks, students investigated characteristics of waves and the way they interact with different materials. In doing so, they found that waves carry energy and these types of characteristics and interactions make wave energy a good candidate as an alternative energy source in the forms of both ocean energy and solar energy. While these are two solutions that can be considered in light of the problem students have been examining across this unit, there is another solution that also involves wave technology. In the Engage, students are briefly introduced to example satellite images that monitor Earth's changing landscape due to human activity. In the rest of this task, students explore digital and analog waves in order to decide which would be better to communicate detailed information, like these satellite images, to people around the globe. In the end, students will have an understanding of another wave technology that may help address the phenomenon of human overpopulation and combat the problem of excess resource consumption on Earth.

Alignment Table

Performance Expectations	Scientific and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
MS-PS4-3. **Integrate qualitative scientific and technical information to support the claim that digitized signals are a more reliable way to encode and transmit information than analog signals.** [Clarification Statement: Emphasis is on a basic understanding that waves can be used for communication purposes. Examples could include using fiber optic cable to transmit light pulses, radio wave pulses in wifi devices, and conversion of stored binary patterns to make sound or text on a computer screen.] [*Assessment Boundary: Assessment does not include binary counting. Assessment does not include the specific mechanism of any given device.*]	**Obtaining, Evaluating, and Communicating Information** • Integrate qualitative scientific and technical information in written text with that contained in media and visual displays to clarify claims and findings.	**PS4.C: Information Technologies and Instrumentation** • Digitized signals (sent as wave pulses) are a more reliable way to encode and transmit information	**Structure and Function** • Structures can be designed to serve particular functions.

8th Grade Science Unit 4: Using Engineering and Technology to Sustain Our World

Task 5: Using Waves to Communicate Information

Supplementary Science and Engineering Practices • Engaging in Argument From Evidence   ○ Construct an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.
Equity and Groupwork • Work with a partner to test out analog vs. digital sounds. • Discuss similarities and differences between waves with a partner. • Discuss ideas in a group.
Language • Read and annotate articles. • Use a Venn Diagram to compare and contrast. • Critique an argument's evidence and reasoning. • Construct an argument supported by evidence and using compare-and-contrast language. • Learn and apply new vocabulary terms related to waves.

Learning Goals

This learning task explores how digital waves are a more reliable way to encode and transmit information. More specifically, the purpose is to:

- Explore the difference between analog and digital sounds.
- Gather information about analog and digital waves.
- Create a Venn Diagram to compare and contrast analog and digital waves.
- Use evidence to write a recommendation on which type of wave to use.
- Apply knowledge of analog and digital waves to satellite imaging.
- Brainstorm other ways waves can be used to communicate information to solve the problem.

Content Background for Teachers

In this task, students continue their study of waves, but specifically focus on the difference between analog and digital waves, including which is better for communicating information over long distances. Because the science and engineering practice for this unit is **Obtaining, Evaluating, and Communicating Information**, you can find all the necessary background in corresponding student resources for this task as well as in the teacher instructions below. The student resources are in many different formats in alignment with the goal of this SEP to integrate qualitative scientific and technical information in written text with that contained in media and visual displays. For more general background on waves, please see the Background sections of Task 3 and Task 4.

Academic Vocabulary

- Digital wave
- Analog wave
- Communication
- Satellite imaging
- Monitor
- Mitigate

8th Grade Science Unit 4: Using Engineering and Technology to Sustain Our World

Task 5: Using Waves to Communicate Information

Time Needed (Based on 45-Minute Periods)
4-5 Days
- Engage: 0.5 period
- Explore: 1-2 periods
- Explain: 1 period
- Elaborate: 0.5 period
- Evaluate and Reflection: 1 period

Materials
- Unit 4, Task 5 Student Version

Engage (Per Pair)
- Device with Oscilloscope app downloaded (same as used in Task 3 and 4)

Explore
- Whole Class Materials
    - Computer and Projector
    - Explore Photos
    - LP Record and CD or Radio and handheld device
    - Speakers
- Individual Materials
    - Analog and Digital Waves Article

Explain
- Critique Clarify Correct Graphic Organizer (Optional – 1 per student)

Evaluate
- Project Organizer Handout

Instructions

Engage
1. Introduce to Task 5: So far, we have learned that waves transfer energy; this means water waves and light waves might be good options for alternative forms of energy that place less strain on Earth's systems. Think about what you were still wondering about at the end of the last task (look back if you need to). What questions do you still have?
    - Before you pass out their student guide, give students time to reflect individually or with a partner about the questions they recorded at the end of the last task. Share a few of these out as a class, using facilitating questions to guide students toward questions that relate to this task.

2. Transition to Task 5: These technologies, however, are not the only ways waves might help you with the problem you are facing in your culminating project. Today we will consider the question, what other wave technologies might help us reduce the ways humans harm Earth?
    - Now pass out their Task 5 student guide. We recommend reading the introductory material on the student guide aloud. This introductory material introduces students to satellite imagery and also transitions them to the question of how analog vs. digital waves communicate information.

3. In pairs, have students discuss the question: How do you think our voices compare to digital recordings. Then they will investigate this using the same oscilloscope app they used in Task 3 and 4 and following the directions on their student guides.
   - By comparing how their own voice appears in the oscilloscope to the way a digital recording appears in the oscilloscope, they will notice a few patterns that will lay the foundation for the rest of the task.

4. After students do the investigation, have them discuss and answer the questions on their student guide, which pull out some of the patterns we want them to see. We highly recommend debriefing these questions in a class-wide discussion. You may use the questions on the student guide as facilitation.
   - Students should have noticed that the digital sounds are easiest to copy exactly. This would be really important to send waves to many people. In the case of the satellite images, it is also important that the images of the area remain the same so comparisons can be noticed over time. This would require the wave to be copied exactly for each image. Responses to the last question will be opinion-based at this point, but students will likely guess digital sounds are best for people far apart, since they can be copied exactly.
   - To get the discussion started, use equity sticks for more equitable participation (See "How To Use This Curriculum" for more details).

Explore

1. Now that students have begun to make comparisons between analog and digital waves based on experience, it is time for them to collect more detailed information for a better comparison.
   - In this activity, students are practicing the skill of **Obtaining, Evaluating, and Communicating Information,** as they integrate qualitative scientific and technical information from an article with that contained in media (song recordings, videos) and visual displays (photographs). They will then combine all this information to clarify a claim in the Explain.

2. First, review the image of a digital wave vs. an analog wave present in their student guide. You may want to project this on the board.
   - Optional: Conduct a brief discussion on the differences and similarities they notice.
   - Emphasize to students that they should keep these structural differences in mind as they gather information and think about the way the structure affects function. This draws attention to the crosscutting concept students are exploring in this task, **Structure and Function**—specifically how the structure of digital waves are designed to be able to be reproduced accurately for transmission over long distances (function).

3. Present the first set of information—pairs of images and different recordings of songs.
   - For each of these pairings, you may choose to have students do their observations independently, in pairs, or in groups. We recommend having students first record their own observations, then discuss the images in pairs/groups, debrief in a class-wide discussion, and add to their observations.
   - Project the images provided in the corresponding document to this task.
   - Then play recordings of songs from either a radio vs. a handheld device, recording vs. singing in person, or a CD vs. LP record, depending on the materials you have available.

- Here students are really trying to notice patterns of similarities and differences between analog and digital waves.

4. The next set of information is also presented as a class. Play the following video about analog and digital waves: https://www.youtube.com/watch?v=XCu6L4kQF3k.
    - We recommend playing the video twice. For the first time, students should just watch and listen. During the second time, students can take notes in their student guide.
    - After the video, we highly encourage students share out a few important facts with the class as well as questions they are struggling with. During this discussion, you may want to highlight how the structure of each wave affects their functions in the video, if it is not brought up already. This reinforces student understanding of the crosscutting concept of **Structure and Function**, defined above.
        i. As always, the use of equity sticks is encouraged for more equitable participation in class-wide discussions (See "How To Use This Curriculum" for more details).

5. Lastly, students read a much more detailed article on analog and digital waves. They should use whatever annotation strategy is most familiar to them in your classroom.
    - If you don't have a specific strategy, you may want to use the following option:
        i. Highlight key information (use sparingly)
        ii. Underline unclear text
        iii. Circle words you find important
        iv. Write summaries and questions in the margins

Explain

1. Because students were given a lot of information in the Explore, it is important they have time to process and organize this information with a partner.
    - Both partners should look through their information collection charts as well as their article annotations. Using these sources, they will fill out the Venn diagram with key information, citing where they got the information in parentheses. In the end, this will create a complete picture that compares and contrasts analog and digital waves, so they can make an informed recommendation in the next step. It also scaffolds the process of including evidence and an identification of where each piece came from.

2. Now it's time for students to choose a wave: analog or digital. Which wave is a more reliable way to communicate information about excess resource consumption to people around the world? Why?
    - Students should individually write a recommendation that uses evidence and solid reasoning. This emphasizes the supplementary SEP of **Engaging in Argument From Evidence**, as students construct a written argument supported by evidence and scientific reasoning to support one solution to a problem over another. This also concludes students' practice of the SEP of **Obtaining, Evaluating, and Communicating Information** in this task, as students use the variety of information they have already gathered to clarify claims and findings in this recommendation.
    - Optional Sentence Stems to Provide:

• Based on the evidence, _____ are more reliable to communicate information about excess resource consumption, like satellite images, to people around the world.

- In the Engage, my partner and I noticed that…
- While the analog wave was ____, the digital wave was ___.
- While the analog wave appeared ____, the digital wave appeared ____.
- This was reinforced by the video when…
- Analog waves….Digital waves, however,….
- This was also shown in the digital vs. analog photos, in which…
- Because ____, it is best if the waves…
- We want the satellite images to ______, so….
- Thus, ____ are a better option for…

- Sample Paragraph:

Based on the evidence, digital waves are more reliable to communicate information about excess resource consumption, like satellite images, to people around the world. In the Engage, my partner and I noticed that while the analog wave was difficult to recreate exactly on the oscilloscope, the digital wave was always the same. This was reinforced by the video, where it showed how an analog wave between phones would degrade over time and wouldn't get put back together correctly. However, digital waves, with the 0-1 signal, were able to be put back together very accurately. This was also shown in the digital vs. analog photographs, in which the digital photograph was much clearer than the analog. Because information, like the satellite images, have to be communicated long distances all over the globe, it is best if the waves can be easily recreated. We also want the images to be very clear, so people can compare two images to see the problem. Thus, digital waves are a better option for this purpose than analog waves.

3. To scaffold this recommendation as well as highlight the writing skills of using evidence and reasoning in an argument, we recommend doing a "Critique, Clarify, and Correct" language strategy for this activity.
   - First, have students write their claim in pairs or individually.
   - Then provide students with the following template to do a "Critique Clarify Correct" focusing on evidence and reasoning. We recommend having them do their analysis of the sample individually, then discuss as a group and debrief as a class (Directions #1 and #2 below)
   - After the analysis, writing time should be individual (Direction #3 below), as you may want to use it as a formative assessment. If used as a formative assessment, collect student work to identify trends in students' ability to incorporate evidence that is relevant to the claim and connect with solid scientific reasoning. See "How to Use This Curriculum" for strategies on utilizing formative assessment data to provide feedback to students and inform classroom instruction.

Critique, Clarify, and Correct: Analog vs. Digital Waves

In pairs:

1. Critique: Analyze the paragraph for **evidence and reasoning**.
2. Clarify: Look at what the prompt asks and identify what the sample might be missing.
3. Correct: Write a response that is more complete on your student guide.

Prompt: Now it's time to choose your wave: analog or digital. Which wave is a more reliable way to communicate information about excess resource consumption to people around the world? Why? Individually write a recommendation, using evidence from the Engage and Explore and scientific reasoning to support your choice. Sample Recommendation**:** I recommend using digital waves to communicate information about resource consumption because evidence shows that they are better for long-distance, accurate communication. I saw that with digital waves, you could create the same exact wave each time. They also create clearer images and sounds. We would want this for things like satellite imaging, so people could really see what is happening to Earth over time.

Elaborate

1. Lastly, students can use everything they have learned to apply to a solution specific to the overarching problem.

2. Project the following video so students can see more satellite images of how human activities are affecting Earth: https://www.youtube.com/watch?time_continue=147&v=MNQ9z_Eb-Jc.
   - After the video, review the information on their student guide that explains how this satellite imaging works, taking questions as needed.

3. In groups, have students then discuss the two questions on their student guide.
   - For the first question, students should identify that digital waves are necessary because they can be reconstructed accurately after travelling long distances. This is essential not only because the satellite is in space and these images must be widely distributed to have impact, but also because the images would need to be very accurate to show change over time in the same area.
   - For the second question, students make a connection back to the criteria of the problem. In other words, how exactly does this help mitigate the effects on resource consumption? We hope students will consider their own reactions to the video and think about how this kind of awareness globally might make humans consume less, based on an ethical and moral perspective.
   - Optional: We highly recommend discussing responses to these questions in a class-wide discussion. This will bring students back to the intention behind learning about analog and digital waves in this task.

4. Return to the whole-class concept map from the Lift-Off Task
   - In small groups, have students brainstorm new concepts and new connections that they have learned in this task, as well as any new questions that have come up for them. Then have groups share these aloud in a class-wide discussion and add to the class concept map. The use of equity sticks is encouraged for more equitable participation in class-wide discussions (See "How To Use This Curriculum" for more details).
     - Some facilitating questions to ask students are: What new ideas/concepts do you want to add to the map? What connections do you want to add or change? What is your reason for that addition/revision? What connections can we make between the questions/ideas already on the map? What new questions do you have about the phenomenon?

        - Draw circles around each question and boxes around each concept.
        - Write connector words to describe connections between the concept boxes.
        - For this task, students may begin to connect some of their previous question circles to concept boxes about the following: another solution that uses wave technology, digital vs. analog signals, and satellite image monitoring of resource consumption.
    - Have students analyze the additions to the class concept map for as many examples of this task's crosscutting concept as they can find. Once a student has identified the crosscutting concept, you can trace the circle in the corresponding color (decided on in the Lift-Off task). We recommend asking students to share key words that helped them identify the crosscutting concept for that concept or question. Some identifying words students might look for are:
        - **Structure and Function**: These could be phrases such as, "its shape affects its function by," "structure causes it to," "functions this way because of," etc.
    - Once again, the purpose of this concept map is to facilitate generation of student questions, promote language development, and support understanding of the science content throughout the unit. Allowing students to ask their own questions and use their own words to make meaning of the concepts will not only help them make deep connections about science content, but will also help their oral and written language development.

Evaluate: Connecting to the Culminating Project

1. Students independently complete the Task 5 section of the Unit 4 Project Organizer in class. Revisions can be done for homework, depending upon student's needs and/or class scheduling.

2. Students have been tasked with presenting a poster at a Resource Conservation Conference that showcases one solution to help monitor or lessen the effects of human overpopulation and excess resource consumption. Their prompt is as follows: Besides alternative energy sources, there are other ways we can use waves to monitor resource consumption or mitigate (reduce) the effects on Earth.
    - What technology did you learn about in this task that can be used to monitor resource consumption or mitigate the effects on Earth?
    - Can you think of any other ways that waves can communicate information to help mitigate effects on Earth?
    - Are analog or digital waves a better option for these solutions? Why? Explain using knowledge of their structure and function.

Reflection

1. At the end of the task, ask students to reflect on what they have learned over the course of this task by answering the following three questions in their student guide:
    - At the beginning of this task, you experienced and compared analog vs. digital waves for the first time. Look back at your conclusions: after gathering all the information in this task, how would you add to or revise your conclusions?
    - In this task, we focused on the following crosscutting concept: **Structure and Function**: by noticing how an object's structure can be designed to serve particular functions. Where did you see examples of **Structure and Function** in this task?
    - Now that you have learned about another technology involving waves and will soon be moving on to your culminating project, what questions do you still have?

2. There are no right answers, but encourage students to look back at their Engage and their class concept map. They should not change their initial responses, but rather use this reflection space to add their ideas and questions based on what they have learned throughout this task. By generating more of their own questions, students continue to engage in sense-making of the phenomenon and the gathering of knowledge and skills for their final project.

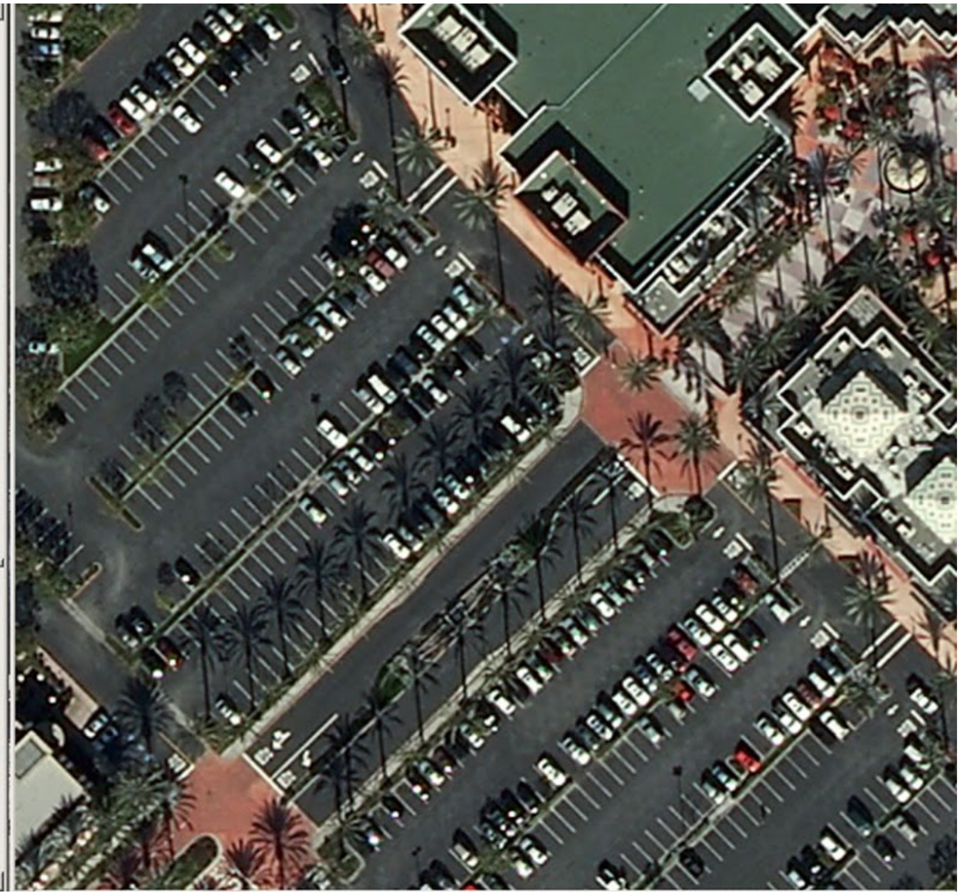
Assessment

1. You may collect the Project Organizer and assess using:
   - *Criteria of your choice.* We recommend using the Alignment Table at the beginning of this document to inform your criteria.
   - This can be a formative tool to periodically look for trends in student understanding after the completion of a task. You can then use this formative data to inform any re-teaching, as necessary.

2. You may also give students time to make revisions with one of the two options:
   - Students may make changes to their Project Organizer according to your comments OR
   - Ask students to exchange Project Organizers with a partner and give partners 5 minutes to give written feedback. Then allow students time to make changes to their work according to the feedback.

Analog

Digital



Analog

Digital

Analog and Digital

Adapted from Chris Woodford (2016)

Images from www.explainthatstuff.com/analog-and-digital.html

Back in the late 1970s, one of the most exciting things you could own was a digital watch (see image left) Instead of trying to figure out the time from slowly rotating hands, as you had to do with an old-style analog watch (see image right), you simply read the numbers off a digital display. Since then, we've got more used to the idea of digital technology. Now pretty much

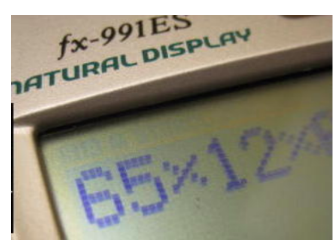
everything seems to be digital, from television and radio to music players, cameras, cell phones, and even books. What's the difference between analog and digital technology? Which is best? Let's take a closer look!

What does analog actually mean? If you have an analog watch, the hand's movements over the dial are a way of representing passing time. It's not the same thing as time itself: it's a representation or an analogy of time. The same is true when you measure something with a ruler. If you measure the length of your finger and mark it on the surface of a wooden ruler, that little strip of wood or plastic you're looking at (a small segment of the ruler) is the same length as your finger. It isn't your finger, of course—it's a representation of your finger: another analogy. That's really what the term analog means.

Analog measurements? Until computers started to dominate science and technology in the early decades of the 20th century, virtually every measuring instrument was analog. If you wanted to measure an electric current, you did it with a moving- coil meter that had a little pointer moving over a dial. The more the pointer moved up the dial, the higher the current in your circuit. The pointer was an analogy of the current. All kinds of other measuring devices worked in a similar way, from weighing machines and speedometers to sound-level meters and seismographs (earthquake-plotting machines).

Analog information? However, analog technology isn't just about measuring things or using dials and pointers. When we say something is analog, we often simply mean that it's not digital: the job it does, or the information it handles, doesn't involve processing numbers electronically. An old-style film camera is sometimes referred to as example of analog technology. When the film is developed (chemically processed in a lab), it's used to print a representation of the scene you photographed. In other words, the picture you get is an analogy of the scene you wanted to record. The same is true of recording sounds with an old-fashioned cassette recorder. The recording you make is a collection of magnetized areas on a long reel of plastic tape. Together, they represent an analogy of the sounds you originally heard.

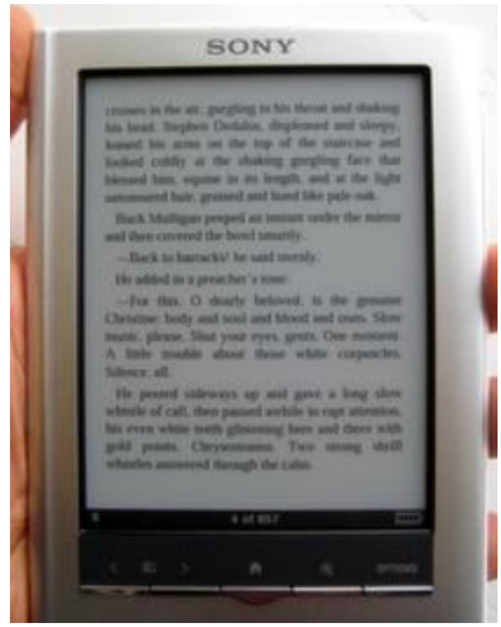
What is digital technology? Digital is entirely different. Instead of storing words, pictures, and sounds as representations on things like plastic film or magnetic tape, we first convert the information into numbers (digits) and display or store the numbers instead.



Digital measurements. Many scientific instruments now measure things digitally (automatically showing readings on LCD displays, like the calculator in the image to the right) instead of using analog pointers and dials. Thermometers, blood-pressure meters, multimeters (for measuring electric current and voltage), and bathroom scales are just a few of the common measuring devices that are now likely to give you an instant digital reading. Digital displays are generally quicker and easier to read than analog ones; whether they're more accurate depends on how the measurement is actually made and displayed.

Digital information. All kinds of everyday technology also works using digital rather than analog technology. Cell phones, for example, transmit and receive calls by converting the sounds of a person's voice into numbers and then sending the numbers from one place to another in the form of radio waves.

Which is better, analog or digital? Used this way, digital technology has many advantages. It's easier to store information in digital form and it generally takes up less room. You'll need several shelves to store 400 vinyl, analog LP records, but with an MP3 player you can put the same amount of music in your pocket! Electronic book (ebook) readers are similar: typically, they can store a couple of thousand books— around 50 shelves worth—in a space smaller than a single paperback!



Digital information is also generally more secure: cell phone conversations are encrypted before transmission—something easy to do when information is in numeric form to begin with.

You can also edit and play about with digital information very easily. Few of us are talented enough to redraw a picture by Rembrandt or Leonardo in a slightly different style. But anyone can edit a photo (in digital form) in a computer graphics program, which works by manipulating the numbers that represent the image rather than the image itself.

Just because digital technology has advantages, that doesn't mean it's always better than analog. An analog watch might be far more accurate than a digital one if it uses a high-precision movement (gears and springs) to measure time passing, and if it has a sweeping second hand it will represent the time more precisely than a digital watch whose display shows only hours and minutes. Generally, the most expensive watches in the world are analog ones (of course, that's partly because people prefer the way they look). Although, the world's most accurate atomic clocks show time with digital displays

One interesting question is whether information stored in digital form will last as long as analog information. Museums still have paper documents (and ones written on clay or stone) that are thousands of years old, but no- one has the first email or cell phone conversation. Open any book on the history of photography and you'll see reproductions of early photos taken by Niepce, Daguerre, and Fox-Talbot. But you won't see any pictures of the first digital photo: even though it was much more recent, probably no-one knows what it was or who took it!

Lots of people own and cherish plastic LP records that are decades old, but no-one attaches the same importance to disposable MP3 music files. That's why, though the future may be digital, analog technology will always have its place.