SEEd Swap Workshop
2017
6th Grade
Welcome to the 2017 SEEEd Swap Teacher Workshop

It’s an exciting time for the world of science instruction; advances in cognitive and pedagogical research are reshaping the way we think about engaging students in science and engineering. The state of Utah has reflected these improvements in the new 6-8th grade SEEEd (Science and Engineering Education) Standards, which will be implemented across the state during the 2017-2018 school year. While this change is exciting, it also poses significant challenges. The SEEEd standards are built on Disciplinary Core Ideas, as were the previous standards. The new components include the explicit integration of Science and Engineering Practices into every single standard, and the framing of ideas within Crosscutting Concepts to allow instructors to help students organize their thoughts. These three components, called ‘dimensions,’ when anchored to instruction that allows students to explore phenomena they encounter in the world, allows students to act as sense-makers and science/engineering practitioners.

In order to provide 6-8th grade teachers with professional learning support to successfully implement the new standards, the Center for Science and Mathematics Education (CSME) is offering a week-long workshop focusing on the content that has ‘swapped,’ or is new to each grade – the “SEEEd Swap.”

USBE Credit:
80% documented attendance, taken 2x daily by your instructor, as well as an accurate CACTUS ID number on record, are required to earn 3 USBE credits.

Supply Stipend
A $150 check will be issued to each attendee who
Completed the pre-assessment by the July 29th deadline
Attend 100% of the workshop
Complete the post-assessment between noon on Aug. 4 and midnight Aug. 8th.

Curricular Resources
The majority of the resources found in this book will be available online at the Center for Science and Mathematics Education website: https://csme.utah.edu/resources/k12curriculum/
Megan Black

Megan Black is an elementary science curriculum specialist in Granite School District. She taught science for twelve years working with students in grades 4 - 9, but most often 6th grade. Megan was on the 6th grade SEEd standards writing committee and has been involved with developing the 6th Grade SEEd OER textbook. She is interested in developing curriculum and instructional strategies that engage students as scientists as they explore and figure out the natural world around them.

Sarah Braden, Post Doc Fellow

Sarah K. Braden started her career in education as a high school biology, physics, and English as a Second Language (ESL) teacher. Dr. Braden is currently an Assistant Professor of English Language Learner education in The School of Teacher Education and Leadership at Utah State University. Her research centers on understanding language socialization phenomena and promoting equity the sciences.

Ben Breinholt, Professional Educator at Granite School District

I am a Utah native and have lived in the Salt Lake area primarily. I worked over twenty-five years as an outside sales representative in the private sector before I was inspired to go back to school to become a school teacher. I have been a sixth-grade teacher for the past eleven years at West Valley Elementary. Through the opportunities provided by Granite School District I have received my ESL and Math Endorsements, a Master of Education, and most recently my STEM Endorsement. I feel extremely fortunate to be a teacher and love working with kids and my colleagues.

Brad Carroll, Professor Emeritus - Physics, Weber State University

Brad Carroll began his career as a high school math and physics teacher in Bakersfield, California. After receiving his Ph.D. in astrophysics from the University of Colorado, Brad spent time as a postdoc at the University of Rochester before joining the Physics Dept. at Weber State University in 1985. At WSU, Brad collaborated with faculty in the Dept. of Chemistry to develop a unique physical science course for elementary education majors. He also co-authored An Introduction to Modern Astrophysics, the standard undergraduate astrophysics text. Brad retired in 2015 after 30 years at WSU, 10 of them as chair of the Physics Department. In retirement, he continues to teach with the Physics Department and Honors Program, and is working on the third edition of his astrophysics text.
Jordan Gerton, Director of CSME and Associate Professor of Physics

I received my Bachelor’s degree in Engineering Physics from the University of Arizona and my Master’s and Doctorate degrees in Physics from Rice University. I have had a number of formative experiences over the years that have stoked my passion for math and science education and have driven me to leadership roles in these areas. Math and Science are among the most important and impactful human pursuits, and I am committed to helping students of all ages and backgrounds develop a passion for and proficiency in these enabling disciplines.

Holly Godsey

Dr. Holly Godsey is the Director of Student Success and Teacher Development at the CSME and an Associate Professor (Lecturer) in the Department of Geology and Geophysics. She has a BS and PhD in Geology from the University of Utah and an MS in Oceanography (Marine Geology and Geochemistry) from the University of Michigan. Since 2004, she has been involved with several science education projects that connect faculty, graduate and undergraduate students to K-12 teachers and students to inspire, empower and educate learners from across generations and disciplines.

Maura Hanenberger

Maura Hahnenberger is an Assistant Professor in the Geosciences Department at Salt Lake Community College. At SLCC she teaches and advises in the Atmospheric Sciences and Geography programs in both face to face and online settings. Maura is the founder of the WaterGirls outreach program which provides middle school girls with field experiences conducting water science. She also serves on the boards of the SLCC Chapter of the Utah Women in Higher Education Network, Utah Chapter of the American Meteorological Society, and the Earth Science Women’s Network.

Emily Harward, 7th & 8th Grade Science & Biology Teacher at Granite Schools

Emily was lucky to grow up in the Salt Lake Valley, with opportunities to spend time exploring nature. She graduated from the University of Utah in 2004, and has been teaching science at Evergreen Junior High in Granite District ever since. For Emily, the most rewarding part of teaching is developing lessons and activities that provide a pathway for students to develop their own understanding and make sense of the world they live in.
Patrice Kurnarth

Patrice received her B.S. in Biology from Ithaca College and worked in academia for a few years at Yale University and UC Berkeley. She earned her Ph.D. in Biology from the University of Utah in 2016. During her doctoral thesis, Patrice worked with middle school science teachers in the Salt Lake valley for two years as part of a GK-12 graduate school fellowship funded by the National Science Foundation. This experience was truly transformative for Patrice because she learned about pedagogical theory and experienced first-hand the set-backs and successes of teaching.

Jaleigh Mecham, 6th grade teacher at Granite School District

My name is Jaeleigh Mecham. I graduated from the University of Utah in 2013 with a bachelor’s degree in Elementary Education with a minor in Spanish Teaching. I have endorsements in Early Childhood, ESL, and STEM. I have been at Fox Hills Elementary for 4 years. In my spare time I love to be active outdoors! Hiking, biking, and camping are some of my favorites.

Candace Penrod, District Science Supervisor at SLC School District

Candace’s teaching career began in California in elementary education. Upon moving to Utah, she transitioned to secondary science teaching, followed by several years as instructional coach. She is currently the District Science Supervisor for Salt Lake City School District. Candace obtained a Master in Education from the University of Utah in 2009 and a Master of Science in Earth Science Teaching from the University of Utah. Candace is passionate about K-12 science education and continually seeks for opportunities to improve science teaching and student learning at all levels.

Scott Roskelley, Science Assessment Specialist at Utah State Board of Education

Scott was born and raised in Chicago, Illinois and from a young age loved science. He holds degrees in wildlife biology, marine biology, teaching and learning, and educational administration. Never expecting to work in education, Scott fell into teaching in 2001 as he entered the alternative route to licensure in Utah. Scott worked for 15 years in the Jordan School District, mostly teaching middle school. Now as the state science assessment specialist, he is responsible for working with Utah teachers to develop the new end-of-year assessment for the new SEEEd standards.
James Ruff

I am an evolutionary biologist studying basic evolutionary topics including sexual selection, and the forces maintaining genetic diversity in populations; furthermore, I apply evolutionary principles and techniques to questions concerning nutrition, toxicology, and pharmaceutical safety assessment. I am passionate about science education and prefer to focus on the process of science relative to the ‘fruits’ of the process. In this vein, I incorporate study designs, data analysis and writing into each of my courses. I have been a teaching fellow at both elementary and middle schools in SLCSD.

Holly Vancouwenberghe

Hi! My name is Holly VanCouwenberghe and I am a 6th grade teacher at Hillsdale Elementary School. I am entering my 13th year of teaching, and have taught 4th grade, 5th grade, and 6th grade, but I have been mostly in 6th. I have a bachelor’s degree in Elementary Education, Master’s in Educational Psychology, and endorsements in Early Childhood Education, English Language Learning, and STEM.

Sara Yearsley

Sara is an Earth Science teacher as Weber school district.

Tamara Young, Academic Advisor in the Department of Physics & Astronomy

Tamara’s interest in physics began in high school. As an undergraduate at Utah State University, Tamara’s studies focused on nuclear and particle physics. Tamara taught science and math for several years in the public education system. After grad school, Tamara again taught science and math in the public education system. For the last couple years, Tamara has taught astronomy at SLCC, participated in course curriculum development with CSME, and taught a computational astronomy course for Master’s students in Physics Teaching. Tamara is the academic advisor in the Department of Physics & Astronomy at the University of Utah. She also engages in public outreach and education, and loves to talk about physics.
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**Strand:** States of Matter and Density 6.2.1 and 6.2.2

6.2.1 Develop models to show that molecules are made of different kinds, proportions and quantities of atoms. Emphasize understanding that there are differences between atoms and molecules, and that certain combinations of atoms form specific molecules. Examples of simple molecules could include water (H$_2$O), atmospheric oxygen (O$_2$), and carbon dioxide (CO$_2$).

Standard 6.2.2 Develop a model to predict the effect of heat energy on states of matter and density. Emphasize the arrangement of particles in states of matter (solid, liquid, or gas) and during phase changes (melting, freezing, condensing, and evaporating).

**Emphasis:** States of Matter and Density

**Anticipated Time Required (assuming 50 minute class periods):** 10

**Dominant CCC:**

Proportion and quantity-time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.

Cause and effect relationships may be used to predict phenomena in natural or designed systems.

Models can be used to represent systems and their interactions.

**Dominant SEP:**

Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms.

Solids, liquids, and gases are made of molecules or inert atoms that are moving about relative to each other. Widely spaced (gas), closely spaced (liquid), or vibrating in place (solid).

The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter.

The term “heat” as used in everyday language refers both to thermal energy (the motion of atoms or molecules within a substance) and the transfer of that energy.

**Management Strategies to support equitable access to content:**

Small groups or partner work, multi-level ability groups, and reteaching when necessary.
Shopping list:

Root beer (enough for your class to have floats)
Vanilla ice cream (enough for your class to have floats)
30 clear plastic cups
30 spoons
Hot pot
Gum drop candies (5-6 bags)
Toothpicks
Food coloring
Clear plastic containers (15 - larger enough to hold a half gallon or more of water)
Empty water bottles (30)
Balloons (60)
Pie pans (15-18 depending upon class size)
Fun size snickers
Fun size kit kats
Fun size milky ways
Fun size 3 musketeers
Fun size m-ms
30 pint jars
Variety of objects for density jars: bolts, nails, screws, rocks, cereals, styrofoam, swedish fish, nuts (metal), bouncy balls, etc.
Sharpies (just black ones, about 10)
Fabric measuring tapes (enough for 15)
Olive oil
Ice cube tray
Anchor Phenomenon: What is happening to the molecules in the ice cream as it melts? (What I want kids to answer.)

When I add ice cream to my root beer, the ice cream starts to melt. If the ice cream is melted, is it still ice cream?

Standards:

6.2.1 Develop models to show that molecules are made of different kinds, proportions and quantities of atoms. Emphasize understanding that there are differences between atoms and molecules, and that certain combinations of atoms form specific molecules. Examples of simple molecules could include water (H₂O), atmospheric oxygen (O₂), and carbon dioxide (CO₂).

Standard 6.2.2 Develop a model to predict the effect of heat energy on states of matter and density. Emphasize the arrangement of particles in states of matter (solid, liquid, or gas) and during phase changes (melting, freezing, condensing, and evaporating).

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<td>Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms.</td>
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<td>Construct an explanation using models or representations.</td>
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occur with variations in temperature or pressure can be described and predicted using these models of matter.

The term “heat” as used in everyday language refers both to thermal energy (the motion of atoms or molecules within a substance) and the transfer of that energy.

| Resources: | What is the world made of? : all about solids, liquids, and gases  
by Zoehfeld, Kathleen Weidner.  

Joe-Joe the wizard brews up solids, liquids, and gases  
by Braun, Eric  

https://www.youtube.com/watch?v=ZqjR2PFvA28 SubZero Ice Cream Science  

http://www.ptable.com/ Interactive Period Table  


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<th>Science Experiences</th>
<th>CCC/SEP</th>
<th>What are students doing?</th>
<th>What specific understandings should students get from this experience? (What)</th>
<th>New questions students have to propel us to the next</th>
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<tr>
<td><strong>Using models to understand and ask questions.</strong></td>
<td><strong>Root Beer Float observations:</strong> Students will be making observations of the root beer floats they were given. They will be drawing a model and labeling the parts of the float with the different observations that they make about each part. They also will be making a list of questions they have about their root beer float.</td>
<td>Matter has three states: solid, liquid, and gas.</td>
<td><strong>Science experience</strong></td>
<td>Model of float in their science notebook with observations made and questions listed. Model of a float must have each part labeled and observations made about each part. With the model, students should have a list of questions that they have about their root beer floats that will drive their learning.</td>
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<td><strong>Gas Demonstration:</strong> <a href="http://www.giftofcuriosity.com/states-matter-dancing-raisins-experiment/">http://www.giftofcuriosity.com/states-matter-dancing-raisins-experiment/</a></td>
<td><strong>Boiling ice cubes:</strong> Students will watch a demonstration of me placing ice cubes into a hot pot. They will watch the ice cubes heat up and melt. When the water starts to boil, they will watch the water turn into steam and evaporate. We will run this demonstration until there is no water left in the hot pot. Students will be prompted after each state change to explain what is happening to the molecules in the different states.</td>
<td>Adding energy changed the substance (water). During a phase change, the arrangement of atoms don’t change; each molecule still has the same atoms.</td>
<td>If adding heat doesn’t change the composition of the molecules, how <strong>does</strong> it affect the molecules?</td>
<td>Students will create a table in their notebooks and fill out the properties of matter illustration to represent the molecular movement in each state of matter. Students will also draw and explain why the ice cubes went from a solid to a liquid, to a gas. They will also show that the molecules found in water do not change</td>
<td></td>
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<tr>
<td>Develop a model to represent molecules.</td>
<td><strong>GumDrop Molecules</strong>: Students will be using gumdrops and toothpicks to build models of molecules found in their root beer floats. They will also be drawing these models in their notebooks using zoom-in boxes so that they will have up close pictures of the different parts of their root beer floats.</td>
<td>Matter is made of molecules. Molecules have individual components called atoms. Water molecules are made of two hydrogen atoms and one oxygen atom, oxygen is made of two oxygen atoms, and carbon dioxide is made of one carbon atom and two oxygen atoms.</td>
<td>How are the molecules in the ice cream changing as it melts into the root beer? Students will be able to build a model of oxygen, carbon dioxide, and water using gum drops.</td>
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</table>

| Develop and use a model to show particles in motion in water. | **Food Coloring in Water**: Students will be creating a model that demonstrates that when food coloring is dropped into water, it mixes into the water without human help. They will be dropping food coloring into hot water, warm water, and cold water. They will be drawing a model of each experiment in their notebook and using a timer to time the distribution of the food coloring throughout the water. 

Note to teacher: Do not have ice in your cold water. It will alter the experiment and not give you the results that you desire. 

Background: Having ice in the water causes the food coloring to mix faster. | Water is made of particles that are constantly in motion. Particles in warm water move faster than particles in cold water but the particles do not change. | What happens to a substance if the molecules are moving faster? How does the movement of molecules affect the substance? Models drawn of the experiment in their notebook. A small table drawn and labeled in their notebook containing the time it takes for the food coloring to mix with water at different temperatures. Temperatures of the water will also be listed. They will also, as a quick assessment, show the changes in the motion of the molecules in ice cream as it is melted. This will be recorded |
The ice floats, but as it melts, the more dense cold water sinks to the bottom taking the food coloring with it.

**Water Bottle Experiment:** With assistance, students will be setting up an experiment using a water bottle, balloon, and two pans of different temperature water. Students will be making observations on what happens to the balloon when the bottle is placed in the pan of cold water. Students will then be making observations on what happens when the bottle is placed in hot water. [http://www.daviddarling.info/childrensencyclopedia/heat_Chapter1.html](http://www.daviddarling.info/childrensencyclopedia/heat_Chapter1.html)

Thermal energy increases particle movement and causes expansion. When thermal energy decreases, particle movement will decrease and will contract.

Experiment and observations in notebook.

Student will design a new models of their root beer float in their science notebook. In this model, they will need to include the structure of the molecules in the root beer float, how the molecules change when heat energy is added (being specific to show that the molecules are made of the same atoms but the state has) and show how the molecules have spread out and are moving.

Students will then compare this model to the original model that they drew on the first day of class. They will note what changes they have made to their model as the experience has progressed.
They could be adding this to their model of the phenomenon (RBF or weather); by now their models have been added to/revised to include:

- Composition of specific molecules (6.2.1)
- Effects of adding thermal energy on molecular motion, density and state (6.2.2)

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**Storyline - Density - VanCouverberghe**

**Anchor Phenomenon:** Why do some objects sink in water while other objects float? (What I want them to answer.)

Joseph likes to play in the water. Last night he dropped a rubber ducky into the bathtub and his bottle of shampoo. The duck floated on the surface of the water, but the bottle of the shampoo sunk to the bottom of the bathtub. Why did this happen?

**Standards:**

Standard 6.2.2 Develop a model to predict the effect of heat energy on states of matter and density. Emphasize the arrangement of particles in states of matter (solid, liquid, or gas) and during phase changes (melting, freezing, condensing, and evaporating).

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Solids, liquids, and gases are made of molecules or inert atoms that are moving about relative to each other. Widely spaced (gas), closely spaced (liquid), or vibrating in place (solid).

The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter.

The term “heat” as used in everyday language refers both to thermal energy (the motion of atoms or molecules within a substance) and the transfer of that energy.

**Resources:**

- [https://www.youtube.com/watch?v=JsoE4F2Pb20](https://www.youtube.com/watch?v=JsoE4F2Pb20) Drum Crush
- [https://www.youtube.com/watch?v=xg5NiQwф_Zw](https://www.youtube.com/watch?v=xg5NiQwф_Zw) Can Crush
- [https://www.youtube.com/watch?v=Zz95_YvTxZM](https://www.youtube.com/watch?v=Zz95_YvTxZM) Railroad Car Vacuum
## Science Experiences

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<th>New questions students have to propel us to the next science experience</th>
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<tr>
<td>Construct an explanation as to why some objects float in water while others sink.</td>
<td>Review molecule movement in different states of matter.</td>
<td>Some things float in water and some things sink in water.</td>
<td>What makes some things float and other things think in water?</td>
<td>Students will have a table to take home where they will have to test 5 home objects to see whether they sink or float with predictions made about each one. They will also have to explain each object. Notebook table with their candy bar experiment results and explanations.</td>
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<tr>
<td>Candy Bar Experiment: Students will get mini candy bars of the following varieties: Kit Kat, Milky Way, 3 Muskateers, Snickers, and M-Ms. They will conduct an experiment where they determine which of the candy bars will sink, and which ones will float. They will make a prediction, run the experiment and record the results, and then develop an explanation as to why certain candy bars float and why others sink.</td>
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<td>CCC: Cause and effect SEP: Developing and using models</td>
<td>Reading: Students read short article to learn how arrangement of molecules affects a substance’s density. They create an explanatory model showing the arrangements of molecules in the candy bars they tested</td>
<td>When molecules are packed more closely, a substance is more dense. If a substance is more dense than water, it will sink in water (and if it is less dense than water, it will float).</td>
<td>What happens when two liquids with different densities put together?</td>
<td>Explanatory models; models could include zoom-in boxes to show the arrangement of molecules; molecules in substances that...</td>
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</table>
Develop a model that shows the different densities of liquids. 

**Layered Liquids in a Jar:**
Students will create their own layered experiment showing the different densities of liquids and the objects in those liquids. A bolt of styrofoam is less dense than the molecules in those liquids. A bolt is more dense than all of the liquids in the jar, while the piece of styrofoam will float. Each object in our jars have different densities. By creating a layered liquid jar, students can explain how the molecules may look in the objects they put in their jars. Also, they need to consider the relative densities of substances. A candybar that sank in water during the first lesson might float in a different liquid. A finished layered jar with written explanations of why their objects are sinking or floating is the assessment. (This will be used as a summative assessment for density.)

A bolt should be closer together than the molecules in the water (molecules in water should be packed more closely than substances that floated).

Each object in our jars have a different density. By creating a layered liquid jar, students will have to think about the way the molecules are arranged in their objects and have an understanding of why that arrangement would make them sink or float.

A finished layered jar with written explanations of why their objects are sinking or floating is the assessment. (This will be used as a summative assessment for density.)

| **Construct an explanation as to why a balloon would shrink when you freeze it.** | **Freezing a Balloon:** Students will be placed in small groups. Each group will blow up a balloon and take measurements on that balloon. The balloon will be placed inside the freezer for 10 minutes. They will then measure the balloon straight out of the freezer. | **We are removing thermal energy from the gas inside the balloon when the balloon is frozen. The gas molecules slow down and move closer together, causing the balloon to shrink.** | **Measurement data and model of experiment in notebook.** |

| **Construct an explanation as to why ice floats. Obtain and communicate information on why ice floating is important.** | **Ice Water Observation:**

First, students will observe a teacher led experiment. Teacher will demonstrate what happens to colored water when it is added to different temperatures of water in clear containers. Students will then use that observation to create an explanation on what happened when the colored water was added to each different temperature of water.

Students will have a glass of ice water set in front of them. From their previous knowledge, they are going to construct a written explanation as to why ice floats on top of the water.

Students will then have a discussion, led in the classroom, as to why ice floating is important on lakes and ponds in the winter. |
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<td><strong>There are more spaces between molecules in ice than in the molecules of water, therefore ice is less dense than water and will float.</strong></td>
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<td><strong>Because ice floats on water, organisms are able to survive in the water under the ice.</strong></td>
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</table>
| **What makes water unique?**

(This is more of making a list type of activity to help with the next lesson.) |
<p>| <strong>Students will record in their notebook their ice observations and an explanation as to why ice floats on water.</strong> |</p>
<table>
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<th>Students will create a brochure, using the information they have gained on water, to communicate why water is unique.</th>
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<td>Water is made of one oxygen atom and two hydrogen atoms. It can be found in all three states (solid, liquid, gas) on Earth. Thermal energy causes water to change states. It also expands when frozen. This makes ice less dense than water and allows ice to float on top of water in the winter.</td>
</tr>
<tr>
<td>Completed brochure showing models of water molecules, it's three states of matter on Earth, and why it is unique.</td>
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# 6.2.2 States of Matter Storyline

## Student Science Performance

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<thead>
<tr>
<th>Topic: Matter Has Three States</th>
<th>Title: Root Beer Float Observations</th>
</tr>
</thead>
</table>

### Overarching Performance Expectations (Standard) from State Standards or NGSS:

Standard 6.2.2 Develop a model to predict the effect of heat energy on states of matter and density. Emphasize the arrangement of particles in states of matter (solid, liquid, or gas) and during phase changes (melting, freezing, condensing, and evaporating).

### Crosscutting Concepts:
- Systems and System Models, Energy and Matter

### Science and Engineering Practices:
- Using models to understand and ask questions.

### Lesson Performance Expectations:
Students will understand that matter has three states: solid, liquid, and gas.

### Students Will... To Construct Meaning

**Engage with a Phenomenon:** When I add ice cream to my root beer, the ice cream starts to melt. If the ice cream is melted, is it still ice cream?

**Gather:** Students will each receive a root beer float. Before anyone in the class can enjoy their root beer float, students must make a model of the root beer float in their science journals. Each part of their root beer float needs to be labeled (for right now something as simple as ice cream, soda, cup, melted ice cream, etc.) and they must describe each part of the float with different scientific observations.

As the students make observations, I want them to ask scientific questions about their root beer floats, having them really try to think like a scientist and ask questions that will help guide their understanding of the different parts of a root beer float.

After the observations are done and before a class discussion on the states of matter take place, I would like to have the students watch a gas demonstration. In this demonstration the teacher will use ¼ cup of raisins in a clear glass and add sprite (or any other clear carbonated beverage) to the glass. The raisins, within second, should begin to dance for the class.

The gas demonstration would lead to a class discussion on the states of matter using a representation of their model that is drawn on the board.

### Teacher Will... To Support Students

While students are making observations about their float, teachers should be walking around the room helping students at different tables make scientific observations. A good reminder for students is that since we have not used the sense of taste, their observations should not include anything that would suggest students have tasted their float. It is perfectly okay to have small groups of kids making observations together as long as every group member has a voice and is actively participating in the discussion.

Students will be using the observations to model and labels the different parts of a root beer float. With my students, I always state that good scientists have good models so that others can see and understand their thinking.

Teachers can also help guide their observations for each part. "Did you notice if the ice cream is hot or cold? What is different about the soda and the ice cream? What are the bubbles at the top of the float? What is happening to the ice cream and why are we seeing it change in the float?"

Teachers may also need to help students come up with questions about their float that will help lead them to further understanding of the states of matter.

Questions specifically I want the students to come up...
Reason: Having the kids observe something that most of them are very familiar with and write down specific observations that they have about their float will hopefully guide them to a firm understanding of states of matter. Using a root beer float gives each child a picture of a clear solid, liquid, and gas working together. It also shows a change in state as the ice cream begins to melt. When all of their observations are made, I would also like them to ask questions about their root beer float in a scientific way and make a list of those questions somewhere on their notebook page.

Communicate: Once their observations are made and the gas demonstration is watched, students will start to have a discussion with the rest of the class on what they observed about their root beer float. This will be added to the model on the board. The teacher should lead the discussion and help students arrive to the conclusion that there are three states of matter. The three states of matter should be added to their drawing in a colored pencil or pen (ice cream - solid, soda - liquid, gas bubbles on top - gas).

<table>
<thead>
<tr>
<th>Assessment of Student Learning</th>
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<tr>
<td>Short description of the evidence the teacher is willing to accept that a student is proficient with the performance expectations. This may be a rubric, narrative or other set of descriptors that are useful for distinguishing proficient from nonproficient performances.</td>
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</table>

Model of root beer float drawn and labeled with their observations in their notebook. I would like this model to include the different layers of the root beer float (ice cream, soda, foam on top) and I would also like them to include gas bubbles they see in their cup as the carbonation rises and maybe even an increase in the amount of foam that rests at the top as the ice cream melts.

Questions about root beer float clearly written in their notebook.

Quick drawing of Dancing Raisins experiment.

With a colored pencil or pen, each part of the float labeled with their state of matter.
### 6.2.1 States of Matter Storyline

<table>
<thead>
<tr>
<th>Student Science Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Topic:</strong> Matter is Made of Molecules</td>
</tr>
</tbody>
</table>

### Overarching Performance Expectations (Standard) from State Standards or NGSS:

6.2.1 Develop models to show that molecules are made of different kinds, proportions and quantities of atoms. Emphasize understanding that there are differences between atoms and molecules, and that certain combinations of atoms form specific molecules. Examples of simple molecules could include water (H₂O), atmospheric oxygen (O₂), and carbon dioxide (CO₂).

**Crosscutting Concept:** System Models, Energy and Matter, Structure and Function

**Science and Engineering Practices:** Developing and Using Models, Asking Questions and Defining Problems

### Lesson Performance Expectations:
Students will understand that matter is made of molecules. Molecules have individual components called atoms.

<table>
<thead>
<tr>
<th>Students Will. . . To Construct Meaning</th>
<th>Teacher Will. . . To Support Students</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Engage with a Phenomenon: What is matter made of?</strong></td>
<td><strong>To start,</strong> I would do a quick review of the lesson from yesterday. This would be as simple as drawing a quick ice cream float on the board and labeling the parts as solid, liquid, and gas. I would also reemphasize that all of these things are matter.</td>
</tr>
<tr>
<td><strong>Gather:</strong> Students will be building models of molecules that make up water, carbon dioxide, and oxygen. They will use gum drops to represent each atom inside of a molecule.</td>
<td>Show the students a glass of water. Ask the students what is inside the glass? The students will say water. Ask them what state it is in? The students will say liquid. Final question, what is water?</td>
</tr>
<tr>
<td><strong>Reason:</strong> This will give students a visualization of how matter is made of molecules and each of those molecules is made of atoms.</td>
<td><strong>Here I would start with a quick discussion about how all matter is made of molecules. Each of these molecules have individual components called atoms. I would then actually tell the class that water is made of two hydrogen atoms and one oxygen atom.</strong></td>
</tr>
</tbody>
</table>
| **Communicate:** Students will be creating models of molecules, and drawing examples of those molecules in their science notebooks to communicate an understanding that matter is made of molecules, and molecules are made of atoms. | **Green Gumdrop - Hydrogen**  
**White Gumdrop - Oxygen**  
**Red Gumdrop - Carbon** |
| **With the materials on their desk, I would have them make, with me, a representation of what one molecule of water would look like. I would attach one green gumdrop to two white gumdrops using toothpicks. I would also probably show them a visual representation of the water molecule as found on google search. I would also tell them that water is an important ingredient found in their soda.** | **I would have the kids leave their water molecule on** |
their desk, and with their chromebook, I would have them google, “what is carbon dioxide made of?” I would also tell them that carbon dioxide is the “fizz” they had in their root beer floats yesterday. The search should show that carbon dioxide is made of one carbon atom and two oxygen atoms. We would review what color oxygen atoms are and then choose a color for the carbon atom (color does not matter so as long as it isn’t the same as the hydrogen atom). Students would then build a model representation of the carbon dioxide atom.

Oxygen is a gas and is found all around us. I would then have them google oxygen molecule and build that model on their own. This would be a time to walk around and help those students who are struggling with this concept or even struggling with the computer. When they are done building, they should have three different models of molecules on their desk.

On a page in their science journals, I would have the students record the pictures of the models they build with labels for each molecules. Zoom in boxed would show the relationship between these models and the molecules that make them up. For example, students would draw a glass of water, and then draw a hand lense. Inside the hand lense, they would draw the different atoms that make up a molecule of water. This would show understanding that matter is made of molecules and molecules are made of atoms. I would probably drawn an example of this on the board, and then have students show a little creativity in coming up with their next two examples. (I would, of course, want to check in with all students to make sure their examples fit.

After the students have recorded the information in their journals, I would pose the question on ice cream, referring back to their root beer floats.

“When we started observations yesterday, we had ice cream that started out as a solid but slowly melted and turned into a liquid. Does the change from solid to liquid change the molecules in the ice cream?”

**Assessment of Student Learning**

*Short description of the evidence the teacher is willing to accept that a student is proficient with the performance expectations. This may be a rubric, narrative or other set of descriptors that are useful for distinguishing proficient from nonproficient performances.*

The assessment that I will use for this particular lesson will be their zoom in models in their science notebooks and their gumdrop molecules that they build for each example.
6.2.1 States of Matter Storyline

Student Science Performance

| **Topic:** States of Matter and Changing Molecules | **Title:** Boiling Ice |

Overarching Performance Expectations (Standard) from State Standards or NGSS:

6.2.1 Develop models to show that molecules are made of different kinds, proportions and quantities of atoms. Emphasize understanding that there are differences between atoms and molecules, and that certain combinations of atoms form specific molecules. Examples of simple molecules could include water (H₂O), atmospheric oxygen (O₂), and carbon dioxide (CO₂).

Standard 6.2.2 Develop a model to predict the effect of heat energy on states of matter and density. Emphasize the arrangement of particles in states of matter (solid, liquid, or gas) and during phase changes (melting, freezing, condensing, and evaporating).

Lesson Performance Expectations: Students will understand that adding heat doesn’t change the composition of the molecules even though it may change the state of that molecule.

Crosscutting Concept: System and System Models, Energy and Matter, Cause and Effect

Science and Engineering Practices: Developing and Using Models, Asking Questions and Defining Problems, Constructing Explanations and Designing Solutions

| Students Will. . . To Construct Meaning | Teacher Will. . . To Support Students |

*Engage with a Phenomenon:* When we started observations yesterday, we had ice cream that started out as a solid but slowly melted and turned into a liquid. Does the change from solid to liquid change the molecules in the ice cream?

*Gather:* Students will watch a demonstration of ice being put into a hot pot, brought to a boil, and boiled until nothing is remaining in the hot pot.

*Reason:* Students will see, from the demonstration, that the ice cube will go through the three states of matter. After each state change, we will discuss what the molecules in the ice cube look like. They will see, at the end of the demonstration, that nothing about the molecular makeup of the water changes. Then, we will watch a short video which shows what DOES change as substances change states. We will walk through the observation again talking about what happens during each state change.

*Communicate:* During the observation and the explanation afterward, there will be lots of discussions about the changes that go on during a state change. The students will then take this information and try to make

Remind students of the question that we ended science with yesterday and begin with this phenomenon.

Place ice into a hot pot, have the students tell you what state of matter the ice is. Ice is made of frozen water, so they should also be able to identify for you the atoms that make up a molecule of water.

As the ice cubes begin to melt, have the students identify what state of matter the ice is changing into. As the ice melted, ask them what it is turning into. Ask them to identify, again, the molecules in the melted ice cube.

As the water now begins to boil, you will have to point out to the class that steam is rising from the water. Hold a tin pie plate over the boiling water for a minute or so, and show the class what was collected on the tin. Ask the students what the steam was called? (They may or may not remember this from 4th grade science.) Condensation rises from the water as the water begins to evaporate. The evaporation is what is collected on the plate. The evaporation collected is water. Ask them
a prediction about what does change if it's not the structure of the molecules. With their table, they will create this prediction and record it on the board. The class will create the table together, and then use the table to help them on a quick check assessment.

again what molecules make up water?

After the experiment is over, have the class discuss if the molecules found in ice, which we talked about when we first put them in the hot pot, changed after they melted, boiled, condensed, and evaporated? The answer from the class should be no, heat didn’t change the molecules. If there are questions, go over the molecules that were discussed at each state of matter.

At this point, when it was decided that their was no molecular change, I would ask the kids to brainstorm with their table groups what might have changed about the molecules/atoms, since the heat didn’t change their makeup but did change their state. Each group would make a prediction about what possible could have changed and write it on the whiteboard or smartboard.

Then I would have the students watch this video: https://www.brainpop.com/science/matterandchemistry/statesofmatter/

(My school has a subscription to this website, but there are also great videos online. There is also a Bill Nye on states of matter.)

With my help, students would fill out a table that identifies the properties for each of the states of matter in their science notebook. Verbally walk through how the molecules in ice change as they walk through their boiling ice observations.

At this point, have them label a piece of paper with these three things: ice cube (solid), water (liquid), and condensation (gas). Have them describe in words and pictures what is happening to the molecules in each of those examples.

From here, go back to the phenomena. As an end to science class, have them tell two people what changes when ice cream melts? Then record the answer in their science journals.

Assessment of Student Learning
Short description of the evidence the teacher is willing to accept that a student is proficient with the performance expectations. This may be a rubric, narrative or other set of descriptors that are useful for distinguishing proficient from nonproficient performances.

Table with properties of matter in their notebooks.
Ice Cube, Water, Condensation quick check.
Answer to phenomena question written in their notebook.
6.2.1 States of Matter Storyline

<table>
<thead>
<tr>
<th>Student Science Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Topic:</strong> Particles in Motion</td>
</tr>
</tbody>
</table>

**Overarching Performance Expectations (Standard) from State Standards or NGSS:**

6.2.1 Develop models to show that molecules are made of different kinds, proportions and quantities of atoms. Emphasize understanding that there are differences between atoms and molecules, and that certain combinations of atoms form specific molecules. Examples of simple molecules could include water (H₂O), atmospheric oxygen (O₂), and carbon dioxide (CO₂).

Standard 6.2.2 Develop a model to predict the effect of heat energy on states of matter and density. Emphasize the arrangement of particles in states of matter (solid, liquid, or gas) and during phase changes (melting, freezing, condensing, and evaporating).

**Crosscutting Concept:** Energy and Matter, Energy and Matter

**Science and Engineering Practices:** Developing and Carrying Out Investigations, Asking Questions and Defining Problems, Analyzing and Interpreting Data, Obtaining, Evaluating, and Communicating Information

<table>
<thead>
<tr>
<th>Lesson Performance Expectations: Students will understand that particles are constantly in motion. Particles in warm substances move faster than particles in cold substances.</th>
</tr>
</thead>
</table>

**Students Will. . . To Construct Meaning**

*Engage with a Phenomenon: How does the movement of molecules affect the substance?*

*Gather:* Students will be conducting their own experiments using food coloring and three cups of different temperature water (cold, warm, and hot). In each temperature of water, the students will be dropping a dropper of food coloring into each glass one at a time. They will observe what happens to the food coloring as it disperses and jot down small notes as they watch the experiment happen. They will time how long it takes for the food coloring to disperse throughout their glass of water and record that information in a data table in their science notebooks.

*Reason:* The food coloring being dropped into different temperature water allows students to visibly see particles in the water moving at different rates. Doing this experiment will show that particles in warmer substances move faster than particles in colder water.

*Communicate:* This will be a small group experiment with small group discussions. Students will need to communicate with each other what they see happening in each of the cups of water as the experiment is running, record the time it took for the food coloring to

**Teacher Will. . . To Support Students**

Make sure each small group has the materials that they need to do the experiment. Remind students the importance of making sure that every cup hold the same amount of water and get the same amount of food coloring. The only difference in the cups should be the temperature.

Help students set up a data table to show the different temperatures of water and the time it takes for the food coloring to disperse. (I would do this in a smart board app, and revisit with other timed experiments.)

During the experiment, remind students to make observations in their notebook by noting things they see happening in the water. This is on top of timing the experiment.

At the end of the experiment, check tables and help with table discussions to lead each table to the conclusion that particles move faster in warmer substances. (This is a pretty easy conclusion to make when the experiment is done correctly.)

Follow up experiment with assessment referring back to the root beer float.
disperse, and draw conclusions as to what is happening or being modeled in the experiment. Teacher communication will happen in these small groups, as well, as the teacher walks around to monitor and help guide discussions in the small group.

### Assessment of Student Learning

*Short description of the evidence the teacher is willing to accept that a student is proficient with the performance expectations. This may be a rubric, narrative or other set of descriptors that are useful for distinguishing proficient from nonproficient performances.*

Time table and model of experiment in notebook with written observations.

Assessment to hand in - students will be given a drawing of melting ice cream from their root beer float. They will need to show, with zoom in boxes, what is happening to the molecules in ice cream as they are melting. (This doesn't have to be the exact molecules in ice cream, molecules can be represented by a variable.) Once graded and returned, this should be glued or drawn into their science notebook to help them with later lessons on states of matter and/or density.
### 6.2.2 Density Storyline

#### Student Science Performance

<table>
<thead>
<tr>
<th>Topic: Density</th>
<th>Title: Freezing Balloons</th>
</tr>
</thead>
</table>

#### Overarching Performance Expectations (Standard) from State Standards or NGSS:

Standard 6.2.2 Develop a model to predict the effect of heat energy on states of matter and density. Emphasize the arrangement of particles in states of matter (solid, liquid, or gas) and during phase changes (melting, freezing, condensing, and evaporating).

#### Lesson Performance Expectations:

Students will understand that density measures how closely particles are packed in matter.

#### Crosscutting Concept:

Energy and Matter

#### Science and Engineering Practices:

Developing and Carrying Out Investigations, Asking Questions and Defining Problems, Analyzing and Interpreting Data, Obtaining, Evaluating, and Communicating Information

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<th>Teacher Will. . . To Support Students</th>
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<tbody>
<tr>
<td><strong>Engage with a Phenomenon:</strong> By removing thermal energy from the gas inside the balloon when the balloon is frozen, the gas molecules slow down and move closer together, causing the balloon to shrink.</td>
<td>Put students into small groups (partners would even work if you have the freezer space available).</td>
</tr>
<tr>
<td><strong>Gather:</strong> Students will first blow up their balloons and take measurements. Once they have this done and recorded, have them place the balloons in the freezer for 45 minutes to an hour. Once the time is up, have them retrieve their balloons and take another set of measurements.</td>
<td>Have each group blow up a regular size balloon. Have the students draw two lines on the balloon, they can pick the distance the two lines are from each other, but make sure they are at least a couple of inches. Have them take measurements, using a fabric tape measure, of the balloon around the middle, top, bottom, and the distance between the two lines. Record these measurements in their notebook.</td>
</tr>
<tr>
<td><strong>Reason:</strong> Students will be able to see a great example of how removing thermal energy from an object slows down the molecules and causes them to move closer together and shrinks the object.</td>
<td>Once every group is ready to go, have each group place their balloons into the freezers at school. At my school, we don’t have enough space, so I would do this in sets and have the students in the classroom working on something else while we complete this experiment. You could also do this experiment several times throughout the day so that all groups get the same experience. Each balloon group should be in the freezer for 45 minutes to an hour.</td>
</tr>
<tr>
<td><strong>Communicate:</strong> Measurements will be collected in pairs or small groups twice. They will have to communicate with each other the best possible place to draw their lines for measurement. They also, after the experiment is over, will have to decide why their balloon shrunk when exposed to the cold.</td>
<td>When the time is up, have the students take their balloons out of the freezer and re-do all of their measurements. They should see a decrease in their measurements they took to begin the experiment. Have them record these measurements in their notebooks. Ask the students to write down why they think the balloons shrunk when put in the freezer.</td>
</tr>
<tr>
<td><strong>Once they have worked together to have a prediction, the class will have a discussion as to why the shrinkage occurred.</strong></td>
<td></td>
</tr>
</tbody>
</table>
After they have their prediction down, have a class discussion on their reasonings behind the shrinking of the balloon. If needed, prompt them with talk of molecule differences in solids, liquids, and gases. Use past experiences from their density lessons as well.

**Assessment of Student Learning**

*Short description of the evidence the teacher is willing to accept that a student is proficient with the performance expectations. This may be a rubric, narrative or other set of descriptors that are useful for distinguishing proficient from nonproficient performances.*

Drawing of initial balloon measurements either in a data table or using a picture of the balloon. Give students the choice of which way they want to record the data, but make sure they do record it.

Drawing of final balloon measurements either using a data table or a picture of the balloon. (Think before and after pictures.)

Prediction as to why the balloon shrunk, followed by the key idea with the scientific reasons as to why the balloon shrunk in kid friendly form.
# 6.2.2 Density Storyline

## Student Science Performance

<table>
<thead>
<tr>
<th>Topic:</th>
<th>Layers of Different Densities</th>
<th>Title: Layered Liquids in a Jar</th>
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## Overarching Performance Expectations (Standard) from State Standards or NGSS:

Standard 6.2.2 Develop a model to predict the effect of heat energy on states of matter and density. Emphasize the arrangement of particles in states of matter (solid, liquid, or gas) and during phase changes (melting, freezing, condensing, and evaporating).

## Lesson Performance Expectations:

Students will understand that each object in our jars have different densities. By creating a layered liquid jar, students will have to think about the way the molecules are arranged in their objects and have an understanding of why that arrangement would make things sink or float.

Also, they need to consider the relative densities of substances. A candy bar that sank in water during the first lesson might float in a different liquid.

## Crosscutting Concept: Energy and Matter

## Science and Engineering Practices:

Developing and Carrying Out Investigations, Asking Questions and Defining Problems, Analyzing and Interpreting Data, Obtaining, Evaluating, and Communicating Information

### Students Will... To Construct Meaning

**Engage with a Phenomenon:** What happens when you put two objects (or more) of different densities together?

**Gather:** Students will be using a variety of different objects to create a layered jar showing what happens when you mix objects of different densities together. They will build their jar with the different layers of objects/liquids, and then they will draw their completed jar in their science notebooks with written explanations as to why objects floated in water and others did not, or why they sank in water, but floated in water... etc. I would suggest doing this experiment and reasoning with a partner.

**Reason:** Students will use their knowledge of density to create a layered jar and explain why things are sinking/ floating in their jar. This shows a true understanding of density.

**Communicate:** Communication will be between partners as they put together their jars and develop explanations as to what is happening in their jars.

### Teacher Will... To Support Students

The most important aspect of today’s lesson is to be monitoring the class as they complete their jars to help them understand why things are sinking/ floating and to help them construct an explanation for these things. It’s also important to monitor the pouring of liquids into their jars to prevent overfilling.

Have a variety of objects available for the students to use in their jars: styrofoam, bolts, nails, candy bar pieces, cereal pieces, water, oil, balsamic vinegar, pennies, bouncy balls, corn syrup, etc.

### Assessment of Student Learning

Short description of the evidence the teacher is willing to accept that a student is proficient with the performance expectations. This may be a rubric, narrative or other set of descriptors that are useful for distinguishing proficient from nonproficient performances.
Their finished jar with the different layers of floating/sinking objects is their assessment for today's experience. You could do a couple of different things for their notebooks: 1. You could have the students take a picture of their finished jars with their device and print them a colored copy of it. Then they could label and identify why objects sunk or floated in their jar, or 2. You could have them draw the whole jar with colored pencils and have them do the same labeling.
# 6.2.2 Density Storyline

## Student Science Performance

<table>
<thead>
<tr>
<th>Topic: Density</th>
<th>Title: Building Background - Density</th>
</tr>
</thead>
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## Overarching Performance Expectations (Standard) from State Standards or NGSS:

Standard 6.2.2 Develop a model to predict the effect of heat energy on states of matter and density. Emphasize the arrangement of particles in states of matter (solid, liquid, or gas) and during phase changes (melting, freezing, condensing, and evaporating).

## Lesson Performance Expectations:

Students will understand that density measures how closely particles are packed in matter.

## Crosscutting Concept:

Energy and Matter

## Science and Engineering Practices:

Developing and Carrying Out Investigations, Asking Questions and Defining Problems, Analyzing and Interpreting Data, Obtaining, Evaluating, and Communicating Information

### Students Will. . . To Construct Meaning

*Engage with a Phenomenon: Why do some objects sink, while other objects float?*

*Gather: Students will read the article on this site:* [http://www.shonscience.com/unit-1-earth-as-a-system2/does-the-shape-size-or-temperature-of-matter-affect-its-density](http://www.shonscience.com/unit-1-earth-as-a-system2/does-the-shape-size-or-temperature-of-matter-affect-its-density)

This should give them a little more background information on how different things (size, shape) affect an object’s density. Once the article is read and discussed in class, students will pick three of the objects they tested at home and create an explanatory model showing the arrangement of molecules in their object. This will be completed in their science notebook.

*Reason: Reviewing information on density and building a stronger background with density will help them understand tomorrow’s experience better and will help them understand the special properties of water.*

*Communicate: Students will be showing their understanding of density by using parts of a homework assignment and applying the molecular arrangement to show why their object sank or floated. They will also be having a personal conversation with me so I can do a quick check on their understanding of density.*

### Teacher Will. . . To Support Students

*Review density with the class before starting today’s lesson.*

*Have the students read the article in their small groups highlighting information that they feel is important.*

Once the article is read, discuss with the students the main points of the article and record them on the board. Basic points that they need to understand: When molecules are packed more closely, a substance is more dense. If a substance is more dense than water, it will sink in water (and if it is less dense than water, it will float).

Once they are at the independent part of their lesson, walk around the room helping students decide which objects they should choose for their molecular arrangement and check for understanding.

### Assessment of Student Learning

Short description of the evidence the teacher is willing to accept that a student is proficient with the performance expectations. This may be a rubric, narrative or other set of descriptors that are useful for distinguishing proficient from nonproficient performances.
The assessments for this particular experience are the personal conversations with the teacher and their models they make from their homework assignment showing the arrangement of molecules. This can be done by using zoom in boxes.
# 6.2.2 Density Storyline

## Overarching Performance Expectations (Standard) from State Standards or NGSS:

Standard 6.2.2 Develop a model to predict the effect of heat energy on states of matter and density. Emphasize the arrangement of particles in states of matter (solid, liquid, or gas) and during phase changes (melting, freezing, condensing, and evaporating).

## Lesson Performance Expectations:

There are more spaces between molecules in ice than in the molecules of water, therefore ice is less dense than water and will float.

Because ice floats on water, organisms are able to survive in the water under the ice.

## Crosscutting Concept:

Energy and Matter

## Science and Engineering Practices:

Developing and Carrying Out Investigations, Asking Questions and Defining Problems, Analyzing and Interpreting Data, Obtaining, Evaluating, and Communicating Information

## Students Will . . . To Construct Meaning

**Engage with a Phenomenon: Why does ice float?**

Gather: Students will first watch a teacher led demonstration with colored water when it is added to containers of different temperatures of water.

Before starting the experiment with ice, start with a quick observation as to what happens with frozen olive oil as it drops into the water. Have them communicate with their table what they saw. Create a quick summary on the board of what they saw.

Then, students will have a glass of water set in front of them. Then they will add ice to the glass of water and make observations about what they are seeing. They will need to write a written explanation as to why ice floats on water.

Once they have an explanation written in their notebook, pose the question why ice floating is important on lakes and ponds and have them record their answers in their notebooks.

Reason: Understanding that density is how closely particles are packed together in matter will help them answer the question as to why ice floats on water. Understanding this means that they understand how density works.

## Teacher Will . . . To Support Students

First, demonstrate what happens to colored water when it is added to different temperatures of water in clear containers. Students will then use that observation to create an explanation on what happened when the colored water was added to each different temperature of water. Record this in their science notebooks. Discuss what they saw and how they explained this in their notebooks. (This can be done as a group explanation, as well.)

You could also show this video as a demonstration:
[https://www.stevespanglerscience.com/lab/experiments/colorful-convection-currents/](https://www.stevespanglerscience.com/lab/experiments/colorful-convection-currents/)

Before they start their experiment, they are going to see an example of what normally happens with frozen things. Take a frozen olive oil ice cube and drop it in water. Initially, the ice cube will sink to the bottom of the glass. Then as the water melts the cube, the oil will float on the surface. This shows that as the molecules speed up due to thermal energy, they will start to expand and become less dense than water.

From there, have the students conduct their own experiment using a glass of water. Ice floats, even though it doesn’t follow the lesson on thermal energy. They will need to use what they know about density, however, to create an explanation as to why ice would float on water. You may have to help a few groups with
Communicate: Communication will be with their small group helping them develop an explanation and through their written journal. examples from their layered jar or bathtub.

**Assessment of Student Learning**

*Short description of the evidence the teacher is willing to accept that a student is proficient with the performance expectations. This may be a rubric, narrative or other set of descriptors that are useful for distinguishing proficient from nonproficient performances.*

Their assessment is their written explanation as to why ice floats (this should be pretty simple and include that ice expands and becomes less dense than water, therefore floats) and why ice floating is important on lakes and ponds (because life still goes on under the ice sheet and by not freezing the whole pond, allows creatures to continue living).
### 6.2.1 Lesson Plan

#### Student Science Performance

<table>
<thead>
<tr>
<th>Topic: Thermal Energy and Particle Movement</th>
<th>Title: Thermal Energy With Water Bottles</th>
</tr>
</thead>
</table>

#### Overarching Performance Expectations (Standard) from State Standards or NGSS:

6.2.1 Develop models to show that molecules are made of different kinds, proportions and quantities of atoms. Emphasize understanding that there are differences between atoms and molecules, and that certain combinations of atoms form specific molecules. Examples of simple molecules could include water (H₂O), atmospheric oxygen (O₂), and carbon dioxide (CO₂).

Standard 6.2.2 Develop a model to predict the effect of heat energy on states of matter and density. Emphasize the arrangement of particles in states of matter (solid, liquid, or gas) and during phase changes (melting, freezing, condensing, and evaporating).

**Crosscutting Concept:** System Models, Energy and Matter

**Science and Engineering Practices:** Planning and Carrying Out an Investigation, Analyzing and Interpreting Data (through observation and maybe measurement), Constructing an Explanation, and Obtaining, Evaluating, and Communicating Information

#### Lesson Performance Expectations:

<table>
<thead>
<tr>
<th>Students Will... To Construct Meaning</th>
<th>Teacher Will... To Support Students</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Engage with a Phenomenon:</strong> Why do particles in warmer liquids move around faster compared to particles in colder liquids?</td>
<td>Clearly explain how to set up their experiment step by step.</td>
</tr>
<tr>
<td><strong>Gather:</strong> Students will be conducting an experiment using an empty water bottle, balloon, and two bins full of water at different temperatures. Students will put the balloon on top of the empty water bottle. They will then place the water bottle in the bin filled with cold water. They will make observations (can include measurements of the balloon even though it might be difficult) as to what happens to the water bottle and balloon and record them in their notebook. Then they will place the water bottle in the bin with hot water and record observations on what happens to the water bottle and balloon in the hot water.</td>
<td></td>
</tr>
<tr>
<td><strong>Reason:</strong> Using the data collected on what happens to the</td>
<td>Students should also be drawing a model of their experiment in their science notebook in order to easily recall information learned via this experiment.</td>
</tr>
</tbody>
</table>

Walk through how students should be making observations and how they should be recording them in their science notebooks in an organized way. Remind them of how to create tables, charts, or take notes on observations. Show them how they could possibly measure the balloon with yarn to be more scientific and to add actual calculations into their experiment.
balloon when placed in waters in different temperatures, students will try to figure out why there was no change in the balloon when placed in cold water and why the balloon started to inflate when placed in the hot water.

Remind students that matter is made of particles that are constantly in motion, and particles in warm water move faster than particles in cold water.

Using the information from the previous lesson, why do we think that the balloon filled water bottle, when placed in warm water, would start to inflate? Have students write down their explanations in their science notebook. For those struggling, make sure to give the students the keywords of particles in motion when warmed, and ask them questions about the material the balloon is made from. (Can even show them the stretch of a balloon when blown up.)

Communicate: Once an explanation is reached, written in notebook, and a thumbs up received from a teacher, students will be sharing their conclusions/explanations with other table groups to see if everyone agrees with your group’s explanation.

I, as a teacher, will give them the thumbs up or down on their explanation and their model of the experiment that was completed.

As a class, write a kid friendly, yet scientific, explanation of what happened with the balloon in hot water.

Explanation that I want students to reach: Thermal energy increases particle movement and cause expansion. When thermal energy decreases, particle movement will decrease and will contract.

**Assessment of Student Learning**

Short description of the evidence the teacher is willing to accept that a student is proficient with the performance expectations. This may be a rubric, narrative or other set of descriptors that are useful for distinguishing proficient from nonproficient performances.

Model of the experiment drawn in their science notebook.

Observations from their experiment organized in a readable manner, with or without balloon measurements. (Can be a table, chart, can be written observations, etc.)

Explanation of why the balloon expanded when placed in a hot water bath.

Thumbs up received from me on explanation and observations.

Kid friendly explanation written in their notebook as lesson summary.

http://www.daviddarling.info/childrensencyclopedia/heat_Chapter1.html
**Strand: 6.2.3**

**Emphasis:** Energy flow

**Anticipated Time Required:**
- LE 1: 20-30 minutes
- LE 2: 45-60 minutes
- LE 3: 45 minutes
- LE 4: 20 minutes
- LE 5: 40-60 minutes

**Dominant CCC:** Energy and matter

**Dominant SEP:** Planning and carrying out investigations, engaging in argument from evidence

**Management Strategies** to support equitable access to content:
- Explain-regroup-explain the explanation (students work with a group to construct an explanation; new groups are made, and students explain their explanations to their new group members)
- Group discussion with alternating leaders (students take turns leading their group in a discussion)
- Question stems for partner and small group discussions

**Shopping list:**

<table>
<thead>
<tr>
<th>LE</th>
<th>What</th>
<th>How many</th>
<th>Where to get it/$$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ice melting blocks (a wooden block and metal jar lid could also be used)</td>
<td>1 set</td>
<td>Ice melting blocks can be ordered for $17-25 from Educational Innovations, Amazon, Flinn Scientific, etc.; google “ice melting blocks”</td>
</tr>
<tr>
<td>2</td>
<td>1” steel spheres</td>
<td>1 per 3 students (10ish)</td>
<td>Can be ordered from Amazon: <a href="https://www.amazon.com/gp/product/B007B2AA0K/ref=oh_aui_detailpage_o00_s00?ie=UTF8&amp;amp;psc=1">https://www.amazon.com/gp/product/B007B2AA0K/ref=oh_aui_detailpage_o00_s00?ie=UTF8&amp;amp;psc=1</a></td>
</tr>
<tr>
<td>2</td>
<td>1” wooden spheres</td>
<td>1 per 3 students (10ish)</td>
<td>Can be bought at a craft store or ordered from Amazon: <a href="https://www.amazon.com/gp/product/B00R3F4K1U/ref=oh_aui_detailpage_o01_s00?ie=UTF8&amp;amp;psc=1">https://www.amazon.com/gp/product/B00R3F4K1U/ref=oh_aui_detailpage_o01_s00?ie=UTF8&amp;amp;psc=1</a></td>
</tr>
<tr>
<td>2</td>
<td>1” glass spheres</td>
<td>1 per 3 students (10ish)</td>
<td>Can be bought at toy store (large marbles) or ordered from Amazon: <a href="https://www.amazon.com/POPLAY-Marbles-1-inch-Whistle-Random/dp/B01C852ETE/ref=sr_1_1?ie=UTF8&amp;amp;gid=1499964667&amp;amp;sr=8-1-spons&amp;amp;keywords=1+inch+marbles&amp;amp;psc=1">https://www.amazon.com/POPLAY-Marbles-1-inch-Whistle-Random/dp/B01C852ETE/ref=sr_1_1?ie=UTF8&amp;amp;gid=1499964667&amp;amp;sr=8-1-spons&amp;amp;keywords=1+inch+marbles&amp;amp;psc=1</a></td>
</tr>
<tr>
<td>Quantity</td>
<td>Item Description</td>
<td>Number per Group</td>
<td>Source</td>
</tr>
<tr>
<td>----------</td>
<td>----------------------------------------------------------------------------------</td>
<td>------------------</td>
<td>--------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>2</td>
<td>Thermometers</td>
<td>1 per 3 students (10ish)</td>
<td>See LE 5 supply list for ordering ideas</td>
</tr>
<tr>
<td>2</td>
<td>Cups/containers that can hold 3 1&quot; spheres and hot water; can use plastic or styrofoam cups</td>
<td>1 per 3 students (10ish)</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Cups/containers that can hold hot water; can use disposable plastic cups; using cups that can conduct heat (not styrofoam) will reduce the amount of time students need to investigate</td>
<td>3ish per group of 3 students (30ish)</td>
<td></td>
</tr>
</tbody>
</table>
| 5        | Thermometers                                                                      | 1-3 per group; more thermometers will allow groups to collect more accurate data and complete the investigation faster | Nasco (10 for $8.50)  
https://www.enasco.com/product/TB19654J  
Amazon (10 for $12.44-$16.52)  
https://www.amazon.com/Learning-Resources-LER0302-Student-Thermometers/dp/B0006PJ0L4/ref=sr_1_1?ie=UTF8&keywords=student+thermometer  
Carolina (5 for $15.50)  
### 6.2.3 Heat Transfer and Engineering Storyline Overview

**Anchor Phenomenon:** Ice melts on a block that feels cold and doesn’t melt on a block that feels warm

*Real-world examples of this could be brought in at some point; these could include:*
- Snow that doesn’t melt on a bridge but does melt on the road leading to and from the bridge
- Oven mitts let you touch something without getting burned

**Student Performance Expectation** *(please note that part students will continue investigating the relationship between heat transfer and type/amount of matter in storyline 6.2.4):*

6.2.3 Plan and carry out an investigation to determine the relationship between temperature, the amount of heat transferred, and the change of average particle motion in various types or amounts of matter. Emphasize recording and evaluating data, and communicating the results of the investigation.


<table>
<thead>
<tr>
<th>Dominant DCI</th>
<th>Dominant CCC</th>
<th>Dominant SEP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy</td>
<td>Energy and matter</td>
<td>Planning and carrying out investigations, developing and using models</td>
</tr>
</tbody>
</table>

### Science Experiences

<table>
<thead>
<tr>
<th>CCC/SEP</th>
<th>What are students doing?</th>
<th>What specific understandings should students get from this experience? (What pieces of the performance expectation does the experience provide?)</th>
<th>New questions students have to propel us to the next science experience</th>
<th>Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1: Ice melting blocks 1</td>
<td><strong>Gather:</strong> Students are introduced to anchor phenomenon and record their observations about how the blocks feel and then what happens to the ice when placed on the blocks. <strong>Reason:</strong> Students create an initial model to show how the molecules in the ice are Molecules in the ice cube that is melting are gaining thermal energy and their motion is increasing; molecules in the ice cube that is not melting are not gaining energy and their motion is largely unchanged</td>
<td>Why would the ice melt on the block that feels cold? Why aren’t both of the ice cubes melting at the same rate?</td>
<td>Formative: Student models, inferences, and participation in partner/class discussions should be used to check for understanding of concepts from 6.2.2</td>
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<td></td>
</tr>
<tr>
<td><strong>changing (or not) as it melts (or not).</strong></td>
<td><strong>Communicate:</strong> Students explain their models to a partner, then participate in a class discussion about the energy and motion of the molecules in the water</td>
<td></td>
<td><strong>and identify misconceptions that will need to be addressed throughout the unit</strong></td>
<td></td>
</tr>
<tr>
<td><strong>2: Conduction investigation</strong></td>
<td><strong>Gather:</strong> Students investigate the flow of heat energy in a system by measuring how the temperature of hot water changes after spheres of different materials are added to it. They also gather evidence from the resulting temperature of the spheres.</td>
<td><strong>Reason:</strong> Students work together to describe the flow of thermal energy in the system. In small groups, they use evidence from their investigation to construct a model to show the energy flow in the system.</td>
<td><strong>Communicate:</strong> Students share and compare/contrast their models with each other.</td>
<td></td>
</tr>
<tr>
<td>CCC: systems, energy and matter</td>
<td><strong>Thermal energy flowed through the system from the water to the spheres to the air; more energy flowed to some of the spheres than to others.</strong></td>
<td><strong>Why didn’t all the spheres heat up the same amount or cool down at the same rate?</strong></td>
<td><strong>Formative assessment:</strong> Students’ ability to measure data and then interpret it to construct an explanation should be used as a formative assessment of these skills; their ability to communicate their understanding and answer other students’ questions about their models/explanations should also be used as formative assessments. Group models should be used to assess how well they understand the energy flow in the system and to identify misconceptions they may have.</td>
<td></td>
</tr>
<tr>
<td>SEP: carrying out investigations, interpreting data, developing models</td>
<td></td>
<td></td>
<td><strong>Gather:</strong> Students participate in a game to obtain information about heat transfer, conductors and insulators. Inspired by <a href="http://possibleworlds.edc.org/sites/possibleworlds.edc.org/files/activity_downloads/feel_the_heat.pdf">http://possibleworlds.edc.org/sites/possibleworlds.edc.org/files/activity_downloads/feel_the_heat.pdf</a>,</td>
<td><strong>Thermal energy always moves from the hotter substance to the colder substance.</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Some substances absorb less thermal energy than others.</strong></td>
<td></td>
<td></td>
<td><strong>Formative:</strong> Revisions of group models and student discussions should be used as formative assessments of their understanding of</td>
</tr>
<tr>
<td>and using models, arguing from evidence</td>
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<td>------------------------------------------</td>
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<tr>
<td><strong>Reason:</strong> Students work together to revise the diagram they made during the last lesson. Their model should include information learned during the game regarding heat flow at the molecular level.</td>
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</tr>
<tr>
<td><strong>Communicate:</strong> Students use evidence to construct and support an argument supporting a claim about energy flow in the system.</td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>4: Ice melting blocks 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gather:</strong> Students use digital thermometer to learn that the blocks (from the first lesson) are actually the same temperature.</td>
</tr>
<tr>
<td><strong>Reason:</strong> Students construct an explanation for why the blocks feel like they are different temperatures, even though they are not.</td>
</tr>
<tr>
<td><strong>Communicate:</strong> Students revisit the original models of the ice melting blocks. They revise their models to show why the ice melted faster on the block that feels cold (and slower on the block that feels warm).</td>
</tr>
<tr>
<td>Thermal energy moves from air through the conductor and into the ice, causing the ice to melt; thermal energy is blocked from the ice by the insulator, causing the ice to stay cold.</td>
</tr>
<tr>
<td>Conductor feels cold because thermal energy moves from your hand to the molecules in the conductor; insulator feels warm because thermal energy cannot move from your hand to the molecules in the insulator.</td>
</tr>
<tr>
<td>What happens if you change the amount of material (use more ice, larger blocks, etc.)?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>5: Goldilocks (relationship between amount of matter and heat transfer)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gather:</strong> Students plan and carry out an investigation to determine how the amount of matter is related to energy transfer.</td>
</tr>
<tr>
<td><strong>Reason:</strong> Students work together to explain the results of their investigation by using evidence collected during the investigation to support a claim.</td>
</tr>
<tr>
<td><strong>Communicate:</strong> Students rewrite the porridge section of the Goldilocks story and include an explanation for why the</td>
</tr>
<tr>
<td>When there are more molecules, the substance has more total thermal energy; it will take longer for the energy to flow from an object with more mass because it has more total energy, even if the temperature is the same as an object with less mass.</td>
</tr>
<tr>
<td>What happens if you increase the amount of insulating molecules?</td>
</tr>
</tbody>
</table>

| energy flow in the system before asking them to do the CER |
| Students’ CERs can be used as formative or summative assessments of their understanding of energy flow in the system. |

<p>| Formative: |
| Student investigations, data collection, and ability to use evidence to create and support a claim should be used to assess how well they understand the relationship between amount of material and energy transfer before they are asked to rewrite the |</p>
<table>
<thead>
<tr>
<th>Information</th>
<th>Cereal cooled at different rates.</th>
<th>Goldilocks story</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>The rewriting of</td>
</tr>
<tr>
<td></td>
<td></td>
<td>the Goldilocks</td>
</tr>
<tr>
<td></td>
<td></td>
<td>story could be</td>
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<tr>
<td></td>
<td></td>
<td>used as a formative</td>
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<tr>
<td></td>
<td></td>
<td>or summative</td>
</tr>
<tr>
<td></td>
<td></td>
<td>assessment.</td>
</tr>
</tbody>
</table>
# 6.2.3 Learning Episode 1

## Student Science Performance

<table>
<thead>
<tr>
<th>Topic: Heat Transfer</th>
<th>Title: Ice Melting Blocks 1</th>
</tr>
</thead>
</table>

### Overarching Performance Expectations (Standard) from State Standards or NGSS:

6.2.3 Plan and carry out an investigation to determine the relationship between temperature, the amount of heat transferred and the change of average particle motion in various types or amounts of matter. Emphasize recording and evaluating data, and communicating the results of the investigation.

### Lesson Performance Expectations:

Students will observe the changes that take place in two systems and will use their observations to develop models of the systems. Students should be able to identify which system remained stable and which changed, and use a model to communicate their understanding of the changes that took place in the matter of the system.

**CCC:** Systems, stability and change (in one system, water changes from solid to liquid and in the other system, the water is more stable and remains solid for a much longer time)

**SEP:** Developing models, asking questions

### Students Will . . . To Construct Meaning

Engage with a Phenomenon: Ice melts on a block that feels cold but does not melt on a block that feels warm

Gather: Discuss the similarities and differences you observe in the blocks.

Predict what will happen when an ice cube is placed on each block. Write your prediction in your lab book, using one of these sentence stems:

- "I think that the ice cube on __________ block will melt faster because _______.”
- "I think the ice cubes will melt at the same rate because _______.”

Once the ice cubes are placed on the blocks, record your observations.

### Teacher Will . . . To Support Students

Display the ice melting blocks to the class and ask them to find similarities/differences in the blocks. You can ask them to share their ideas with their partners and/or ask them to record their ideas in the lab books or on a graphic organizer. Walk around the room to allow everyone to see the blocks up close (if logistics allow, you could also stand at the door as students enter the room at the beginning of class, after recess, etc. and have each student observe the blocks as they come in). Also allow students to feel the blocks. Help the class summarize the differences what you overheard students sharing or that they recorded. Make sure you include student observations regarding the perceived temperatures of the blocks; if no one offers this, ask questions and allow students to feel the blocks again to draw it out. Everyone should agree that one block feels warm and one feels cold.

Tell the students you will be placing an ice cube on each block and ask them to write their predictions. If needed, provide sentence stems so that they stay on topic and also explain their reasoning. Before placing the ice on the blocks, conduct a quick class survey of students’ ideas. Allow a few students to share their reasoning. Almost all of the students will predict that the ice will melt faster on the “warm” block, because it is warmer.

Place an ice cube on each block and ask the students to record their observations below their predictions.
**Reason:** In your lab book, create a model showing how the water molecules in each ice cube were affected. Which molecules changed? How did they change? Which molecules didn’t change? Your model should include:

- Water molecules in the ice on each block
- Water molecules in the liquid water that melted
- Why the water changed from a solid to a liquid

**Communicate:** With your partner, identify the system in which you observed more stability and the system in which you observed more changes happening. Add these descriptions to your models.

Share your model with your partner. When it is your turn to talk, show your partner how you represented the water molecules, and how you represented the motion of the molecules in your model. When it is not your turn to talk, show your partner that you are actively listening by:

- Facing your partner
- Looking at his model and making eye contact
- Giving your partner one piece of feedback on his model after he finishes talking:
  - "I like the way you ___ because ___.”
  - “___ makes it easy to understand ___.”
  - “___ is confusing because ___.”
  - “If you ___ , it might improve your model because ___.”

As a class, we will be discussing the following questions. Before we discuss, take two minutes to write a response to each question.

- What can we infer about the motion of the students will want to know why the ice on the “cold” block is melting faster and will start coming up with ideas. Although they will not be investigating what is causing the ice to melt faster during this lesson, it may be good to conduct a short class discussion to allow students to share their ideas. If you do this, you don’t need to comment on or validate their responses; just give them the chance to voice their ideas so they can step back to what they already know while constructing their models.

While giving instructions to develop a model, focus their attention back to what they know about the water molecules in the ice. Instruct them to create a model in their lab book that shows what happened to the water molecules in each of the systems. From previous lessons, they should know that as the temperature of the water increases, the ice will melt and the water molecules will move faster. As they work on their models, circulate through the class and use questions to help students clarify the ideas they are trying to communicate through their models. Also make note of misconceptions that may need to be addressed at some point (for example, if students are showing that the composition of the water molecules changed).

Tell students how you would like them to label the systems they modeled; writing the labels on the board will be useful to ELL students (for example, maybe you would like students to add “the water in this system was stable” and “the water in this system changed” to their models).

Display the tasks that students will be completing with their partners, including sentence stems for the partner providing feedback. If needed, model the discussion they should have and assign which partner will talk first (for example, “partner on the left will talk first, and partner on the right will listen first”). Tell students how much time they have to discuss and display a timer.

After students have had a chance to write their response, facilitate a class discussion to check for student understanding. From the previous storyline, students should remember that substances change
molecules in each system?
- What can we infer about the heat energy in each system?

What questions could you ask that would help us understand these systems better? What do we need to know to explain why the ice melted faster on one block than on the other? With your partner, write 1-3 questions that you think would help us learn more about this system. Write each question on a sticky note and post it on the question board.

Management Strategy: As students write their responses to the questions, circulate through the room with a clipboard and make note of student responses that will help facilitate the class discussion. You may also want to give some students a heads-up that you will be asking them to share during the discussion; if you do this, consider telling them why you would like them to share and be specific about what you want them to share. During the class discussion, try not to do the explaining yourself. Use strategies such as questioning, summarizing, or connecting student ideas to allow students to be the ones doing the explaining.

Allow students a few minutes to discuss questions, write them on sticky notes, and post them on the board. Depending on what type of space/technology is available, you could also use whiteboard space or a large piece of poster paper that students write directly on, or an app like padlet. Once students have posted their questions, sort them into groups and identify the grouping to your students. If needed, you could group them at a later time and then start the next lesson by reminding students of the questions and showing them how they are grouped. Possible groupings:
- Questions about where the energy came from
- Questions about the blocks
- Questions about how changing part of the system would affect the results

The groups you create will vary depending on the questions students asked.

Assessment of Student Learning
This is an introductory/review activity; student models of the water molecules should be used to identify misconceptions from the previous storyline.

Students’ models of the ice cubes should indicate that they understand the relationship between molecular motion and states of matter (the molecules in the liquid water are moving faster than the molecules in the solid
water). Student models should include:

- A representation of water molecules
- The motion of the molecules
- Explanation of what caused the water to change from a solid to a liquid

Misconceptions students have might include:

- The number of molecules changing as the ice melts
- The composition of the molecules changing as the ice melts.

Participation in the class discussion should also be used to assess student understanding and possible misconceptions that may need to be addressed.

Example student product:
Name _________________________________________________________________

Blocks

Record your observations about the two blocks:

<table>
<thead>
<tr>
<th>Block 1</th>
<th>Block 2</th>
</tr>
</thead>
</table>

Prediction:
________________________________________________________________________________________
________________________________________________________________________________________
________________________________________________________________________________________
________________________________________________________________________________________

Observation:
________________________________________________________________________________________
________________________________________________________________________________________
________________________________________________________________________________________
________________________________________________________________________________________
Ice Melting Blocks

Create a model that includes:
- Water molecules in the ice on each block
- Water molecules in the liquid water that melted from the ice
- Explanation of why the water changed from a solid to a liquid

As you develop your model, think about what you have learned about molecules. Are the molecules in the ice different from the molecules in the liquid water? How are they different?

| What can we infer about the motion of the molecules in each system? |
| What can we infer about the heat energy in each system? |
### 6.2.3 Learning Episode 2

<table>
<thead>
<tr>
<th>Student Science Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Topic:</strong> Conduction/transfer of thermal energy</td>
</tr>
</tbody>
</table>

**Overarching Performance Expectations (Standard) from State Standards or NGSS:**

6.2.3 Plan and carry out an investigation to determine the relationship between temperature, the amount of heat transferred and the change of average particle motion in various types or amounts of matter. Emphasize recording and evaluating data, and communicating the results of the investigation.

**Lesson Performance Expectations:**

Students will carry out an investigation to collect evidence to develop a model of energy flow through a system. Students should be able to model the flow of heat energy from a hotter substance (water) to cooler materials (the spheres). Students will also begin to ask questions about why the heat energy did not flow uniformly through the system (why did more heat flow to the metal sphere than to the wood sphere?).

CCC: Systems, energy and matter (heat energy flows through the different materials in the system)

SEP: Carrying out investigations, analyzing and interpreting data, developing models

<table>
<thead>
<tr>
<th>Students Will... To Construct Meaning</th>
<th>Teacher Will... To Support Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engage with a Phenomenon: When different materials are exposed to heat energy, some of them heat up more than others</td>
<td>Review what students observed during the last learning episode, and explain that they will be gathering information that will help them make the models of the ice melting blocks more complete. Remind them that we know the blocks are made of different materials (if needed, help students recall some of their observations of the blocks that indicate they are different materials; for example, one block was shiny and the other was not). Point out any questions (from the previous lesson) that students asked about the materials/blocks, and tell them that is what they will be investigating today.</td>
</tr>
</tbody>
</table>

Gather: We know that the ice melting blocks are made of different materials. To gather information to help explain the phenomenon, you will be investigating different materials. You will need to gather evidence about how the different materials interact with heat energy.

Make sure you record the evidence you collect during the investigation.

Explain the investigation and hand out investigation sheets, or instruct students on how they should record their data/observations in their lab books. Since students will be using their hands (instead of a thermometer) to measure the relative temperature of the spheres, you may want to provide examples, or allow students to make suggestions, of different ways to record the temperature of the spheres. For example, they could use descriptive words, or rank the spheres according to their temperatures. Because the data is somewhat time sensitive, make sure you go through the entire procedure with the students and allow them to ask questions, so they understand what to do and when to do it. If students are recording data on the data
Once your group has recorded your data/observations and cleaned up, answer the following two questions about the system you investigated. You should answer these questions individually, but will have a chance to discuss your ideas with others later.

1. Define the system you investigated. (You could make a list of the parts of the system or make a diagram of the system and label the parts.)
2. How do you think heat energy flowed through the system? (You can use words to describe how energy moved through the system, or make a picture of the system and use arrows or other symbols to show how energy flowed through the system.)

Reason: Share your ideas with your group. Discuss one question at a time, and allow everyone in the group to share his ideas. When it is your turn to share, you can either read your response, or show your diagram to the group and explain it. When it is not your turn to share, you should be actively listening; this means you should be looking at the group member who is talking.

Once everyone has shared their ideas about both questions, use the following format to discuss your ideas; when it is your turn to be the group leader, you will pose the question to your group and make sure that everyone has a chance to participate in the discussion. Remember that being a leader does not mean that you are the one doing the talking!

- Person A: What similarities are there in our ideas about the parts of the system?

If needed, go over the questions with students before they answer them; as students work individually, circulate through the class and use questions to help students clarify their ideas and provide verbal instructions for students who may be having a hard time getting started.

Management Strategy:

Asking students what they think is going on as they are investigating is a great way to find out what they are thinking, and also to help them start thinking about what they think. As you ask students what they think is going on, listen to their answers and ask further questions, but don’t tell them if their ideas are right or wrong.

Explain/model how students should share their ideas with their group; if needed, review active listening with students and set up procedures for deciding who goes first, time limits, etc.

Explain the group discussion with alternating leaders strategy to your students. When using this strategy, students are placed in a group and one student is given the opportunity to be the group leader as they discuss a question. When time is up, or they are done discussing
Person B: What similarities are there in our ideas about the energy flow through the system?

Person C: Now that we have talked about the parts of the system and the energy flow through the system, what ideas can we all agree on? What evidence can we use to support our ideas?

Now that you have had a chance to discuss your ideas, you will be working with your group to make a model of the energy flow through the system. Your model should include:

- The system (what were the parts of the system?)
- Why did the temperature of the substances change? How was energy moving through the system?

the question, a different student becomes the group leader and they discuss a new question. It is important to review the role of the leader, which is to keep the discussion moving forward. Providing sentence stems for the group leader will be helpful, especially for students who are not used to facilitating a discussion:

- “_____ hasn’t had a turn yet; what do you think?”
- “What evidence do you have to support your idea?”
- “These ideas are very different; what evidence do we have to support each one?”

After explaining the strategy, identify the first leader and post the question for the group to discuss.

Management Strategy:

You can allow students to decide who will be the A, B, or C, or can assign these roles. Assigning roles can be done while students are sharing their answers in the previous activity by circulating through the room and writing a letter on each students’ paper or placing a card next to each student. An advantage of assigning roles is that you can assign ELL or other students who may struggle with this to be student B. This will allow them to observe how student A leads the discussion on a similar question. If needed, model the role of the group leader. Use a timer so students can monitor themselves; each time the timer goes off you can display the next question and students can switch discussion leaders.

As students discuss their ideas, circulate through the room and listen to what they are saying. Make note of student interactions that you may want to bring up to the whole class, and/or comment directly to students as you see quality interactions happening. For example:

- “I love the way you asked _____ for more evidence to support her idea.”
- “I noticed that your group took a second
Communicate: When your new group gets to the model you helped create, allow them 30-60 seconds to examine it. Then ask what questions they have, and provide answers. If there is any part of the model that you didn’t explain when you answered their questions, explain it to your group members. When your group is at a model that you didn’t create, examine the model, ask questions about it, and then listen to the explanation to complete the graphic organizer.

For this section, students will be using the explain-regroup-explain your explanation strategy. Students will work with their group to construct an explanation; in this case, their explanation will be in the form of a model. Students are then scrambled into new groups, and take turns explaining their explanations (models) to their new group members. This allows each student to take ownership of his understanding as he explains his group’s model to others, and to hear ideas from other groups.

Provide poster paper and markers and allow them time to work on their group models. Display the expectations for the model on the board or provide a list of “gotta haves” to each group so they can check to make sure they meet the expectations.

Ask students to either hang their models or leave them on their tables. Models need to be displayed in a way that allows students to examine them in groups.

Scramble the groups so each student is with new people. One quick way to reassign groups would be to point to three groups, and say, “all the A’s from these three groups will start here (point to one of the group’s models), all the B’s from those groups will start here (point to another group’s model), and all the C’s will start here (point to the last group’s model); when it is time to rotate, you’ll rotate with your new group in this direction (indicate the direction students will move among the three models).” This can be repeated until all the students have been reassigned to a new group. Once students know where they will be moving, tell them that they will be explaining their model to their new group members. If needed, model what their discussion should look like and how to fill in the graphic organizer. If the class will be successful with more rigid procedures, set a timer and allow students a set amount of time to present their model before moving to the next one. Otherwise, you can allow students to move through the models with their groups at their own pace. Emphasize that all students should fill in

Evidence you have to support your idea about how energy flowed through the system?
their own graphic organizer. As students work, circulate through the room and listen to their explanations so you have an idea of what they are thinking (as well as misconceptions they may have). Collect the group models; students will be revising them during the next lesson.

Assessment of Student Learning

This is a formative assessment and should be used to understand students’ ideas and misconceptions that may need to be addressed.

Students’ ability to collect and interpret data should be used as a formative assessment; their participation with their groups should be used to assess both their understanding of the data they collected, as well as their ability to use evidence to support their ideas and communicate effectively. Student work (discussions, group models, and individual work, including the graphic organizer at the end of the lesson, etc.) should be used to assess student understanding of energy flow; at this point, students should understand that heat energy can move from one material to another when the materials are in contact with each other, and that the amount of energy transferred can depend on the material. A major misconception that students may have at this point is that “cold” energy moves from something that is cold to something that is warm, cooling it down. They may think that the spheres somehow gave their coldness to the water (instead of heat moving from the water to the spheres).

Student models could be assessed according to the following rubric:

<table>
<thead>
<tr>
<th>Above proficiency</th>
<th>Meets requirements for proficiency, and may include the following:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>● Recognition of second system after the spheres are removed (spheres and the air); energy flow in this system is from the spheres to the air; evidence is that the spheres are cooling down; recognition that there is not evidence that air temperature around the spheres increased, but this inference could be made based on what happened in the sphere-water system</td>
</tr>
<tr>
<td></td>
<td>● Inclusion of air as part of the sphere-water system, with heat energy also moving from the water to the air</td>
</tr>
<tr>
<td></td>
<td>● Inclusion of heat flow into the cup (or not); for example, if students were using styrofoam cups and noticed that the cups got warm but not hot, they could include flow of some heat energy to the styrofoam; if plastic or glass cups were used, they may include more heat energy flowing to the glass/plastic</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Proficient</th>
<th>Model includes the following:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>● System includes water, spheres (and possibly cup and thermometer)</td>
</tr>
<tr>
<td></td>
<td>● Heat energy flows from the water to the spheres at this point, some groups may think that “cold energy” is moving from the spheres to the water; their evidence might support this (the water did get colder, so maybe the cold from the spheres moved to the water); these groups would need to be reassessed for their understanding of the flow of heat energy after the next lesson, which is designed to address this misconception</td>
</tr>
<tr>
<td></td>
<td>● More heat energy flows to the metal sphere than to the wooden sphere</td>
</tr>
<tr>
<td></td>
<td>● Evidence to support flow of energy includes: temperature of water decreased, temperature of metal sphere increased more than the temperature of the wooden sphere</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Approaching proficiency</th>
<th>Elements required to meet proficiency is included, but may be incomplete or contain errors. For example:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>● Students may have included their stopwatch or other materials as part of the system, or may have left out part of the system</td>
</tr>
<tr>
<td></td>
<td>● Heat energy is shown flowing only to the metal sphere, or to all spheres equally</td>
</tr>
<tr>
<td></td>
<td>Evidence is not sufficient to support claims made by the model or is unrelated to the</td>
</tr>
</tbody>
</table>
claims made by the model. For example:
- Decrease in water temperature is included but nothing about the temperature of the spheres
- Times from student data are included but the model makes no claim about the rate of energy flow

<table>
<thead>
<tr>
<th>Below proficiency</th>
<th>Model is missing most elements needed to meet proficiency; elements that are present are inaccurate and/or incomplete</th>
</tr>
</thead>
</table>

Example of a proficient student model:

Our system: it had water and four spheres that were glass, metal, wood, and plastic.
What we think happened: the heat went from the water to the spheres, but more heat energy went from the metal sphere. Our evidence is that the metal sphere got the hottest.
Energy Flow Investigation

Collect your materials:
- Cup with hot water
- Plastic spoon
- Four spheres
- Thermometer
- You’ll also need a timer; you can use your phone or the clock on the wall

Put the thermometer in the water, and once the temperature stops rising, record the starting temperature of the water. Then add the four spheres to the water, and continue to record the temperature every 30 seconds.

<table>
<thead>
<tr>
<th>Time (seconds)</th>
<th>Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 (starting)</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td></td>
</tr>
<tr>
<td>60</td>
<td></td>
</tr>
<tr>
<td>90</td>
<td></td>
</tr>
<tr>
<td>120</td>
<td></td>
</tr>
</tbody>
</table>

After the spheres have been in the water for two minutes, use the spoon to take them out. Gently touch each sphere (don’t burn your hands!) and record how hot it feels. Continue to record how hot each sphere feels every 30 seconds for three minutes.

<table>
<thead>
<tr>
<th>Time (seconds)</th>
<th>Describe the temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Metal</td>
</tr>
<tr>
<td>0 (starting)</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td></td>
</tr>
<tr>
<td>60</td>
<td></td>
</tr>
<tr>
<td>90</td>
<td></td>
</tr>
<tr>
<td>120</td>
<td></td>
</tr>
<tr>
<td>150</td>
<td></td>
</tr>
</tbody>
</table>
Once you have recorded all of your data, follow your teacher’s instructions for cleaning up. Then answer the following questions. Later, you will be discussing these questions with your group.

**Define the system that you investigated.** You could make a list of the parts of the system, or draw a picture of the system and label the parts.

**Why did the materials in the system change temperature?** How did energy move through the system? You can use words to describe how the energy moved, or draw a picture and use arrows or other symbols to show how the energy moved through the system.

<table>
<thead>
<tr>
<th>Models</th>
</tr>
</thead>
<tbody>
<tr>
<td>As you examine the other groups’ models, ask questions, and listen to explanations, fill in the table below.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Group member who created the model</th>
<th>How is this model similar to the model I made?</th>
<th>What are some things this model are useful?</th>
<th>How does this model represent the flow of energy?</th>
</tr>
</thead>
</table>
### 6.2.3 Learning Episode 3

<table>
<thead>
<tr>
<th>Topic: Conduction/transfer of thermal energy</th>
<th>Title: Conduction Game</th>
</tr>
</thead>
</table>

### Overarching Performance Expectations (Standard) from State Standards or NGSS:

6.2.3 Plan and carry out an investigation to determine the relationship between temperature, the amount of heat transferred and the change of average particle motion in various types or amounts of matter. Emphasize recording and evaluating data, and communicating the results of the investigation.

### Lesson Performance Expectations:

Students will use observations made while participating in a game to continue developing their model to show how heat energy flows through a system. They will then use the evidence collected throughout the unit to support a claim regarding the flow of energy in the water-sphere system. By the end of this lesson, students should understand that heat energy flows from molecules with more energy to molecules with less energy. They should also be able to relate the amount of heat energy to the motion of the molecules (specifically, that molecules with more heat energy are moving faster, and that when they contact a molecule with less energy, some of their energy is transferred, which results in a change in the motion of both molecules).

CCC: Energy and matter, systems (heat energy is conducted through a system from molecules with more energy to molecules with less energy and results in a change in motion of the molecules)

SEP: Arguing from evidence and developing models

#### Students Will . . . To Construct Meaning

*Engage with a Phenomenon: When different materials are exposed to heat energy, some of them heat up more than others*

*Gather:* You will be participating in an activity to model energy flow through the molecules in a system. As you participate in the activity, pay attention to how your number of cards changes.

When you hear the timer go off, you'll drop off your cards and return to your seat.

*Reason:* Your group will be discussing three questions. When it is your turn to be the group leader, you will be in charge of the discussion. This does NOT mean that you will be the only one talking! It will be your job to direct the discussion; these sentence stems may be helpful to the leader:

- “What do you think about ______?”
- “We haven’t heard from ____ yet; what is your idea about _____.”
- “Can you explain what you mean?”
- “What evidence do you have to support your idea?”

#### Teacher Will . . . To Support Students

Explain the activity (instructions are included with the lesson materials), pass out the cards, and remind the students to pay attention to how their number of cards changes. Instruct the students to return their cards and then return to their assigned seats when they hear the timer go off. Allow students to play the game for two minutes (two minutes allows them enough time to find patterns in the way the cards are being passed without getting too rowdy).

Instruct students to sit with the group they made their model with during the last lesson, and drop off a set of colored pencils (one pink, one green, and one blue) to each group. Tell the students that they should each take one colored pencil. They will be using the *group discussion with alternating leaders* strategy that they learned last time.

Tell students that they will be discussing three questions with their group, and each of them will have a turn to lead the discussion. Remind students what they should be doing when it is their turn to be the
Discussion questions (the discussion leader is the student with the corresponding colored pencil):

- **Green:** What happened to the number of cards you had? What would have happened to the number of cards everyone had if we had played the game for an hour?
- **Pink:** Describe the way the heat energy moved through the system. What factors affected how the energy flowed?
- **Blue:** How does the way the energy moved through the system during the game relate to the data we collected during the sphere investigation last time?

Display the first question on the screen and tell students how much time they will have to discuss it (approximately 2 minutes per question); when time is up, move on to the second and then the third question. Students will be using the ideas they are discussing as they revise their models; you may want to tell them this upfront so they know why they are discussing these particular questions.

**Management Strategy:** As students are discussing, circulate through the room and redirect group leaders if needed (particularly if there are students who are using their leadership role to dominate the discussion or diminish others’ ideas); make note of students/groups you may want to call on during the class discussion to share the ideas they are discussing. Also make note of communication/leadership skills that students are displaying that you would like to share with the class; if a particular student might be embarrassed to be recognized this way in front of the class, you can quietly compliment them as you are moving through the class.

- “I noticed that Johnny’s group moved their chairs so they were all facing each other.”
- “I liked the way Zoe asked someone in her group for evidence to support his idea.”
- “I noticed that everyone in Henry’s group had a different idea about _____; can you share with the class how you were able to come to consensus?”

If needed, facilitate a short class discussion. Before students start revising their models, they should come...
time, and look over the third row, where you recorded things from other groups’ models that you found useful. Take one minute and let everyone in the group share the things they liked about the other models you saw. Your group may want to consider some of these things as you revise your own model. After you have all had a chance to share the things you liked about the other models, pick up your own model from the teacher. Use the ideas you just discussed with your group to revise your model; when you get done it should include the following information:

- What is happening to the energy and the molecules where the water and wooden sphere are touching
- What is happening to the energy and the molecules where the water and metal sphere are touching
- Why the temperatures of the water and spheres is changing

Remember that you can include zoom-in boxes to show what is happening to the molecules and written descriptions.

Communicate: You will be sharing your model with the class. You will be sharing your group’s idea about ONE of the following:

- What is happening to the molecules and energy where the water and metal sphere touch
- What is happening to the molecules and energy where the water and the wooden sphere touch
- What is causing the change in temperature of the water and the spheres

When it is your group’s turn to share:

- Tell the class which of the ideas you will be sharing “Our group is going to share our idea about what is happening where the water and metal are touching.”
- As you explain your idea to the class, show how you represented it on your model “We think that ____, and we used ___ symbols to represent ____ and ....”

Management Strategy: As students revise their models, circulate through the class and use questions to help students clarify and explain their ideas:

- “Why did you choose to include ____?”
- “How could you include the evidence you have for ____?”
- “What do these symbols represent? How can you make that clear?”
- “Earlier I heard you discussing ____; how are you going to incorporate that into your model?”

to the understanding that:

- Heat energy moves from the molecule with more energy to the molecule with less energy
- Heat energy moves from one molecule to another when the molecules touch
- Some molecules can’t get heat energy from other molecules

If you notice that there are students who have not grasped these concepts, a class discussion that allows other students in the class to express these ideas may help struggling students.

At this point, if students in the class demonstrate understanding the concept of insulators and conductors, you can introduce these terms; you could also wait until the next learning episode to introduce this vocabulary.

Direct students to the “what are some things this model has that are useful?” section of the graphic organizer they filled out as they viewed others’ models last time. Allow them time to share and discuss the useful features with their groups.

Explicitly tell students the additional information that their models should contain and invite them to revise/cross off anything that they included last time that they now realize may be incorrect. Sticky notes may also be helpful to provide more writing space for groups who didn’t leave much white space on their poster. Display the information that should be included in the revision and/or provide a hard copy that students can refer to as they revise their models. Give them a time limit, and consider displaying the timer so they can self-monitor.
<table>
<thead>
<tr>
<th>Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tell the class the evidence that you used to support your idea “The evidence we have to support the idea that ____ is ____.”</td>
</tr>
<tr>
<td>Identify features included on their models that you would like to use as examples for other students to see during the class discussion, and also note misconceptions you observe; taking a clipboard with you as your circulate can make remembering features/misconceptions easier.</td>
</tr>
<tr>
<td>Individually, make a claim about how the energy flowed through the system and then use evidence to support your claim. Record your claim and the evidence to support it in your lab book, and then construct an argument for how the evidence supports the claim.</td>
</tr>
<tr>
<td>- Why weren’t the spheres the same temperature when you took them out of the water?</td>
</tr>
<tr>
<td>- What is happening on the molecular level when energy is transferred from the water to the sphere?</td>
</tr>
<tr>
<td>- If the spheres stayed in the water for several hours, what would happen to the temperature of all the parts of the system? Support your answer.</td>
</tr>
</tbody>
</table>
share features (zoom-in boxes, symbols, keys, descriptions, etc.) that they liked in the different models.

Management Strategy:
Depending on the students in your class, you may want to create a class model during the discussion. As students discuss both the content and the mechanics of the various models, play the role of the scribe and record their ideas in a new model. Constructing a model together can be very beneficial to ELL and other students who may struggle with understanding the discussion without visual cues, or who may need to interact with the information a second time.

As an individual assessment, have students summarize their understanding of energy flow by constructing an argument about the energy flow through the system. Please note that this is hard for students! If this is the first time students have been asked to make a claim, provide evidence to support it, and then construct an argument, you will need to model what to do, possibly walk students through the process, and/or provide scaffolding. A graphic organizer can be provided to students, or you can show them how you would like them to format their responses in their lab books. Suggestions for scaffolding and a graphic organizer are included in the lesson materials.

Assessment of Student Learning
This is a formative assessment and should be used to understand students’ ideas and misconceptions that may need to be addressed. If a graded assessment is needed at this point, you could use the rubric below as a guide for grading their claim and evidence. When assessing student claims/evidences, a student’s ability to argue from evidence should be valued at least as much as having the correct answer about energy flow through the system.

Student models should include:
- Molecules (zoom-in boxes could be included to show the molecules; water, metal, and wood molecules should be included)
- Symbols and/or descriptions to show molecular motion (for example, students may use squiggly lines to show the motion, with longer lines indicating more motion)
- Transfer of heat energy from the water to the metal (for example, students could use arrows to show that energy moves from the water molecule to the metal molecule)
- Key/descriptions to communicate what different symbols represent
- Temperature change of the water and metal/wood
- Evidence to support the claims made by their model (for example, an explanation that the temperature changes show that heat is moving from the water to the metal, making the water cool down as it loses heat energy and the metal heat up as it gains heat energy)
Example of a revised model:

The claim/evidence statements should be used to assess individual student understanding. The rubric below can be used as a guide to assess their arguments; adjustments would need to be made if additional scaffolding is used to help some students construct their arguments.

<table>
<thead>
<tr>
<th>Surpasses proficiency</th>
<th>Meets requirements for proficiency, PLUS:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>● Analysis of the system of the spheres in the air is included to support the claim</td>
</tr>
</tbody>
</table>

| Proficient            | ● Claim is included |
|                       | ● Evidence to support the claim is included, sufficient and correct (for example, a student shouldn’t have evidence that the temperature of the water increased) |
|                       | ● The evidences are used in an argument to support the claim |

| Approaching proficiency | ● Claim is included |
|                        | ● Evidence to support the claim is included and correct, but may be insufficient (for example, the student may only have one piece of evidence) |

| Below proficient       | ● Claim is included |
|                       | ● Evidence is missing, incorrect, and/or insufficient or may not support the claim |
|                       | ● No argument is made |
Claim: Energy flowed through the system when a molecule with more energy touched a molecule with less energy

<table>
<thead>
<tr>
<th>Evidence:</th>
<th>Reasoning:</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Temperature of the water before the spheres were added was 98°C.</td>
<td>When the spheres were in the water, they got hotter and the water temperature lowered by 26°C. This shows that the water was losing heat energy and the spheres were gaining heat energy. Since the water was hotter than the spheres to start with, the heat must have been moving from molecules with more energy in the hot water to molecules with less energy in the colder spheres. This supports the part of my claim that says the heat energy moves from something with more energy to something with less energy.</td>
</tr>
<tr>
<td>- Temperature of the water one minute after the spheres were added was 72°C.</td>
<td>But this only happened after the spheres and water were touching. Before the spheres touched the water, they weren’t getting hotter and the temperature of the water stayed the same. Also, during the game, the energy cards couldn’t get passed from one person (or molecule) to another unless they were touching. If you didn’t actually bump into someone, you couldn’t get any energy from them. These evidences support the part of my claim that says the molecules must be touching each other for the heat energy to move.</td>
</tr>
<tr>
<td>- The water started out hotter than the spheres.</td>
<td></td>
</tr>
<tr>
<td>- During the game, cards were passed from high to low.</td>
<td></td>
</tr>
<tr>
<td>- Temperature of the spheres increased after they were in the water.</td>
<td></td>
</tr>
</tbody>
</table>

Note: This “student” example is probably more than you should expect from your students if this is the first time they have done a CER. If time allows, have students review each other’s CERs and make revisions to polish their reasoning. Also present some excellent student-produced examples from the class at the end so that students can see what is expected the next time they do a CER. Also note the use of the word “support” in this example, which is very intentional. Students may say that their evidence “proves” their claim. It is important for students to understand that scientists don’t claim to prove their ideas. Using the word “prove” implies that the game is over, when in reality, scientists realize that no matter how overwhelming the evidence, there is always room for further questioning and discovery.
Pass out 0-4 slips of paper (or tokens, or paper clips, etc.) to each student (this does not need to be precise). Tell the students that the class will be modeling the system you investigated last time. The students are molecules and the cards represent how much energy they have. The more cards they have, the faster they are allowed to move through the room. When they bump into another student (you may need to explain and/or model what “bumping” into another student should look like), each student will hold up their cards. The student with more cards must give one card to the other student. If the students have the same number of cards, they can either do nothing or exchange one card each (they will end up with the same number of cards). Pick a few students and tell them that they have to keep their hands in their pockets. If they don’t have actual pockets, they can just pretend. What this means is that they don’t have hands to take cards from anyone. So even if they bump into someone with more cards, they can’t take any of them. One way to pick these students is to look around the room and call out a color that you see 2-4 students wearing. (“If you are wearing a red shirt, you have your hands in your pockets.”) You could also make a mark on a couple of the slips of paper and then tell the students that if they got that slip of paper they have their hands in their pockets. Emphasize that students should pay attention to how their number of cards changes as they play the game.

Claim, Evidence, Reasoning Scaffolding Ideas

Note: Students may be familiar with the term “argument” from writing arguments in their ELA classes. In many science lessons and teaching resources, the “reasoning” section is similar to the argument used in ELA. In the claim-evidence-reasoning (CER) model, the reasoning section is where students provide an argument that the evidence they cited actually supports their claim. Differentiating between the evidence and reasoning is difficult for students and takes practice. The evidence consists of the data they collected and/or the observations they made, while the reasoning is an explanation of how or why the data supports the claim. In this case, let us say that students collected data that the water started at 100° and then dropped to 70° after the spheres were added. Students may want to use this evidence to support a claim that energy moved from the water to the spheres, but this one piece of evidence is not enough to support the claim. They may need to combine it with an additional piece of evidence (maybe that the metal and glass spheres got hot while they were in the water). In the reasoning section, they would describe how these two pieces of evidence could be used together to support the claim. The first few times students do a CER, they will need some scaffolding. Three different levels of scaffolding are included below, with level III providing the most scaffolding.

**Level I:** Provide students with possible claims and allow them to select the claim they have the most evidence to support. They can then use the evidence they generated to construct their argument. Possible claims:

- More heat energy moved from the water to the metal sphere than to the wooden sphere
- Heat energy moved from the water to the spheres
- Heat energy moved from the spheres to the water
- In order for the heat energy to move from the water to the spheres, they must be touching
- If the water started out hotter, the metal sphere would have gotten hotter

Additionally, sentence stems could be provided to help students write their reasoning. This could be particularly helpful to ELL students.

**Level II:** Provide students with claims and evidences; allow them to determine which pieces of evidence could support each claim. Note that some of the evidences could be used to support multiple claims, and that all the claims could be supported by the evidence that students gathered. Students then select one claim and use the evidence to construct their argument. You could provide these in a list and allow students to draw lines from the evidence to the claim that it supports, or cut them into strips that students can sort. Possible claims/evidence:
● Heat energy moved from the water to the spheres
● The sphere must be touching the water for the heat to move from the water to the sphere
● More energy moved from the water to the metal than to the wood

● The water went from _____ ° to _____ °
● The metal sphere got hotter than the wooden sphere
● When we played the game, you had to touch someone before you could get their energy
● When we played the game, energy always went from the molecule with more to the molecule with less
● The metal sphere and the wooden sphere both got hotter when they were in the water

**Level III:** Provide students with only one claim and a list of evidences (these could be from the examples in the table above). Students determine which of the evidences could be used to support the claim, and then use the evidences they selected to write their reasoning. If additional scaffolding is needed:

- Students could be given the claim and the evidence to support it, and then asked to write their reasoning. In this case, students would be responsible to explain why/how the evidence provided supports the claim given to them.
- Sentence stems could be provided to help students write their reasoning; this may be particularly helpful for ELL students.
**Flow of Heat Energy**

*Claim-Evidence-Reasoning*

<table>
<thead>
<tr>
<th><strong>Claim</strong> (remember that this is a statement about how heat energy flows through the system):</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Evidence</strong> (what data did you collect that supports the claim you made?):</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Reasoning</strong> (this is your argument; explain how/why the evidence you listed above supports the claim you made):</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>
6.2.3 Learning Episode 4

Student Science Performance

| Topic: Conduction/transfer of thermal energy | Title: Ice Melting Blocks 2 |

**Overarching Performance Expectations (Standard) from State Standards or NGSS:**
6.2.3 Plan and carry out an investigation to determine the relationship between temperature, the amount of heat transferred and the change of average particle motion in various types or amounts of matter. Emphasize recording and evaluating data, and communicating the results of the investigation.

**Lesson Performance Expectations:**
Students will use evidence to develop a model that shows the relationship between temperature, particle motion, and state, and the relationship between the amount of heat energy transferred and the type of material.

CCC: Stability and change, cause and effect, energy and matter (student models should show that heat transfer to a material causes change in the system and that materials that limit heat transfer can result in more stability in the system)

SEP: Constructing explanations, developing and using models

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**Students Will... To Construct Meaning**

*Engage with a Phenomenon: When ice cubes are placed on two blocks, one melts and the other does not*

Gather: We’ll be using a digital thermometer to find the temperatures of the ice melting blocks that we used in class earlier. Find the models you made of the ice melting blocks and record the temperature of each block.

What questions do you have about your observations?

Reason: Come up with an explanation for why one block feels colder than the other, even though they are the same temperature. Write your idea in your lab book. If you have more than one possible explanation, write them both/all.

Share your idea and/or comment on another student’s idea during the class discussion.

---

**Teacher Will... To Support Students**

Show the students the ice melting blocks and ask if they remember how they felt; allow students to feel the blocks again to reinforce that one feels colder than the other.

Instruct students to find their original models and then use the digital thermometer to read the temperature of each block. If students don’t believe that they are the same temperature, allow a few students to come up and verify the results.

Ask for questions (if needed; many students will begin asking questions related to their surprise that the blocks are the same temperature); tell students that they will be constructing an explanation for the “how can they be the same temperature?” questions.

Display the task on the board (“construct an explanation for why one block feels colder than the other, even though they are the same temperature”). Tell students that they can use words and/or pictures in their explanations. You may also want to suggest that students find their sphere system models and/or CERs from previous lessons to help inform their explanations.

---

Management Strategy:
Communicate: Find your original ice melting block models from a few lessons ago. You will be revising your model so that it shows what causes the ice to melt on one block but not the other. Revise your original models to include:

- Water molecules in the ice on each block
- Water molecules in the liquid water that melted
- Why the water changed from a solid to a liquid
- How heat energy is transferred from the block to the ice
- Why the ice melts on one block but not the other

Give students a specific amount of time to work on their explanation(s) and display a timer so they can monitor themselves. As they work, circulate through the room with a clipboard and note any students whose ideas you would like them to share with the class. You could also give those students a heads-up, but quietly telling them that you will be asking them to share their explanation with the class. Also use questions to help guide students who look like they are struggling to get started:

- “What makes your fingers feel cold?”
- “What would your fingers feel like if the heat were removed?”
- “What do you think happens to the heat energy in your fingers when you touch the block that feels cold?”

Facilitate a class discussion to help all students understand that one block is a conductor, and heat energy flows from their fingers to the block, causing their fingers to feel cold (since the heat is leaving). The other block is an insulator, so the heat energy in their fingers stays put instead of being transferred to the block. Once these concepts become clear, focus the discussion on the ice. One block conducts heat to the ice, causing it to melt. The other does not.

Management Strategy:
Construct the discussion so that students are the ones explaining the concepts; you can do this by strategically selecting which students should share their ideas, and/or asking questions during the discussion to allow students to develop and express their ideas. Referring students to the model they made previously of the spheres in the water may also be useful in helping them apply their understanding from that activity to the ice melting blocks.
You may also want to explicitly tell students that as they hear new ideas or realize their initial explanation is flawed, to make notes/revisions to their explanation.

You could choose to have students make a new model, based on their first one to reduce the amount of clutter. Display a list (or hand out hard copies) of the features that the models must have and allow students time to work on them. As students work, circulate through the room and use questions to help students clarify their ideas and models. This model is fundamentally the same as the revised model of the water-sphere system, with the addition of the relationship between thermal energy and state.

### Assessment of Student Learning

*Student explanations of why the blocks feel like they are different temperatures should be used as formative assessments that drive the discussion; student participation in the discussion should also be used to assess understanding. Individual models of ice melting blocks could be used as a formative or summative assessment at this point.*

Suggested rubric for grading student models:

| Surpasses proficiency | Model includes requirements to meet proficiency, plus additional information regarding relationships between temperature, state and molecular motion, and transfer of heat energy. Examples could include the following:  
| --- | --- |
|  | ● Flow of energy from the air, through the conducting block to the ice  
|  | ● Flow of energy through the water, showing water molecules with more heat energy transferring the energy to water molecules with less heat energy  
|  | ● Possible flow of energy from a water molecule with more energy to a metal molecule with less energy, with the recognition that the net flow of energy is initially from the metal block to the water  
|  | ● Recognition that if allowed to sit long enough, all the molecules in the ice-block system would have the same amount of heat energy  
|  | ● Explicit mention of how the water molecules are changed as heat energy is added or removed; that is, they are made of the same atoms but their motion and placement relative to other molecules changes  
|  | ● Since air is not very dense, not as much thermal energy can flow directly from the air to the ice (not as many air molecules available to contact the outside of the ice and transfer energy) |
| Proficient | Model includes evidence of the following:  
|  | ● Relationship between temperature, state and molecular motion (for example, zoom-in boxes with symbols that represent molecules and how fast they are moving with molecules in the ice moving more slowly than molecules in the liquid water)  
<p>|  | ● Transfer of heat energy between molecules (for example, a zoom-in box showing the metal and water molecules; symbols/descriptions included to show that when the metal molecule with more heat energy bumps into the water molecule with less heat energy, some of the energy is transferred from the metal to the water molecule) |</p>
<table>
<thead>
<tr>
<th>Proficiency Level</th>
<th>Model Description</th>
</tr>
</thead>
</table>
| **Approaching proficiency** | Model includes the following, but may contain incomplete and/or incorrect information:  
- Relationship between temperature, state and molecular motion  
- Transfer of heat energy between molecules  
- Difference between conductors and insulators |
| **Below proficiency** | Model does not include:  
- Relationship between temperature, state and molecular motion  
- Transfer of heat energy between molecules  
- Difference between conductors and insulators  
Information that is included is incomplete/incorrect |

**Example of student revised model:**

![Diagram of heat transfer between different types of blocks](image-url)
Ice Melting Blocks Explanation

Construct an explanation for why one block feels colder than the other, even though they are the same temperature. You can use words and pictures in your explanation.

If you have more than one idea, you can write them both.
6.2.3 Learning Episode 5

<table>
<thead>
<tr>
<th>Student Science Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Topic:</strong> Conduction/transfer of thermal energy</td>
</tr>
</tbody>
</table>

**Overarching Performance Expectations (Standard) from State Standards or NGSS:**
6.2.3 Plan and carry out an investigation to determine the relationship between temperature, the amount of heat transferred and the change of average particle motion in various types or amounts of matter. Emphasize recording and evaluating data, and communicating the results of the investigation.

**Lesson Performance Expectations:**
Students will plan and carry out an investigation to determine the relationship between the amount of material and the amount of heat energy transferred. They will use the evidence they gather during the investigation to support a claim about the relationship between amount of material and amount of heat energy transferred.

CCC: Energy and matter; scale, proportion and quantity

SEP: Plan and carry out an investigation, analyzing and interpreting data, constructing explanations, communicating information

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**Students Will. . . To Construct Meaning**
*Engage with a Phenomenon: Different volumes of hot water that start at the same temperature do not cool down at the same rate.*

**Introduction:** In the story of *Goldilocks and the Three Bears*, Baby bear’s porridge is “just right” but Mama and Papa bears’ porridges are too hot. You are going to investigate how this is possible. Assuming the porridge all came out of the same pot, why would some be hotter than others?

**Gather:** You will have access to plastic cups, thermometers, measuring cups, and hot water. Your task is to figure out how the porridge in the bears’ bowls could be different temperatures. You will be making a claim, and using the evidence you collect during your investigation, to support it.

With your group, determine how you will conduct your investigation. Set up your data tables, collect your materials, and then start investigating! You can do more than one investigation to collect the evidence you will need to make and support a claim.

---

**Teacher Will. . . To Support Students**
*Note:* You could integrate this lesson into the storyline or start introducing this concept earlier by adjusting the investigation with the spheres in learning episode 2 by including a metal sphere of a different size. Students will then be able to gather information about how the type and the amount of material affects heat transfer at the same time. This could help streamline the lessons, but could also result in cognitive overload for some students, since they will be working to understand two different variables at the same time.

Read the beginning of the Goldilocks story to students and make sure that everyone knows what “porridge” is (especially ELL students). Conduct a short discussion about how porridge was made back in the day; instead of microwaving individual bowls, like students might do at home now (if they eat oatmeal), all the porridge would be made together in one pot and then portioned out. This is important, because students should understand that the porridge all started out the same temperature.

Provide students with their task, which is to determine how it is possible for the porridge to be poured into bowls and then end up being different temperatures. Depending on the class, you can:
- Allow students to start planning and conducting their investigations.
- Provide additional information/support and then allow students to start planning and
Reasoning: With your group, write a claim that both matches the story and can be supported by evidence. This means that your claim should state how it is possible for Baby bear’s porridge to be cooler than Mama and Papa’s. Also determine which pieces of evidence collected during the investigation could be used to support the claim.

Write your claim and the evidence to support it in your lab book. Although you are working with your group, everyone is responsible to record the information in their own lab books.

Communicate: You will be meeting with a partner and sharing your claims and evidence with each other.
- Each partner should share his claim
- Together, compare your claims. Are they the same? How are they different?
- Partner 1 should share the evidence to support his claim; partner 2 should listen and ask questions/provide feedback:

conducting their investigation. This may include clarifying that students are trying to find a way to replicate the temperatures in the story; how can they make it so the water in one cup cools down faster than the water in another cup? It may also involve discussing data collection: what data could students possibly collect (amount of water, temperature, time, etc.) and how they will record the data.

- Help the students plan the investigation together as a class. This may be beneficial if you have several students who will struggle with planning the investigation or data collection without specific instructions. This could also be a useful strategy if time is limited; making sure that all students have a clear plan that will get them the data they need will require less time for them to conduct the investigation.

Management Strategy:
Students should be in groups of three. Provide limits on time and supplies to students. (“Each group can have three cups, three thermometers, and start with 200 ml of hot water” and/or “You will have ___ minutes to plan and ___ minutes to investigate.”) If students are planning their investigations with their group, structure their time so that they have planning time before collecting their materials. This can be short; you also have the option to ask students to write down their investigation plan and show it to you before they are allowed to collect their materials.

To help students focus their claims, display a question on the board, such as “what causes the water to cool down at different rates?” If needed, you can provide scaffolding by providing 2-3 claims to the students and allowing them to select claim to support. As students work with their groups, circulate through the room; if needed, remind students that they should all be recording the claim and evidences (not just one person); also use questions to help students focus the
○ “How does ____ relate to the claim?”
○ “How did your group gather that piece of evidence?”
○ “I don’t think that piece of evidence supports your claim because ____.”

● Switch roles, so partner 2 can share his evidence and partner 1 can ask questions/give feedback.

When you are finished discussing with your partner, return to your assigned seat.

Participate in the class discussion to help construct an explanation for how the amount of water in the cup affects the rate of temperature change. You will be using this information to write a story later, so you should be recording your ideas during the discussion.

You will be rewriting the part of *Goldilocks and the Three Bears* where Goldilocks eats the porridge to be scientifically accurate. Your story should include:

● The amount of porridge in each bowl
● An explanation of why they porridge is different temperatures

Your story could include:

● Pictures
● Scientific drawings

evidence that they are recording.

Group students so that they are paired with someone that they did not do the investigation or claim/evidence statements with. Review the norms for the discussion, and if needed, provide sentence stems and/or model what the discussion should look like. You may also want to establish time limits for each part of the discussion and display the timer so students can monitor their conversations.

**Management Strategy:** As students discuss, circulate through the class with a clipboard and make note of student ideas that you would like to bring up during the class discussion. Listen for students whose claims/evidence focus on the amount of water, and make a note to ask those students to share during the class discussion. You can also give those students a heads-up, so they know that you will be asking them to share a specific idea during the discussion.

Facilitate a class discussion to emphasize the relationship between the amount of water and the rate of cooling. Before starting, you may want to provide a graphic organizer or specific task to help all students engage in the information being discussed. For example, you could ask students to put a star by an claim or evidence written on their paper that the class decides is important during the discussion, or to add it to their paper if they don’t already have it. Allow students to share their evidences to help convince everyone that the less water, the faster the rate of cooling. Then continue the discussion by asking students *why* this would be the case. By the end of the discussion, students should understand that the more total molecules in the water to start with, the more heat energy it will contain, and the longer it will take for this heat energy to be transferred to the air. Creating a class model during the discussion can help visual students and ELLs understand the concept. When creating a class model, act as the scribe, and record ideas that the class agrees are important, and include features/symbols that the class agrees will make the model effective.
Explain the task and if available, show students an example product that would be acceptable. Provide a rubric or list of things that students must include in their rewrite of the story.

If there is time, provide a format for students to read each other’s stories, select a few to show the class, or ask for a few volunteers to read their stories to the class.

Assessment of Student Learning

Student investigation techniques (including data collection), claim-evidence statements, and discussions should be used as formative assessments of skills and understanding that can help drive the class discussion. Goldilocks stories could be used as formative or summative assessments of student understanding of the relationship between heat transfer and the amount of material.

Examples of claims and evidence that would be acceptable:

<table>
<thead>
<tr>
<th>Claim</th>
<th>Evidence</th>
</tr>
</thead>
</table>
| The less water there is, the faster it cooled down | 100 ml of water went from 98º to 96º in 3 minutes  
50 ml of water went from 98º to 94º in 3 minutes   
20 ml of water went from 98º to 90º in 3 minutes |
| The more water there is, the longer it took to cool down | 100 ml of water took 7 minutes to drop 4 degrees  
50 ml of water took 5 minutes to drop 4 degrees  
20 ml of water took 2 minutes to drop 4 degrees |
| When the water starts out hotter, it cools down faster | 98º water cooled down 2 degrees in 3 minutes  
80º water cooled down 1 degree in 3 minutes |

Note: The last claim reveals that the students misunderstood the background for the investigation or the question they were supposed to investigate. When assessing, the teacher should take into account that the students were able to plan and carry out an investigation, and were clearly able to make a claim that is supported by the evidence they collected.

Example of Goldilocks story:
“This porridge is too hot!” Said Goldilocks.
She looked through her special magnifying glass to see
the molecules moving around. She noticed that when the
molecules bumped into an air molecule, some of their heat
in this bowl! It will take forever for all their heat to get
transferred to the air! There are too many of them!”
Said Goldilocks. She looked at another bowl of porridge.
“I bet this bowl won’t be as hot because
there isn’t very much porridge. It didn’t take as
long for the heat to move into the air, because there
aren’t very many.

Possible Goldilocks rubric:

<table>
<thead>
<tr>
<th>Surpasses proficiency</th>
<th>Story meets the requirements for proficiency, and contains information regarding the relationship between the amount of porridge and temperature beyond what was explicitly discussed in class. For example, the story may include a prediction about how long the porridge had been sitting on the table, based on data the students collected during the investigation.</th>
</tr>
</thead>
</table>
| Proficient            | Story includes:
  ● Relative amounts of porridge related to temperature (“too hot” bowl has the most porridge while the “too cold” bowl has the least)
  ● Explanation of why the porridge is different temperatures; this could be done in pictures and/or words; for example, Goldilocks could offer explanations for why the porridge is too hot or cold, or there could be a zoom-in box showing the molecules and containing a description of why molecules in one bowl are moving faster than others
Pictures and explanations help make the concepts more clear. |
| Approaching proficiency | Story includes the how the relative amounts of porridge relate to temperature and an explanation of why the porridge is different temperatures, but the information may be incomplete and/or contain misinformation. |
| Below proficiency      | Story does not include the relationship between amount of porridge and temperature and/or an explanation of why the porridge is different temperatures; information that is included is incomplete or wrong. |
Goldilocks Investigation

You will be planning and conducting an investigation to discover what could cause the porridge to cool down at different rates. Instead of porridge, you will be using water.

How will you investigate this question? Use words and/or pictures to show how you can start your investigation.

What data will you collect? Make a table where you can record your data:
<table>
<thead>
<tr>
<th>Question: What causes the water to cool at different rates?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Claim:</td>
</tr>
<tr>
<td>Evidence:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Class discussion notes:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>
Strand: 6.2.4

**Emphasis:** Energy flow/engineering

**Anticipated Time Required:**
- LE 1: 30 minutes
- LE 2: 35-60 minutes (depending on how long you give students to plan and conduct their investigations)
- LE 3: 30 minutes
- LE 4: 45-60 minutes (or even more, depending on how long you give students to test and rebuild their prototypes)
- LE 5: 20-30 minutes to diagram and build final designs
  - 10-15 minutes to provide feedback on the design after it has been tested

**Dominant CCC:** Energy and matter

**Dominant SEP:** Planning and carrying out investigations, engaging in argument from evidence

**Management Strategies** to support equitable access to content:
- Explain-regroup-explain the explanation (students work with a group to construct an explanation; new groups are made, and students explain their explanations to their new group members)
- Group discussion with alternating leaders (students take turns leading their group in a discussion)
- Question stems for partner and small group discussions

**Shopping list:**
Buy/order enough materials for students to:
- Use samples to test structural features in LE 2; for this LE, have enough materials for each group of 3 students to have a sample or two of each material
- Build and test prototypes during LE 4; for this LE, each individual student will need several samples of each material (exact amounts depend on how much time students have to investigate; how many iterations will they have time to do?)
- Build a final design in LE 5; for this LE, each individual student will need samples of each material to build their final design

**Material ideas:**
- Aluminum foil
- Cotton (balls or batting)
- Plastic (ziploc bags, tupperware, plastic cups, etc.)
- Bubble wrap (which is really just air)
- Foam wrap (used for packing; can buy a large roll or order [https://www.amazon.com/UBOXES-Foam-Wrap-Thick-Perforated/dp/B005K0A9WY/ref=sr_1_1_sspa?ie=UTF8&qid=1499997457&sr=1-1&keywords=foam+wrap+roll](https://www.amazon.com/UBOXES-Foam-Wrap-Thick-Perforated/dp/B005K0A9WY/ref=sr_1_1_sspa?ie=UTF8&qid=1499997457&sr=1-1&keywords=foam+wrap+roll)
- Styrofoam (cups, rectangles from a craft store)
- Paper (newspaper could be used)
- Cardboard

For their prototype construction and final design, also have various types of tape and scissors available to students.
6.2.4 Heat Transfer and Engineering - Storyline Overview

Anchor Phenomenon/Problem: When the cafeteria serves ice cream sandwiches for lunch, you have to eat yours, even if you wanted to save it for later, because it will melt.

Note: This problem should be adjusted to fit your school/class. Other ideas for framing the problem:
- A student’s older sister is dropping off ice cream sandwiches for the student’s birthday, but will be dropping them off in the morning and the students can’t eat them until lunch
- Ice cream is going to be included in the sack lunches students will be taking on a field trip, but they can’t eat them until the lunch time
- The PTA is dropping off ice cream sandwiches in the morning for field day, but students can’t eat them until after the field day activities
- You and your friends like to walk to the park and play in the summer, and it would be nice to be able to bring ice cream and eat it after you are tired of playing

You could also have your students work on a problem that is a bit less first-world; these problems require empathy design, but since students are not trying to solve a peer’s problem, the interview pieces would need to be adjusted/deleted from the storyline. A few ideas of problems that require keeping something the same temperature:
- Ebola vaccines need to be kept cold. How could we package them in a way that they would stay cold without refrigeration? Is there a way to package the vaccines so they could be dropped into an area where there is an ebola outbreak and they could land without breaking and stay cold?
- Babies need to stay warm. In some places, mothers may have to walk for a day or more to get their sick or premature baby to a clinic, and during this time, the baby could get too cold and die. Design a baby carrier that a mother could use to transport her baby on foot without the baby losing heat. Search “design that matters” or go to embraceinnovations.com for additional ideas and information.

Allowing for student choice here is also an option. Students could engage in the same activities and graded according to the same rubric while working on a design challenge of their choice (ice cream sandwich saver, vaccine packaging, baby warmer, etc.).

Target question: How can we keep the ice cream from melting until you want to eat it?

Student Performance Expectation:

6.2.4 Design an object, tool or process that minimizes or maximizes heat energy transfer. Identify criteria and constraints, develop a prototype for iterative testing and analyze data from testing, and propose modifications for optimizing the design solution. Emphasize demonstrating how the structure of differing materials allows them to function as either conductors or insulators.


Note: if empathy in design is new to you, this document is a good introduction: https://dschool-old.stanford.edu/sandbox/groups/designresources/wiki/36873/attachments/74b3d/ModeGuideBOOTCAMP2010L.pdf?sessionID=573efa71aea50503341224491c862e32f5edc0a9
<table>
<thead>
<tr>
<th>CCC/SEP</th>
<th>What are students doing? (This should match your SEP!)</th>
<th>What specific Disciplinary Core Idea understandings should students get from this experience?</th>
<th>New questions students have to propel us to the next science experience</th>
<th>Assessment</th>
</tr>
</thead>
</table>
| 1: The ice cream sandwich problem | *Gather:* Students are introduced to the problem; record own concerns; interview client to determine criteria and constraints  
*Reason:* Students brainstorm designs; identify structure and function relationships  
*Communicate:* Students meet with client and describe possible designs; record features that the client likes/does not like | Students should understand problem and criteria and constraints of possible design solutions | Which of the available materials are conductors/insulators?  
What other properties of the materials need to be considered as I design my product? | Formative: Initial student designs, including structure-function relationships  
Student discussions |
| CCC: Stability and change, structure and function, cause and effect  
SEP: Defining problems, obtaining information |                                                                                     |                                                                                |                                                                                |                                  |
| 2: Investigating materials for ice cream savers | *Gather:* Students investigate different materials to learn about their ability to conduct or insulate thermal energy, as well as other structures that may serve a function in their solution design  
*Reason:* Students determine which materials could be functional in their design and identify the structural features/properties that would provide these functions  
*Communicate:* Students meet with client and describe possible designs; record features that the client likes/does not like | Some materials more efficiently minimize transfer of thermal energy; increasing amount/thickness of materials can affect their ability to minimize energy transfer | How can these materials be used effectively in the product design to meet the needs of the client? | Formative: Student ability to plan an investigation, record data and analyze it  
Arguments about which materials could be useful in the solution, |
<table>
<thead>
<tr>
<th>Analyzing and interpreting data, engaging in argument from evidence</th>
<th><strong>Communicate:</strong> Students construct a short argument regarding which structural features/properties would provide a function in their solution</th>
<th></th>
</tr>
</thead>
</table>
| **3: Design a prototype**  
**CCC:** Structure and function, energy and matter, stability and change  
**SEP:** Defining problems, designing solutions | **Reason I:** Students create detailed diagram of prototype, which includes materials and descriptions of how the prototype solves the problem and addresses constraints  
**Communicate:** Students present diagram to their group (client is not in the group) to get feedback and discuss ways to revise and improve the design  
**Reason II:** Students use feedback from their group to make a new iteration of the prototype design | Developing prototype for iterative testing; address criteria and constraints | **What changes need to be made to meet the needs of the client?**  
**Formative:** Diagrams of prototypes should be used to assess student understanding of the relationship between structure and function  
Second iteration should show that students used information gathered during the design/test (through focus group) process to improve their design |
<table>
<thead>
<tr>
<th>5: Finial ice cream saver iteration</th>
<th><strong>Gather/reason:</strong> Students use feedback from client to build and test final design</th>
<th><strong>Communication:</strong> Students present final design to client; and the design is tested using ice cream sandwiches</th>
<th><strong>Summative:</strong> All iterations can be used to assess student engagement in the iterative design process and understanding of structure/function relationships (specifically the structure/function of insulators)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CCC: Structure and function, energy and matter</td>
<td>Students create final design blueprint with explanation and complete an evaluation for their engineer</td>
<td><strong>How well did the final design work? What changes could be made for the next generation of this product?</strong></td>
<td></td>
</tr>
</tbody>
</table>
6.2.3 Learning Episode 1

Student Science Performance

| Topic: Heat Transfer/engineering design | Title: The ice cream sandwich problem (intro) |

Overarching Performance Expectations (Standard):

6.2.4 Design an object, tool or process that minimizes or maximizes heat energy transfer. Identify criteria and constraints, develop a prototype for iterative testing and analyze data from testing, and propose modifications for optimizing the design solution. Emphasize demonstrating how the structure of differing materials allows them to function as either conductors or insulators.

Lesson Performance Expectations:

Students will define a problem and determining the criteria and constraints they will have while designing a solution to the problem.

CCC: Structure and function
SEP: Defining problems, constructing solutions, communicating information

Students Will. . . To Construct Meaning

Engage with a Problem: When the cafeteria serves ice cream sandwiches at lunch, you have to eat it at lunch, even if you wanted to save it for later, because it will melt.

Gather: Sometimes the cafeteria serves ice cream sandwiches, but you may not want to eat yours right away. Since the ice cream will melt, you either have to eat it or throw it away. You are going to design a system to keep the ice cream from melting until you want to eat it. In your lab book, record problems associated with having an ice cream sandwich between lunch and the end of school (besides the ice cream melting). These should be problems that you would face.

Your partner will be your engineer. As the client, you will be telling your engineer the problems that you wrote in your lab book. When it is your turn to be the engineer, listen to your client and record what he tells you. Also ask questions if you are not sure what your client means. You will have 60 seconds to tell your engineer the problems you listed, and then you will switch roles.

Teacher Will. . . To Support Students

Present the problem to your class; consider bringing in an ice cream sandwich or two (and maybe seeing what happens as they melt). This may be especially helpful if you have students from other countries who may not know what an ice cream sandwich is.

Allow them 1-2 minutes to record the problems in their lab books (or provide guiding questions to help students think of specific problems; examples are included in the student handout). If needed, provide examples of problems that may arise, such as:

- you like to play on the monkey bars at recess, and don’t want to be holding an ice cream sandwich in your hand
- your desk is a mess and you don’t have room to store an ice cream sandwich in it

Emphasize that everyone is going to have different problems because everyone has different needs. Also reiterate that students are not designing a system that they want; they are thinking ahead to problems that they would have if given an ice cream sandwich that they weren’t going to eat until later.

Determine how you want to group students. The simplest way to do this is to pair the students and have them design systems for each other. You could also do this in groups, with a small group of students designing a solution for another group or individual. This allows students to work together on their
Reason: In your lab book, brainstorm as many designs as you can; but come up with at least four. For each design, make a quick sketch (no little details here!). The goal here is to make several different designs.

Look over your design ideas, and find at least two features where the structure is related to the function. Make a note of how these structures are related to their functions.

Management Strategy: Students are going to be meeting with their partners several times during this unit, so setting up norms for discussions is important. For this discussion, you may want to model the discussion and/or provide sentence stems as a guide, but let students know that their discussions might look a little different, depending on their concerns:

- “I would have a problem storing the ice cream in my desk because _____.
- “At recess, I like to _____.
- “My main concern with keeping ice cream with me at recess (or during class) is _____.”

Before students meet with their partners, tell them how long they have to discuss; setting a timer allows students to monitor their discussions. Students should know that the first time they hear the timer they switch roles, and the second time they hear the timer they return to their seats. This same process can be used each time they meet together, and the consistency helps the transition from the discussion back to their seats very smooth.

Allow a specific amount of time to do this (somewhere in the neighborhood of five-seven minutes); emphasize to students that they should come up with as many ideas as they can. If needed, give them an example of an outlandish idea so they know that at this point, they shouldn’t discount any idea (for example, maybe a student sketches a hot air balloon that carries the sandwich up in the atmosphere where it is cold). As students work on their designs, circulate through the room. Quietly remind students who are spending a lot of time perfecting one sketch that the goal is to come up with many different ideas, and that they will have time to add in details later.

Throughout this unit, students will need to consider the relationship between structure and function, and having them identify a few structural features on their own designs may be a good introduction. You may need to provide examples to help students identify these relationships. For example, a student designed a
Communicate: Present your design ideas to your client. Quickly show them the designs and explain anything they have questions about. When it is your turn to be the client, tell your engineer the features that you like and the features that you don’t like, and why. As the engineer, make note of the things your client does and does not like.

Instruct students on what they will be discussing when they meet with their partner; again, allow a specific amount of time and use a timer so students can switch roles and return to their seats on their own. If needed, provide sentence stems and/or model what the discussion should look and sound like.

- “I like _____ because ________.”
- “I don’t think ______ would work for me because ______.”
- “_______ would be o.k. if you changed it so that ______.”

Before students meet with their partners, encourage them to make notes of what their client tells them about their designs. They will be able to use their notes as they continue to design and build the device.

Management Strategy: As students discuss their designs, circulate through the class with a clipboard and make note of student communication skills that you want to highlight to the class. If there are students who would be embarrassed to be recognized this way in front of the class, you can quietly tell the student and/or tell the class what you observed without naming the student.

- “I loved the way Hazel made eye contact with her client.”
- “I noticed that Micah made a lot of notes on his sketches. It showed he was really listening to what his client did and didn’t like.”
- “Mike asked his engineer a question about one of the designs. That is a great way to make sure you understand each other.”

Now that you have talked with your client, you should have a better idea of design features that he may or may not like. In your lab book, make two lists. One list of features you really want to have in the solution you design, and one list of features that you definitely do not want to have. You should write at least two features in each list. Next to each feature, record why you think that feature would or would not work for your client.

Allow a few minutes for students to make specific notes on features that would work (or not) for their clients. At some point, students will need to be familiar with the words “iterate” and “iteration.” You can begin using them now, by telling students that...
they will be able to use these notes on future iterations of their design.

If needed, facilitate a class discussion about the importance of listening to your client. In the real world of engineering, you might have a great idea, but if other people don’t find it useful, no one is going to pay you for it. You have to be able to listen to what other people need and design solutions that will work for them.

**Assessment of Student Learning**

*Partner discussions should be used to assess students’ communication skills; notes that students make about their initial design ideas should reflect how well they listened to their client.*

Example of student recording of features to include or not include; note that this engineer not only listened to his client’s feedback, but took into consideration other things he knew about his client:

<table>
<thead>
<tr>
<th>Features I should have in the design:</th>
<th>Features I should not have in the design:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Something pink -- because my client kept talking about how much he loves pink, and he wears a pink shirt all the time</td>
<td>Buttons or zippers -- because he told me once in fourth grade that he hated the sound of zippers and one of my designs had buttons and he said he didn’t like them</td>
</tr>
<tr>
<td>Can be worn on wrist -- because my client liked that feature in my design ideas, plus he already wears lots of bracelets so this would fit in with his style</td>
<td>Hat -- because one of my ideas was to make an ice cream holder on a hat and he said it would be embarrassing to wear</td>
</tr>
</tbody>
</table>
The Ice Cream Sandwich Problem

If you were given an ice cream sandwich at lunch but didn’t want to eat it until after school, what are some problems that you might run into (besides the ice cream melting)? Think about what you do at recesses and in the classroom between lunch and the end of school. What are some things that would make keeping an ice cream sandwich difficult or inconvenient?

What do you usually do at recess?

Describe anything about this activity that might make keeping an ice cream sandwich with you difficult:

Describe your desk:

Is there anything about your desk that would make storing an ice cream sandwich in it difficult? What?

Describe your backpack:

Is there anything about your backpack that would make storing an ice cream sandwich difficult? What?

What else could make keeping an ice cream sandwich with you difficult or inconvenient?
Possible Design Solutions

Sketch as many designs as you can. Don’t worry if an idea is “good enough” or not. If you have a crazy idea, sketch it out anyway! Don’t add details to your sketches; you’ll have time to fill in the details later. For now, the goal is to come up with as many ideas as possible.
After presenting your ideas to your client, record at least two features that you think you must include in the design and at least two features that you really shouldn’t include. Also make a note of why you should (or shouldn’t) include each feature. Remember that you are thinking about your client’s needs, not your own! You will be using these notes in later iterations of your design.

An example of each has been done for you.

<table>
<thead>
<tr>
<th>Features I want to include:</th>
<th>Features I do not want to include:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Can be worn on wrist -- because my client liked that feature in my design ideas, plus he already wears lots of bracelets and things so this would fit in with his style.</td>
<td>Zippers -- because he told me once in fourth grade that he hated the sound of zippers, and one of my designs had a zipper and he thought it might be hard to use</td>
</tr>
</tbody>
</table>
### Student Science Performance

<table>
<thead>
<tr>
<th>Topic: Heat Transfer/engineering design</th>
<th>Title: Investigating materials for ice cream savers</th>
</tr>
</thead>
</table>

### Overarching Performance Expectations (Standard) from State Standards or NGSS:

**6.2.4** Design an object, tool or process that minimizes or maximizes heat energy transfer. Identify criteria and constraints, develop a prototype for iterative testing and analyze data from testing, and propose modifications for optimizing the design solution. Emphasize demonstrating how the structure of differing materials allows them to function as either conductors or insulators.

### Lesson Performance Expectations:

Students plan and carry out an investigation to understand the structure of various materials, and then relate those structural features to the function they could possibly perform in the solution students are designing.

**CCC:** Structure and function  
**SEP:** Planning and carrying out investigations; analyzing and interpreting data; engaging in argument from evidence

### Students Will . . . To Construct Meaning

**Engage with a Problem:** When the cafeteria serves ice cream sandwiches at lunch, you have to eat it at lunch, even if you wanted to save it for later, because it will melt.

**Gather:** You will be investigating different materials that will be available to use when you create your ice cream sandwich saver. Some properties of the materials that you may want to investigate:

- Ability to conduct heat
- Ability to insulate heat
- Flexibility
- Strength
- Texture
- Density
- What else?

With your group, determine how you will test the materials and how you will record your data. You may also want to investigate if changing the amount of a material affects its properties (for example, if you have a thicker layer of material, is the

### Teacher Will . . . To Support Students

Provide students with a list of materials that will be available for them to use when they build their ice cream sandwich savers (the list could be written on the board or printed and distributed to the students). Examples of materials could include:

- Aluminum foil
- Cotton (balls or batting)
- Plastic (ziploc bags, tupperware containers, etc.)
- Air (in the form of bubble wrap)
- Foam wrap (used for packing; can buy a large roll at Home Depot or similar store)
- Styrofoam (cups)
- Paper (newspaper works well)
- Cardboard

Also provide students with other materials that will be available to them for the investigation:

- Thermometers
- Ice
- Rulers

Make sure that you choose materials that you can supply enough of for students to investigate (much of what they use during the investigation may be damaged/ruined), build and test prototypes and then build and test their final system. To limit waste, have all materials portioned out for the investigation; if students need additional materials they can ask for them (as opposed to putting everything out and allowing students to take as much as they want in the beginning; they tend to take more than they use and then throw the extra away). When purchasing supplies, note that
flexibility, strength and ability to conduct heat the same?).

some materials will be more popular than others. For example, the foil is a conductor and will result in melted ice cream, so (hopefully) not many students will use it. The bubble wrap is a good insulator and flexible, so more students might incorporate it into their designs.

Before students begin, you may want to help them set up data tables and/or allow students to share ideas for investigating the different properties with the class. You can also provide a form to help guide their investigation (example is included with the lesson materials; students can fill in the first two columns during the investigation; if using something like this, instruct students to ignore the third column for now). Encourage students to get help from other groups if their group gets stuck (with the expectation that they are still working with their own group, but just asking another group for advice/guidance).

You may want to explicitly tell students to investigate how the amount of material may affect its properties. Depending on the class, you may also want to alert them to the fact that as the ice melts, it might get things wet. The ability of some materials to insulate is changed when wet, and students may not realize this. You could point out to the whole class that some properties might change if the material is wet (like the cardboard might not be as strong if wet) so that they can plan their investigation in a way that things stay dry or record properties of wet vs. dry materials. You could also just let them start finding this out on their own, and use questions with specific groups during the investigation to help them come to this understanding.

As students investigate, circulate through the class and use questions to help them clarify their ideas and/or extend their investigations.

Provide students with a graphic organizer or help them set up their notebooks to record this information (or use the third column in the example included with the lesson materials). Encourage students to look at the data they recorded during the investigation and also review the notes they made on their designs (including their list of must have features) to identify materials that may function well as part of their design. If needed, do one example together as a class to help students get started (the styrofoam is a good insulator so it might keep the ice cream cold; the cardboard is strong so it could keep the ice cream sandwich from getting smashed in a messy backpack).

Put students in groups of four; you may want to group them with students they did not do the investigation with so they can hear what other students learned during the investigation. Assign each group a leader (use height, age, birthday, where they are sitting, etc. to assign the leader) and review norms for the discussion:

- The group leader will call on a student to share
- The student will share ONE material and the properties you think would make it useful
**Reason:** Which of the materials may be useful in your ice cream sandwich saver design? In your notebook, list the materials you tested and identify the properties/structures that each material has that might make it function well in your design.

<table>
<thead>
<tr>
<th>Communicate: Share your ideas with your group. The group leader will conduct the discussion. When it is your turn, clearly tell your group one of the materials that you think might be useful and why. If another student in your group says something that you missed, you can add it to your own notes.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Management Strategy: Modeling what the discussion should look and sound like can help all students understand the expectations for the discussion. Setting a time limit and displaying a timer can help students monitor their discussion; you could even assign each group a timekeeper to make sure that no materials are discussed for longer than one minute to ensure that everyone has time to share at least one material.</th>
</tr>
</thead>
</table>

**Assessment of Student Learning**

The investigations students carry out and the data generated should be used to assess their ability to plan and conduct an investigation, as well as their ability to use the data generated. Their descriptions of how they would use (or not use) each material can be used to assess their understanding of how the properties/structure of each material is related to its possible function in the ice cream saver design. Small group discussion should be used to assess students’ communication abilities.
Example of student assessment of the materials they investigate; the information in the third column shows how well students are able to relate the properties/structure of a material to its possible function in their ice cream saver design:

<table>
<thead>
<tr>
<th>Material</th>
<th>Properties/structure</th>
<th>Which of these properties/structures would function well in an ice cream saver design? Why? How might it function in the ice cream saver design?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cotton</td>
<td>White, soft, squishy and stretchy, absorbs the water as the ice melts, good insulator when there is a lot but not if there is only a little, not strong</td>
<td>It could be used to keep the ice cream from melting because it could insulate the ice cream from the hot air, but only if there was a thick layer of it. My client didn’t like the bulky design I made so I don’t know if cotton would be a good choice for my design.</td>
</tr>
<tr>
<td>Aluminum foil</td>
<td>Shiny, flexible, can hold its shape a little, conductor, one piece isn’t strong and you can tear it, but if it is thick it is stronger and you can’t tear it</td>
<td>This might make the ice cream melt because it is a conductor, but my client likes shiny things, so I think I could use it in the design, just not in the part that should keep the ice cream cold. Maybe it could be for decoration.</td>
</tr>
<tr>
<td>Ziploc bag</td>
<td>Clear, flexible, kind of strong but easy to cut with scissors, waterproof, not a good insulator</td>
<td>This wouldn’t keep the ice cream from melting because it isn’t a good conductor, but it is waterproof, so it might be good to have around the ice cream so that if it does melt, it doesn’t get all over everything and make a mess. Maybe there could be another layer of something else around the ziploc.</td>
</tr>
</tbody>
</table>
## Materials Investigation

<table>
<thead>
<tr>
<th>Material</th>
<th>Properties/structures</th>
<th>Which of these properties/structures would make it functional in an ice cream sandwich saver design? Why? How might it function in the ice cream saver design?</th>
</tr>
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<tbody>
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6.2.3 Learning Episode 3

Student Science Performance

| Topic: Heat Transfer/engineering design | Title: Design a prototype |

Overarching Performance Expectations (Standard):

6.2.4 Design an object, tool or process that minimizes or maximizes heat energy transfer. Identify criteria and constraints, develop a prototype for iterative testing and analyze data from testing, and propose modifications for optimizing the design solution. Emphasize demonstrating how the structure of differing materials allows them to function as either conductors or insulators.

Lesson Performance Expectations:
Students will use information obtained from different sources to develop a solution to the melting ice cream problem; their solution should include structural features that will enable the solution to function.

CCC: Structure and function
SEP: Obtaining information, designing solutions

Students Will. . . To Construct Meaning

Engage with a Problem: When the cafeteria serves ice cream sandwiches at lunch, you have to eat it at lunch, even if you wanted to save it for later, because it will melt.

Reason I: You are going to begin the iterative process.

You will start by using the information you’ve collected from your client and from the investigation to design a prototype. For this iteration, you will be creating a diagram of a prototype. As you design the prototype, think about the needs of your client, the features that he did/didn’t like, and the structures of the materials that you investigated last time. Your diagram should include details such as:
- What materials will be used for different parts
- Different views (top down, inside, cross-section, or other views that will help people understand the design)
- Descriptions/annotations
- Measurements

Teacher Will. . . To Support Students

Note: As students build their prototypes and final designs, you may want to limit how much of a material they are allowed to use. If this is the case, tell them these restrictions before they begin designing their prototypes so they can account for material availability. This can help you plan for how much to buy and can also allow you to discuss the limitations that real engineers face. Not only must they design around the needs/restrictions of their clients, they have limited money/resources, time, and can also be limited by policy/laws.

Introduce or review the concept of iteration. Students should understand that they will design and test a solution, then use the information they learned to redesign and test it again (and again, and again…).

Before students begin their prototype diagrams, allow a minute or two for them to review their notes from previous lessons. Instruct them to look over their “must have” features list from the first lesson, and the notes they made after investigating materials.

Display the detail list so they can refer to it as they design, and encourage students to refer to their notes as they work. You may also want to provide a list of materials that will be available, and instruct students to identify which material will be used for each part of the design. Also, if you haven’t given them the
Communicate: You will be sharing your design sketch with a focus group, which will not include your client. The purpose of meeting with the focus group is to get feedback on how to improve your design. Your group will follow this procedure:

- Everyone passes his design sketch to the person on his left.
- You have two minutes to look over the design. What looks like it will work? What do you have questions about? What looks like it won’t work? Jot down your thoughts in your lab book.
- When you hear the timer, pass the design you just examined to the person on your left. Repeat this process until everyone has looked at all of the designs.

Once everyone has seen the designs, the group will discuss each design. The goal is to provide constructive feedback that can be used for the next iteration of the design. You will follow this procedure:

- The oldest person in the group will put his design in the middle of the table.
- You have two minutes for everyone to share their thoughts about the design and allow the designer to make notes and ask questions.
- When you hear the timer, the next oldest person will put his design in the middle of the table and you will repeat the process until everyone has had a chance to get feedback.

Reason II: After everyone has finished and returned to their seats, you will use the feedback you got to make your next iteration. As you make your new dimensions of the ice cream sandwiches, make sure you do that before they begin designing. Allow 5-10 minutes for them to create their diagrams; if some students finish early, review their diagrams and point out details that they should add. (Did they identify the materials? Can they write a note about why a particular material is going to be used for a specific part? Could they add a top down view or cross-section?)

Assign students groups and review the procedure (if needed, you can model what the group should be doing). Remind students to write down their ideas because they will be sharing them with the designer later; if needed, provide sentence stems:

- “I like ______ because ______.”
- “When you build this, how will you ______?”
- “You might want to use a different material here, because ______.”
- “If you changed ______, it might be better because ______.”

Help students set up a graphic organizer to record their ideas, or distribute organizers. As students work, circulate through the room and prompt students who are stuck. Note: some students will have a hard time recording all of their ideas if they use complete sentences; you may want to tell students that they don’t need to write complete sentences here and then provide the sentence stems for them to use during the discussion portion of the focus group.

Outline the procedure for the students and if needed, model what the group discussion should look/sound like. If needed, review norms for the discussion. Encourage students to make notes as they get feedback; you can instruct them to make notes directly on their design or in their lab books.

If using age (or height, birthday, etc.) for the order, allow students a minute to talk with their groups to determine the order students will go; ask groups to give a signal when they know their order; start the timer when all groups are ready to go. As students discuss, circulate and remind students to take notes on the feedback they get.

Allow students about five minutes to make their new sketches. If there is time, facilitate a short class discussion to allow a few students to share something
design, you will need to consider:
  ● Your client’s needs
  ● How the structure of the materials you will use will help them perform the function you need
  ● The feedback from your focus group
  ● Don’t forget that it needs to keep the ice cream from melting!

<table>
<thead>
<tr>
<th>Assessment of Student Learning</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>This learning episode allows for a lot of peer- and self-assessment. Prototype design and focus group discussions should be used to assess how well students are able to integrate several pieces of engineering design: a solution to a problem, the needs of the people who will be using the product, the properties of the materials available, etc. Focus group discussions and prototype revisions can be used to assess ability of students to accept and use new information as it becomes available.</em></td>
</tr>
</tbody>
</table>
Focus Group

You will have two minutes to look over each design. As you examine each design, think about the feedback you could give the designer to help him/her improve the design. This should take the whole two minutes, so if you think you are done and there’s still time on the timer, look for other feedback you could provide!

<table>
<thead>
<tr>
<th>Designer’s name:</th>
<th>Which parts do you think will work well?</th>
<th>What questions do you have about the design?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Which parts do you think won’t work well?</td>
<td>Other ideas about this design:</td>
</tr>
</tbody>
</table>

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<td>Which parts do you think won’t work well?</td>
<td>Other ideas about this design:</td>
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</tbody>
</table>
When it is your turn to provide feedback to another student in your focus group, please be specific! You should explain why something will work or not and ask questions to help the designer revise and improve his/her design.

- “I like _____ because _____.”
- “When you build this, how will you _____?”
- “You might want to use a different material for _____, because _____.”
- “If you changed _____, it might be better because _____.”
# 6.2.3 Learning Episode 4

## Student Science Performance

<table>
<thead>
<tr>
<th>Topic: Heat Transfer/engineering design</th>
<th>Title: Build a prototype</th>
</tr>
</thead>
</table>

### Overarching Performance Expectations (Standard) from State Standards or NGSS:

6.2.4 Design an object, tool or process that minimizes or maximizes heat energy transfer. Identify criteria and constraints, develop a prototype for iterative testing and analyze data from testing, and propose modifications for optimizing the design solution. Emphasize demonstrating how the structure of differing materials allows them to function as either conductors or insulators.

### Lesson Performance Expectations:

Students will design a solution to minimize heat transfer (to keep ice cream from melting); they will consider how the structure of their design solution will allow it to function well, and will test and modify their design.

**CCC:** Energy and matter; structure and function

**SEP:** Designing solutions

### Students Will . . . To Construct Meaning

**Engage with a Problem:** When the cafeteria serves ice cream sandwiches at lunch, you have to eat it at lunch, even if you wanted to save it for later, because it will melt.

**Reason:** Use the design you made last time to build a prototype. Follow your teacher’s instructions for obtaining materials and clean up.

As you build your prototype, you should also be testing it. How is the size? Will it keep the ice cream cold? Is it durable enough? Think about what your client will be doing. Does he like to jump rope during recess? Will he be holding the device or will it be sitting on the ground? Does the device get wet and soggy? You can use ice and a heat lamp to see how well your device will insulate the ice cream sandwich.

### Teacher Will . . . To Support Students

**Note:** Depending on time, the prototype can be tested and rebuilt several times. The lesson below assumes minimal time for the iterative process, and allows for students to build one prototype out of actual materials before building their final product. If more time is available, you can start by having students build their first prototype out of newspaper. This prototype can be used to test size and shape of the design, as well as construction methods. Once students have built and gotten feedback on their paper prototype, they can then move on to building a prototype out of materials, which will allow them to test the ability of the device to actually keep the ice cream frozen.

Clearly explain the procedure students should follow for obtaining materials, guidelines for working (where should they be in the room. who can they be working with, etc.), time limits (you may want to give them a set amount of time and display a timer so they can self monitor), and clean up. You may want to tell the students how much time they have to work (at least 20 minutes; some students may need much longer, depending on how much testing they do as they build their prototype) and how much time they have to clean up (5 minutes), and then set a timer. The first time the timer goes off students know that they need to stop working and clean up; they should be cleaned up and back in their seats before the timer goes off again.
Communicate: Present the prototype to your client. When you do this, allow him to hold the prototype and interact with it before you dive into any explanation. As your client examines the prototype, watch to see how he interacts with it. Is it easy for him to figure out how to use it? If your client has questions, you can answer them. After he has had a chance to interact with the prototype, show him any features that he may have used wrong or missed. Watch to see how he interacts with these features after you have shown them to him. Once your client has had a chance to interact with the prototype, explain how the structure of the design will function to keep the ice cream from melting.

Some ideas for managing how many materials students take:

- Students must make a list of what they need and how much they need; before obtaining anything, they must show you their sketch and list of needed materials; they can then measure and collect their own materials (this is a good system to use if you did not give students limitations on amount of materials they would be allowed to use; setting the expectation that they carefully measure materials before taking them is important; make sure rulers are available)

- Materials are portioned out and students can pick up a set number of any item (for example, the bubble wrap is cut into squares and students are allowed to take up to two of the squares)

- Materials have a “cost” and students have a budget; they must “pay” for anything they take and when they are out of money, they can’t get any more materials (this system takes a bit of work to set up; providing each student with a budget sheet that has the cost of each material and space for them to keep track of what they’ve used and how much money they have left is helpful for them to monitor themselves)  

Also, tape, glue, scissors, etc. should be made available for students to use as they construct their prototypes. Ice should be available as a stand-in for ice cream, and if available, shop lamps can be used to help test the insulating properties of the device.

Model what this should look like. Students may be eager to show off their prototypes, which usually looks like them holding the device and explaining it. Demonstrate to students that they should hand the device to their client, and watch to see how the client uses the device. To model this, you could hand a student a device that he may not know how to use (like an abacus, some type of fancy kitchen tool, etc.) and watch to see what he does with it. Use a think aloud to help students see what you are watching for and making mental notes of as the student interacts with the device. They should understand that you are trying to see how user-friendly the device is, and what
Gather: Ask for feedback and listen to what your client says. What does he like? What doesn’t he like? If you are not sure why the client likes or doesn’t like a feature, ask him why, so you can avoid similar problems in future iterations. Make notes of your client’s feedback and experience to use for the final revision of the product.

Changes could be made to make its use more intuitive.

Once students understand how to present their prototypes, give them a time limit (approximately 2-3 minutes) and allow them to meet with their partner. Again, you may want to use a timer, and tell students that when they hear the timer go off the first time they should switch roles; when they hear the timer go off the second time, they should return to their seats.

As students work, circulate through the class and listen to their discussions. If needed, remind individual students to let their clients interact with the prototype before showing them all the features.

If needed, allow students additional time to finish making notes. You may want to reiterate that keeping track of what changes have been made, and why these changes were necessary is an important part of the design process, because these notes can be useful in future designs.

Collect the prototypes for students to use for the next iteration; you may want to store them in a box, bag, or on a counter if you have space.

Facilitate a short class discussion to let students share examples of the relationship between the structure and function of the solution they (or their partner) engineered. Emphasize the concept of insulators; students should understand that using insulating materials will help minimize heat energy transfer into the ice cream, so it will stay cold longer. If time permits, you could also allow them to discuss features that they are thinking about changing on the final iteration and why these changes are needed.

Assessment of Student Learning
This learning episode allows for a lot of peer- and self-assessment. Formative assessments of student understanding and progress should be made through examining their designs/notes and listening to/observing their discussions and interactions with their partners.
<table>
<thead>
<tr>
<th>Topic: Heat Transfer/engineering design</th>
<th>Title: Final ice cream saver design</th>
</tr>
</thead>
</table>

**Overarching Performance Expectations (Standard) from State Standards or NGSS:**

6.2.4 Design an object, tool or process that minimizes or maximizes heat energy transfer. Identify criteria and constraints, develop a prototype for iterative testing and analyze data from testing, and propose modifications for optimizing the design solution. Emphasize demonstrating how the structure of differing materials allows them to function as either conductors or insulators.

**Lesson Performance Expectations:**
Build a solution to minimize heat energy transfer; use information from previous tests to modify and improve the design; explain how the structure of the materials allow the design to insulate the ice cream.

- **CCC:** Energy and matter; structure and function
- **SEP:** Design solutions; communicating and evaluating information

<table>
<thead>
<tr>
<th>Students Will. . . To Construct Meaning</th>
<th>Teacher Will. . . To Support Students</th>
</tr>
</thead>
</table>
| **Engage with a Problem:** When the cafeteria serves ice cream sandwiches at lunch, you have to eat it at lunch, even if you wanted to save it for later, because it will melt.  
**Gather/reason:** Find your prototype and the design notes you made last time. Look over your prototype and notes to determine what changes need to be made, why they need to be made, and how you will make them.  
Create a diagram of the final iteration of your design. Include labels, materials, different views, explanations, or anything else that would help someone understand the design. Your final iteration also needs to include an explanation of why it will keep the ice cream from melting. You can use evidence from the materials investigation, the testing of the prototype, and what you know about heat energy and heat transfer. Your final design diagram will be turned in.  
Collect the materials you need to build your final product. Follow your teacher’s instructions regarding collecting materials, work time expectations, and clean up.  
**Final design test:** Present the final design to your teacher.  
Have students look at their prototypes and find their notes; allow them a few minutes to review the changes they would like to make before creating a final diagram.  
Before starting the diagrams, you might want to review things that students found helpful when they looked at each other’s sketches in their focus groups. Allow students to share things they found helpful (cross sections, zoom-in boxes, written descriptions, etc.) and encourage students to incorporate these features in their final diagrams.  
Students should create their final diagrams on a separate sheet of paper that can be handed to their client and then turned in. You may want to provide a checklist for their final design diagram (an example is included in the lesson materials).  
Again outline the procedure for collecting materials and work/behavior expectations during work time. Provide a time limit and display a timer so that students can self-monitor; allow time for clean up.  
Plan the logistics for students to get their device and...
client. Again, allow your client to interact with the design first and then answer questions. Make sure your client knows how to use the device properly; how can you do this without just telling them what to do?

Everyone will be given an ice cream sandwich after lunch; use the device your engineer built for you. At the end of the day, we will eat our ice cream sandwiches.

Before eating your sandwich, meet with your partner. Examine both ice cream sandwiches together so you can see how well the device you designed worked.

Give your client the final design diagram you made earlier. He will be turning it in with his evaluation of the product.

Communicate: Carefully review the grading rubric and provide a score for each category. You also need to provide at least one piece of positive feedback and one piece of constructive feedback for your engineer. Your engineer will NOT see the scores on the rubric, but will see the written feedback you provide.

You can use the following sentence stems to provide feedback to your engineer:

Positive:
- “When you _____, it showed you were listening because _____.”
- “I know you understood what I was saying because _____.”
- “When you _____, it helped me understand your idea about _____.”
- “The _____ on your design would be useful to me because _____.”

pick up their ice cream sandwiches. If devices were designed with recess in mind, it is important that students are able to test their devices during recess!

Model for students what they should do when they examine their ice cream sandwiches. They should examine them to see how melted they got, if they got smashed or broken, etc. Allowing them to do this with their partners lets them see how well the device they designed worked. You can instruct students to give their final design sketch to their client as it is, or allow them to make notes of what revisions they would make, now that they know how well their device actually worked.

At this point, ice cream should be eaten (or cleaned up), devices can be saved or thrown away, students should have the diagram of the device that was designed for them and be in their own seats. It is best if they are not next to their engineer, so they can be more honest in their assessment of the product.

Go through the rubric with the class to make sure they actually read the requirements before assigning a score. Have the students complete the rubric first, even though it is on the bottom of the page. Completing the rubric first can remind students of the expectations and help them provide more effective written feedback. Display the sentence stems on the board and reiterate the expectation that students provide at least one positive and one constructive piece of feedback for their engineer. Also remind them that their engineers won’t see the number grades, but will see the written feedback.

When they are done, they should staple the diagram to the rubric (stapling the diagram on the top might make it easier for some students if they did not give their engineer high marks) and turn it in. This way, you have the feedback on a design stapled to the design itself, making assessment more manageable.
Constructive:
- “I didn’t feel like you were listening because _____.”
- “The product you designed wouldn’t work for me because _____.”
- “I needed something that _____, but the product you designed for me _____.”

You can use both the design and written feedback when grading the project (easier than trying to grade the devices themselves, which may or may not be broken, sticky messes by the time the kids are done). You can also use the previous designs and notes students made throughout the unit to assess their ability to incorporate new information/evidence and revise their designs.

After reviewing the design and student feedback, simply tear off the rubric portion of the paper. When you return the design diagram to the person who made it, the written feedback from his client will be stapled to it.

Assessment of Student Learning

Student’s final diagrams and their client’s comments/feedback should be used to assess:
- Their communication skills throughout the design process
- Their understanding of heat transfer
- Their ability to use evidence (from the investigation and their client/focus group) to design a solution
- Their ability to revise ideas/designs to create a better product
Final Design Diagram

Your final design diagram should include:

- Sketch of the design
- Materials
- Useful view(s) (top down, side, inside, cross-section, zoom-ins, etc.; can have more than one view)
- Explanation of why this design will keep the ice cream from melting (What structures function to keep the ice cream from melting? How are they able to do this?)
- Additional features that make it useful to your client
Your engineer’s name: ______________________________________________

Written feedback for your engineer (continue on the back top of this paper if you need more space):

________________________________________________________________________________________
________________________________________________________________________________________
________________________________________________________________________________________
________________________________________________________________________________________
________________________________________________________________________________________
________________________________________________________________________________________

Your name _______________________________________________________________________

Grading Rubric

Your engineer will NOT see the scores in the table below, but will be given the written feedback you provide above. Make sure your written feedback is constructive! If there is something your engineer could have done better, please tell him/her! Also let him/her know what s/he did well. Be specific and explain your position.

<table>
<thead>
<tr>
<th>Category</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Communication</strong></td>
<td></td>
</tr>
<tr>
<td>4: My engineer did everything for a 3. PLUS s/he checked in with me more than was required</td>
<td></td>
</tr>
<tr>
<td>3: My engineer listened to me when I was talking and asked questions to learn more about what I needed</td>
<td></td>
</tr>
<tr>
<td>2: My engineer usually listened to me but sometimes interrupted or seemed like s/he wasn’t listening</td>
<td></td>
</tr>
<tr>
<td>1: My engineer chatted with friends while I was talking or gave other indications that s/he wasn’t really listening</td>
<td></td>
</tr>
<tr>
<td><strong>Design Process</strong></td>
<td></td>
</tr>
<tr>
<td>4: My engineer did everything for a 3. PLUS, it was obvious that s/he tested the prototype before building the final design because it worked well</td>
<td></td>
</tr>
<tr>
<td>3: Throughout the process, my engineer came up with at least three different ideas that allowed me to explain what type of features I would or would not like; the final design incorporated the feedback I gave to the engineer, even if it didn’t end up working very well</td>
<td></td>
</tr>
<tr>
<td>2: My engineer came up with at least two different ideas that allowed me to explain what type of features I would or would not like and made revisions according to the feedback I provided</td>
<td></td>
</tr>
<tr>
<td>1: My engineer only presented me with one idea for a design and didn’t make adjustments according to the feedback I provided</td>
<td></td>
</tr>
<tr>
<td><strong>Product</strong></td>
<td></td>
</tr>
<tr>
<td>4: The product worked well and met the requirements I gave the engineer, plus it had stylistic features that I like; it is clear that my engineer went out of his/her way to make something that would meet all of my needs</td>
<td></td>
</tr>
<tr>
<td>3: The product met the requirements I gave my engineer and worked fairly well; the ice cream didn’t completely melt</td>
<td></td>
</tr>
<tr>
<td>2: The product met most of the requirements I gave my engineer and worked better than nothing</td>
<td></td>
</tr>
<tr>
<td>1: The product didn’t meet the requirements I gave my engineer and didn’t work very well</td>
<td></td>
</tr>
</tbody>
</table>
**Strand: 6.3.3**

**Emphasis:** Uneven heating of the Earth’s surface (Atacama Desert)

**Anticipated Time Required** (assuming 50 minute class periods):

- **Episode 1:** Why So Dry?  **20 minutes**
- **Episode 2:** What’s in a Desert System?  **20 minutes** (Episodes 1 & 2 can be taught together in one day)
- **Episode 3:** The Convection Connection  **90 minutes** (2 class periods)
- **Episode 4:** It’s All About the Interactions  **20 minutes**
- **Episode 5:** Defining the Cause  **50-70 minutes** (Can be taught over 2 days as needed)
- **Episode 6:** Now I Know Why the Atacama is SO Dry!  **30 minutes**

**Dominant CCC:**
Systems and Systems Models, Energy and Matter, Cause and Effect

**Dominant SEP:**
Develop and use a Model

**Management Strategies** to support equitable access to content:

1. Use exit tickets for quick formative feedback to see where students are having problems. Ask questions that will reveal depth of understanding and misconceptions.
2. Students should be doing most of the work throughout this storyline. That means that the teacher must move around and listen to what students are thinking. Adjust instruction, pacing and grouping of students based on what you are hearing and observing. All students can work in groups, but it may take a few tries to find the right combination of learners.
3. Assess student models as they are developing them. You do not need to “grade” every task your students record, but walk around with a stamp or pen and acknowledge progress, thinking and effort. This will keep students on task, as they will know that their work and thinking is important. You will be able to give immediate feedback and see errors early on.

**Shopping list:**

- Glue Sticks
- Chart Paper and Markers (group sets)
- Colored pencils (red and blue)
- Post-it Notes
- Plastic shoe boxes (one per group) half full of water
- Blue and red food coloring
- Ice cube tray
- Red food coloring
- Hot pot (electric kettle) or access to microwave
- Small bottles or containers for hot red water (one per group)

C. Penrod
C. Penrod

**Anchor Phenomenon:** The Atacama Desert is the driest desert on Earth

**Student Performance Expectation:** Develop and use a model to show how unequal heating of the Earth’s systems causes patterns of atmospheric and oceanic circulation that determine regional climates. Emphasize how warm water and air move from the equator toward the poles. Example of models could include Utah regional weather patterns such as lake-effect snow and wintertime temperature inversions.

<table>
<thead>
<tr>
<th>Dominant DCI</th>
<th>Dominant CCC</th>
<th>Dominant SEP</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Earth processes are the result of energy flowing and matter cycling within and among the planet’s systems.</td>
<td>Patterns Systems and Systems Models Energy and Matter</td>
<td>Develop and use a model Analyze and interpret data</td>
</tr>
<tr>
<td>The complex patterns of the changes and the movement of water in the atmosphere, determined by winds, landforms, and ocean temperatures and currents, are major determinants of local weather patterns.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Global movements of water and its changes in form are propelled by sunlight and gravity. Variations in density due to variations in temperature and salinity drive a global pattern of interconnected ocean currents.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Science Experiences**

<table>
<thead>
<tr>
<th>CCC/SEP</th>
<th>What are students doing? (This should match your SEP!)</th>
<th>What specific understandings should students get from this experience? (What pieces of the performance expectation does the experience provide?)</th>
<th>New questions students have to propel us to the next science experience</th>
<th>Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patterns Analyzing and</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Analyze and interpret data about global climates Ask questions about patterns on map of There are patterns of global climates. Most deserts are located either above or below the equator</td>
<td>Why are there patterns? What causes the patterns? Why is the Atacama so dry?</td>
<td>Exit Ticket: Group questions about the Atacama Desert</td>
<td></td>
</tr>
<tr>
<td><strong>Interpreting Data</strong></td>
<td><strong>global climate</strong></td>
<td><strong>about the same distance.</strong></td>
<td></td>
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<tr>
<td>-----------------------</td>
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<td>-----------------------------</td>
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</tr>
</tbody>
</table>

2 **Systems and Systems Models**  
**Develop and use Models**  
Define the parts of the Atacama system to begin developing a model  
Parts of the system - read about desert  
Ask questions  
The Atacama Desert is a system including the atmosphere, the  
ydrosphere, the geosphere and the biosphere.  
These systems interact on global and local scales.  
How do these systems interact?  
Systems Model of Atacama Desert

3 **Energy and Matter Systems**  
**Carry out an investigation**  
Carry out an investigation to test a prediction on how energy effects the  
movement of matter in two of Earth’s systems - the atmosphere and in the  
ydrosphere (ocean).  
Analyze and Interpret data to find patterns in energy flow and matter  
cycling between Earth’s systems (hydrosphere, atmosphere, geosphere).  
Heat causes matter to become less dense and rise. This is true of any  
fluid-water or air.  
Salt can cause differences in densities in fluids.  
Differences in density cause movement in fluids.  
There are colder and warmer parts of the ocean.  
There are colder and warmer parts of the land.  
There is a predictable pattern of air currents in the atmosphere known  
as Global circulation.  
How do ocean current patterns effect the Atacama Desert?  
How do atmospheric circulation patterns effect the Atacama Desert?  
How does the matter flow and energy cycle through the various systems  
around the Atacama Desert? (systems interactions).  
**Clearest Point Muddiest Point**

4 **Energy and Matter Systems**  
**Obtain information**  
Read to obtain information on how systems interact to create the driest  
desert in the world  
There are many system interactions that effect the Atacama  
Desert.  
Convection in the ocean effects deserts.  
Energy from the sun drives changes in Earth’s systems.  
What is the Rain Shadow Effect?  
How does the ocean's temperature effect the Atacama Desert?  
**Exit ticket:**  
Relating convection cells to Atacama Desert

5 **Cause and Effect**  
Analyze and interpret data to begin developing a model to show how  
onequal heating of the Earth's systems causes patterns of atmospheric and  
oceanic circulation that determine regional climates.  
Cold ocean currents effect the Atacama Desert.  
Elevation causes air to rise, cool and become less dense.  
The Rain Shadow effect means that  
How does all this evidence fit together to explain the  
causal of the dryness of the Atacama desert.  
Student notebooks: review models giving feedback as needed (model of  
Ocean Temperature and Rain Shadow)
<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
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<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>one side of a mountain gets rain and the other side does not. A Rain Shadow is due to the changes in elevation and the condensing and dropping of water on the windward vs the leeward side of a mountain.</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td><strong>Systems and Models</strong>&lt;br&gt;<strong>Develop and use a model</strong></td>
<td>Rain Shadow Effect (winds (atmosphere) carry moisture (hydrosphere) toward mountains, then air loses energy (cools) and rains on the windward side of mountain; less water vapor in air (atmosphere) due to cooler ocean temperature (hydrosphere), and high elevation (geosphere) of the Atacama leads to dry air (atmosphere and hydrosphere). Bonus: The sun heats the ocean and the air over the ocean which causes the moisture to rise and move away from desert regions (convection).</td>
</tr>
<tr>
<td></td>
<td>What are some other weather patterns that cause different climates?</td>
<td>Student’s final model</td>
</tr>
</tbody>
</table>
### 6.3.3 Lesson Plan 1

#### Student Science Performances

**Analyze and interpret data/ Ask questions**

<table>
<thead>
<tr>
<th>Topic: Global Climates and Deserts</th>
<th>Title: Why So Dry?</th>
</tr>
</thead>
</table>

**Overarching Performance Expectations (Standard) from State Standards or NGSS:** Develop and use a model to show how unequal heating of the Earth’s systems causes patterns of atmospheric and oceanic circulation that determine regional climates.

**Lesson Performance Expectations:** Analyze and interpret data about global climates and ask questions about patterns on map of global climate

### Students Will... To Construct Meaning

#### Part 1: Find Patterns on Maps

1. Make observations about Map #1: Earth from Space in small groups. Students record observations in lab notebook.
2. Share out observations with group.
3. Record questions they have about data (map).
4. Make observations about World Climate Map #2. Use same format as above.
5. Share observations with other groups during class discussion.
6. Record patterns found by both maps.
7. Students compare both maps find patterns.
8. Students generate and record questions in lab notebook about patterns and world climate.
9. Students record 2-3 questions they have about world climates in lab notebook.

**Part 2: The Atacama Desert**

1. Record Phenomenon in lab notebook: The Atacama Desert is the driest desert in the world.
2. Give one reason why you think the Atacama Desert is the driest desert in the world.
3. Record 2-3 questions you have about the Atacama Desert.

**Management Strategies:** Plan for map activity by arranging students in group formation at beginning of class. Make groups of 2-4 students. Be sure to have color copies of maps for each group. Do not pass out both maps at once. Give one at a time and require students to record observations in notebook before moving on to next map. Use a timer to keep time urgent and moving. Give groups 2-3 minutes to make and record observations.

### Teacher Will... To Support Students

#### Part 1: Finding Patterns on Maps

1. Hand out Map #1: Earth from Space. Have students work in small groups to analyze and interpret the data and note any patterns. Instruct students to record observations in lab notebook.
2. Listen to groups and circulate as students are analyzing data. Ensure that each student is recording something in lab notebook. Lead class discussion and clarify ideas as needed.
3. Hand out Map #2: Global Climates. Have students work in small groups to analyze and interpret the data and note any patterns. Instruct students to record observations in lab notebook.
4. Look for patterns on both maps and record in lab notebook.
5. Instruct students to find patterns on both maps and record in lab notebook.
6. Instruct students to record questions they now have about the patterns they see the cause of the patterns. You can name the patterns as the “effect” and explain how they need to figure out the “cause.”
7. **Students** ask and record that will lead into next episode and are relevant to what they need to know (what evidence they need to explain phenomenon).

#### Part 2: The Atacama Desert

1. **Introduce the Phenomenon:** The Atacama Desert is the driest desert in the world.
2. Show students Pictures #1 and #2 and Map #3.
3. Point out the Atacama Desert is very close to the Amazon Rainforest.
4. Have students record questions they have
ALSO-The objective in Part 1 is to interpret the dataset presented in the map and then to ask questions about the patterns noted. Students record observations in their science journals. Examples of questions to spur student observation and discussion are below: What does your map represent? What do the colors represent on your map? What patterns do you observe? What questions do you have about the patterns you observe?

5. Instruct students to give one reason why they think that the Atacama Desert is the driest desert in the world.

6. Instruct students to record 2-3 questions they have about the Atacama Desert.

7. Exit ticket: As a group (the same group they worked with earlier) discuss the questions you have and write down the questions on a piece of paper. Each group will turn in a list of 5-8 questions that they have about the Atacama. Instruct them to write each question only once, so that no questions are repeated. This is a formative assessment for you to see what the students are thinking and wondering and what they will need to know to explain this phenomenon.

Materials:
Copies of Maps and Pictures- Sets for each small group.

Assessment of Student Learning

Proficient: The exit ticket is a formative assessment for you to see what the students are thinking and wondering and what they will need to know to explain this phenomenon. Sort through the questions and group and tally them yourself so that you can see where you will need to spend the most time during this storyline. Be sure to eliminate questions that will not generate evidence that explains the phenomenon: The Atacama Desert is the driest desert in the world.

Map #1: Earth from Space
Map #2: Global Climates

Picture #1: The Atacama Desert

C. Penrod
Picture #2: Location of Desert

Map #3: South America

C. Penrod
# 6.3.3 Lesson Plan 2

<table>
<thead>
<tr>
<th><strong>Student Science Performances</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Read to Obtain Information</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Develop and model</strong></td>
<td></td>
</tr>
</tbody>
</table>

| **Topic:** System of the Atacama: Atmosphere, hydrosphere, geosphere and biosphere. | **Title:** What’s in a Desert System? |

### Overarching Performance Expectations (Standard) from State Standards or NGSS:
Develop and use a model to show how unequal heating of the Earth’s systems causes patterns of atmospheric and oceanic circulation that determine regional climates.

### Lesson Performance Expectations:
Read to obtain information and develop a model of the parts of the Atacama Desert system (atmosphere, hydrosphere, geosphere and biosphere)

### Students Will... To Construct Meaning

#### Part 1: Reading - The Atacama Desert
1. Read the article *The Atacama Desert* as a class.
2. Pay attention to and underline the parts of the desert system.

#### Part 2: Systems Model
1. Draw the “Systems Model” in lab notebook.
2. Label the center “Atacama Desert” and each of the four parts as instructed by teacher.
3. In small groups (2-4), discuss and record information found in the article and in the pictures that relates to each part of the larger desert system.

### Teacher Will... To Support Students

#### Part 1: Reading - The Atacama Desert
1. Make copies of the reading, *Atacama Desert*, one each student. (Cut and paste the article below onto one page).
2. Direct students to pay attention to (underline) the parts that make up the Atacama system. Remind them that most of these parts are non-living.
3. Direct a class discussion on what was discovered in the reading.

#### Part 2: Systems Model
1. Put/draw the “Systems Model” on the board for the students to see and instruct each student to draw this in their lab notebook.
2. You can use the labels air, land, water, life, but also refer to atmosphere (air), geosphere (land), hydrosphere (water) and biosphere (life).
3. Check in with each group as they are working. Ask probing questions as needed.
4. Check “Systems Model” as a class to be sure all necessary information is recorded.
5. Tie back to the phenomenon: The Atacama Desert is the driest desert in the world.

### Materials:
Copy of *Atacama Desert* for each student.
Slide or copy of *Systems Model*
Assessment of Student Learning

**Proficient:** Students will include at least 2 of the following for each category:

Hydrosphere: very little water to no, less than 1 mm rain/year, few oases
Atmosphere: dry air, few clouds, 0-25 degrees Celsius average temperature (32-77 degrees F)
Geosphere: near Pacific Ocean, long piece of land, 600 miles, sand dunes, mud cracks, high altitude
Biosphere: hard for plants, animals and humans to live there, small plants/grasses

---

**THE ATACAMA DESERT**

The Atacama is the driest desert in the world. The desert typically gets less than 1 mm of rain a year and some places haven’t ever recorded rain. It is extremely hard for people and plants and animals to live here. Life is concentrated around oases (waterholes) and mining towns.

Deserts are places where rain is scarce, but there is only one area on this earth - the central portion of Chile's Atacama Desert - where it has never ever rained - at least since humans started keeping a record - about 400 years ago! The most amazing part is, that this 600-mile stretch of land lies right alongside Chile's coast, next to the biggest body of water on Earth - The Pacific Ocean. Though drier than all other deserts, the temperature in the Atacama Desert is quite cool, ranging from 0-25 degrees Celsius (32-77 degrees Fahrenheit), thanks to its high altitude.
Atacama FACTS

Size: 40,600 square miles (105,000 square kilometers)
Countries: Chile, Peru
Continent: South America

Edited from:
https://wiki.kidzsearch.com/wiki/Atacama_Desert

Figure 3: Mud cracks on the desert floor.

Systems Model:

Air  Water

Land  Life
6.3.3 Lesson Plan 3

Student Science Performances
Carry out an investigation
Analyze and Interpret Data

| Topic: Convection Cells in the Atmosphere | Title: The Convection Connection |

Overarching Performance Expectations (Standard) from State Standards or NGSS: Develop and use a model to show how unequal heating of the Earth’s systems causes patterns of atmospheric and oceanic circulation that determine regional climates.

Lesson Performance Expectations: Carry out an investigation to test a prediction on how energy effects the movement of matter in two of Earth’s systems- the atmosphere (air) and in the hydrosphere (ocean). Analyze and Interpret data to find patterns in energy flow and matter cycling between Earth’s systems (hydrosphere, atmosphere, geosphere).

Students Will... To Construct Meaning
Part 1: Predicting Energy with Maps
1. Glue two small maps of the world into a lab notebook. Title one “Hydrosphere” and the other “Atmosphere.”
2. Discuss with your small group your prediction on where the surface of the ocean is the warmest (more energy) and where the surface of the ocean is the coldest (less energy) in this system.
3. Use a blue pencil to represent cold. Use a red pencil to represent warm. Draw on your “Hydrosphere” map where these areas (warm and cold) are located. Use arrows, words, coloring in, etc.
4. Now, discuss with your group where you think warm and cold air is in the Earth’s atmosphere (system). Also think of how the air is moving—where it might be causing this.

Part 2: Convection in a Fluid Model
5. Watch your teacher set up this model of a system. It is very important to follow all instructions precisely for desired results.
6. Set up model with small group.
7. Record your data (draw a picture) in your lab notebook using your red and blue pencils of what you observe. Be sure to use arrows to show which way the water (matter) is moving in your model. Identify what the energy source is in your model.
8. Clean up area and return materials to teacher.

Teacher Will... To Support Students
Materials alert: BLUE ice cubes needed! Must make a day ahead!! Fill 8 plastic shoe boxes half full of water a day ahead.

Part 1: Predicting Energy with Maps
1. Arrange students into small groups (2-4).
2. Make 3 copies of the world maps for each student.
3. Instruct students to glue 2 maps in their lab notebook and title one “Hydrosphere” and the other “Atmosphere.”
4. Tell students to discuss in a small group their prediction on where the surface of the ocean is the warmest (more energy) and where the surface of the ocean is the coldest (less energy) in this system.
5. Direct students to use a blue pencil to represent cold and a red pencil to represent warm. Instruct them to draw on “Hydrosphere” map where these areas (warm and cold) are located. Use arrows, words, coloring in, etc.
6. Walk around and listen to what students are saying and what their predictions are. This will help to guide the questions you ask in the next section.

Part 2: Convection in a Fluid Model
7. One method in geoscience is using a model for understanding a process or event. Your students will create a model to help them understand convection in fluids (liquids and gases—ie the ocean and atmosphere). This is not an investigation with a controlled variable, but rather an investigation into understanding a process. Thus, you must model HOW to set the model up.
9. Make a table in lab notebook listing the components of your systems model (container of water, hot red water, blue cold water).

10. Indicate in your table what each component of the model represents for the atmosphere and then for the hydrosphere. (Note: don’t give answers! Let students think and connect).

11. Example:

<table>
<thead>
<tr>
<th>Model we used</th>
<th>Atmosphere</th>
<th>Hydrosphere</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hot red water</td>
<td>Hot, rising air</td>
<td>Warm, rising water</td>
</tr>
<tr>
<td>Cold blue water</td>
<td>Cold, sinking air</td>
<td>Cold, sinking water</td>
</tr>
<tr>
<td>Container of water</td>
<td>An air mass in the atmosphere</td>
<td>Water in the ocean</td>
</tr>
</tbody>
</table>

12. Write a sentence about how energy affects matter in the atmosphere. Label this as convection.

13. Write a sentence about how energy affects matter in the hydrosphere (ocean). Label this as convection.

14. Answer these questions: What is the source of energy (heat) in the atmosphere? What is the source of energy (heat) in the ocean?

Part 4: Revisiting Predictions

15. Glue the last map (3rd) into lab notebook.

16. Follow teacher’s directions on where to draw actual currents with red and blue pencils.

17. Discuss meaning of currents and source of energy.


19. Discuss two questions with your group: What is the source of energy (heat) in the atmosphere? What is the source of energy (heat) in the ocean?

20. Write a statement for each in your lab notebook.

21. Exit Ticket- Clearest Point, Muddiest Point assessment (described in teacher notes).

Management Strategies:

1. Make 3 copies of the world maps for each student. Copy and paste four maps onto one page and then copy and cut apart on a paper cutter. The maps do not need to be large.

2. It is very tempting to want to do the investigation only as a demo, but DON’T! Let

Part 3: Connecting your Model to Earth’s Systems

14. Instruct students make a table in lab notebook listing the components of the systems model. See example to left.

15. Emphasize how energy causes matter to rise (more energy-heat) and sink (less energy-cold). This is a BIG idea here! Warm air rises, cool air sinks. Warm water rises, cool water sinks. This creates currents in the air (atmosphere) and the ocean (hydrosphere). This is a connection to Strand 6.2. The new piece here is to tie this to fluids- liquids and gases- and then label the liquid hydrosphere and the gas atmosphere.

16. Give students the two questions: What is the source of energy (heat) in the atmosphere? What is the source of energy (heat) in the ocean? To discuss with their groups.

17. Be sure to check understanding that the sun is the source of energy that heats both the atmosphere and the ocean.

18. Tie this to the phenomenon-
the students try out it out and investigate. Even if not all groups get a strong, visible convection cell, someone in the class will get it to work and everyone can use that as a model.

http://www.srh.noaa.gov/srh/jetstream/ocean/circulation.html

20. Here is information about atmospheric circulation: http://www.srh.noaa.gov/jetstream/global/circ.html. Your students do NOT need to know the names of the three circulation cells- just that there are large convection cells that transport energy around the Earth. It IS important for them to connect that more energy from the sun at the equator means that warm, moist air is rising. Connect this to the convection cell model.

21. Have students glue the third map in lab notebook. Label Actual Oceanic Circulation.

22. Show the map of oceanic circulation.

23. Instruct students to draw the correct arrows on the map using Basic Ocean Currents as a guide.

24. Discuss the source of energy (the sun) and point out how warm currents are moving away from the equator, while cold currents are moving away from the poles. Connect to the convection cell model.

25. Now, show the map of Global Atmospheric Circulation.

26. Instruct students to draw a circle on their paper to represent the Earth. It is NOT necessary to draw any continents. Label Global Circulation.

27. DO include the equator. This is a BIG deal (most incoming solar radiation).

28. Instruct students to use red and blue pencils, again, to show convection currents in the atmosphere.

29. Exit ticket: Clearest Point and Muddiest Point- Put up two big pieces of chart paper or draw to very large squares on the board. Label one Clearest Point and the other Muddiest Point. Give each student 2 post-it notes. Instruct them to write down one thing from today’s lesson that they got and one thing that still seems unclear. Have them place their notes as they leave/end class.

30. Materials:
Two small copies of map for each student
Glue sticks (one per student)
Colored pencils
Post-it notes
Plastic shoe boxes (one per group) half full of water
Blue food coloring
Ice cube tray
12 blue ice cubes
Red food coloring
Microwave or hot pot (electric kettle)
**Assessment of Student Learning** - After class, group the notes in each category (Clearest and Muddiest) so that you can see what is clear and what (and who) still needs more attention.

**Map of World**

![Map of World](image)

**Global Atmospheric Circulation**

![Global Atmospheric Circulation](image)

**Basic Ocean Currents**

![Basic Ocean Currents](image)
### 6.3.3 Lesson Plan 4

#### Student Science Performances

<table>
<thead>
<tr>
<th>Develop and model</th>
</tr>
</thead>
</table>


#### Title: It’s All About the Interactions

#### Overarching Performance Expectations (Standard) from State Standards or NGSS:

Develop and use a model to show how unequal heating of the Earth’s systems causes patterns of atmospheric and oceanic circulation that determine regional climates.

#### Lesson Performance Expectations:

Read to obtain information on how systems interact to create the driest desert in the world.

---

### Students Will... To Construct Meaning

#### Part 1: Reading - The Atacama Desert

1. Review System Model for the Atacama Desert prepared in previous lesson.
2. Read the article *The Atacama Desert, Chile: The Driest Desert on Earth* as a class.
3. Record system interactions in lab notebook by adding them to your four-box model from Episode 2.

#### Part 2: Asking

1. In small groups (2-4), discuss how this information relates to the phenomenon of the Atacama Desert being so dry.
2. Pay attention to and write down questions you still have about the systems interactions. Record them in lab notebook.

#### Part 3: Connecting Systems Model Convection Model

3. Refer to convection model from previous lesson.
4. **Exit ticket:** How does the convection model relate to what you learned today about the Atacama Deserts’ systems? Make as many connections as you can.

#### Management Strategy:

*Read the article a head of time* and fill out your own systems model interaction. Some of these interactions take thinking about and you will have

---

### Teacher Will... To Support Students

#### Part 1: Reading - The Atacama Desert

1. Make copies of the reading, *Atacama Desert, Chile: The Driest Desert on Earth* one each student. (Cut and paste the article below onto one page).
2. Review the Systems Model students prepared in previous lesson.
3. Direct students to pay attention to (underline) the interactions of the systems in the Atacama system.
4. During reading, stop and check for understating by asking questions. Also, stop and Figure 1. Instruct students to draw Figure 1 in lab notebooks. (This is an important piece of evidence.)
5. Model how to add and label an interaction between the systems by drawing arrows on the outside of the box from one system to another and labeling the interaction. For example, cold ocean water (hydrosphere) prevents moisture that could turn into clouds and rain (atmosphere). The arrow going from hydrosphere to atmosphere could say “prevents moisture that could be rain”. Instruct each student to draw this in their lab notebook.
6. Continue reading as a class and adding information on systems interactions to the model.
7. Also point out how energy and matter are

---

C. Penrod
a difficult time doing this on the spot in front of the students. You will discover were something is unclear and then will be able to help students as they read and make sense of the information.

8. Check “Systems Model” as a class to be sure all necessary information is recorded.
9. Tie back to the phenomenon: The Atacama Desert is the driest desert in the world.
10. Direct a class discussion on what was discovered in the reading.

Part 2: Asking Questions
11. Instruct students to discuss in small groups how this information relates to the Atacama Desert being so dry.
12. Have students record questions in lab notebooks.
13. Move around the classroom and read the questions. Make note of what information the students still need. This is a formative assessment for you to know what to spend time on next.

Part 3: Connecting Systems Model Convection Model
14. Have students review convection model on own.
15. Assign exit ticket: How does the convection model relate to what you learned today about the Atacama Deserts’ systems? Make as many connections as you can.
16. Collect exit tickets and review feedback to guide next lesson.

Materials:
Copy of Atacama Desert, Chile: The Driest Desert on Earth for each student.
Slide or copy of Systems Model

Assessment of Student Learning

Proficient: Exit Ticket
Students will make two or more of the following connections:
Heat energy from the sun causes hot air to rise and move moisture away from the desert.
Hot air can prevent precipitation
Due to high elevation, mountains cause air to rise, cool and drop moisture
A cold ocean current causes on inversion that prevents moisture from rising that would lead to rain
Mountains prevent rain from moving over to the other side (rain shadow effect)

Systems Model:

C. Penrod
A desert is a hot area of land that gets very little rain, and where temperatures during the daytime can get as high as 55°C (131°F). At night, deserts cool down, sometimes even below 0°C. Most deserts lie between 15° and 35° north and south of the equator. The desert climate is due in part to air that rises over the equator and comes down over the Tropic of Cancer and the Tropic of Capricorn. All over the world, around 20% of the deserts lie in these regions.

Figure 1: Rain over the equatorial region (1) is caused by the cooling and condensing of hot, wet rising air (2). Cool, dry air moves out and sinks back toward Earth’s surface (3), resulting in a high-pressure system with no precipitation. (4).

How does this happen? (See figure 1)
1. Land over the equator becomes very hot because the sun’s rays hit the equator at a direct angle between 23°N and 23°S latitude. The hot and wet air rises and it rains a lot in these areas.

2. The air cools down and moves north and southwards as it gets drier.

3. The cool, dry air sinks to the ground over the Tropic of Cancer in the north, and the Tropic of Capricorn in the south, causing high pressure (“sunny weather”).

4. And then again, warm air near the surface moves back to the equator causing the air to rise. These moving air masses are called trade winds. As the rising air cools, clouds and rain develop. The resulting bands of cloudy and rainy weather near the equator create tropical conditions. **But... what makes the Atacama Desert in Chile drier than other deserts?**

A cold ocean current flows northward along the Chilean coast (see figure 2). The cold, humid air produced by the sea stays down along the coastline due to hot air masses rising from the continent (an inversion layer). This reduces the moisture in the air and, also, results in nearly 350 days of clear skies inland.

It must also be considered that the Atacama Desert is located over **high altitudes**, above 8,200 feet (2,500 meters) above sea level. This fact contributes to low, drying temperatures and very low humidity in the air (about 10%).

Another important reason is that two mountain ranges, the Chilean Coastal Range and the Andes Range, run along the west and east sides of the Atacama Desert acting as natural barriers of moisture (the rain shadow effect). A rain shadow is a dry region of land on the side of a mountain that is protected from the prevailing winds (winds that occur most of the time in a particular location on the Earth), also called the leeward or down-wind side of the mountain.

Prevailing winds carry air toward the mountain range. As the air rises, it cools, and water vapor condenses to form clouds over the windward side of the mountain. Here, precipitation falls in the form of rain or snow. The windward
side of a mountain range is moist and lush because of this precipitation. Once the air passes over the
mountain range, it moves down the other side, warms, and dries out. This dry air produces a rain shadow.
Land in a rain shadow is typically very dry and receives much less precipitation and cloud, creating desert
conditions on the leeward side of the range cover. Nowhere else on Earth do these climatic features come
together as they do in Atacama! MODIFIED FROM CARMEN ABUHADBA’S ORIGINAL ARTICLE PUBLISHED ON 9/4/2013
6.3.3 Lesson Plan 5

**Student Science Performances**
Develop a model

<table>
<thead>
<tr>
<th>Topic: Annual Precipitation, Ocean Temperatures, and Rain Shadow Effect</th>
<th>Title: Defining the Cause</th>
</tr>
</thead>
</table>

**Overarching Performance Expectations (Standard) from State Standards or NGSS:** Develop and use a model to show how unequal heating of the Earth’s systems causes patterns of atmospheric and oceanic circulation that determine regional climates.

**Lesson Performance Expectations:** Analyze and interpret data to begin developing a model to show how unequal heating of the Earth’s systems causes patterns of atmospheric and oceanic circulation that determine regional climates.

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### Students Will . . . To Construct Meaning

#### Part 1: Developing A Model
1. Move into small groups (2-4 people).
3. Write down three observations you make from the patterns on this map.
4. As a group, discuss and record evidence and it's cause from this map that would support the phenomenon.

#### Part 2: Rain Shadow and Ocean Currents
5. Teacher will assign group one piece of evidence (B or C).
6. As a group, work together to develop a model of either Ocean Temperatures or the Rain Shadow Effect. Draw pictures, label parts and write descriptions. Also, refer to the article *The Atacama Desert, Chile: The Driest Desert on Earth*. Focus on how this provides evidence that supports WHY or the cause of the Atacama Desert being so dry.

#### Part 3: Refining and Recording the Models
7. Record the model your group created in your lab notebook.
8. Hang up posters. Go visit and study the other models that are the same topic as your own. Add things to your model that you may have missed.
9. Return to your seat.
10. As a group, fix anything you want on your model.
11. Now, record the other model that you do not have that is presented in class by another group.

---

### Teacher Will . . . To Support Students

#### Part 1: Developing A Model
1. Prepare group sets of Evidence A-C. Print in color.
2. Instruct your students that they will begin constructing their model to explain the phenomenon: The Atacama Desert is the Driest desert in the world.
3. Give each group a copy of the Evidence Card A: South America: Annual Precipitation (1976-2009). Instruct students to record evidence from the patterns on this map that would provide evidence of WHY the Atacama is sodry.

#### Part 2: Rain Shadow and Ocean Currents
4. Distribute Evidence Card B: Ocean Temperatures to half the groups and Evidence Card C: Rain Shadow Effect to the other half. The object here is for each group to become experts on one of the pieces of evidence and then share with the class.
5. Hand out a piece of chart paper and markers to each group. Instruct students that each group is to make a poster to share that will explain this piece of evidence. Students must include pictures, label parts and written descriptions/explanations on the model and connect to the Atacama being so dry. Students should also refer to previous article: *The Atacama Desert, Chile: The Driest Desert on Earth*.
6. Move around and listen to groups while they are preparing posters.

---

C. Penrod
Management Strategies:

1. Make color copies of the Evidence Cards are essential to toady's lessons. Students need to see the colors to effectively analyze the data on each card.

2. It is essential to clear up and correct any wrong information about Rain Shadow Effect and Ocean Temperatures BEFORE it is presented as a final model to the class. Take the time you need to be sure posters are accurate.

3. To quickly check all student notebooks, walk around giving immediate feedback on needed corrections and then stamp correct models when satisfactory.

4. Have students hang models up. Spend a few minutes examining each model. Have students take notes on how to improve their model. Look at and study models during this time so that you can correct anything that is wrong in a by asking probing questions to refinetihing.

8. Direct students to return to tables and fix models.

9. Chose most accurate model for each topic (Ocean Temperatures and Rain Shadow Effect). Have students from these groups present their model to class. Students record models in lab notebooks.

10. The objective here is for students to end up with a correct model for Rain Shadow Effect and Ocean Temperature in their own notebook. Make use of a class discussion to clarify and refine anything that needs attention.

11. Check all student notebooks and review models giving feedback as needed. Correct models are essential to the success of the final lesson (the performance expectation).

Materials:

- Group sets of Evidence Cards A-C
- Poster paper
- Markers

Assessment of Student Learning

Proficient:
Each student will have a correct model of Ocean Temperature and Rain Shadow Effect and explain the cause for each. Consult Evidence Cards B and C for details.
EVIDENCE CARD A
SOUTH AMERICA: ANNUAL PRECIPITATION
(1976–2009)

Wettest place:
Lloro, Colombia
(over 500 inches)

Driest place in
Atacama Desert
(zero precipitation)

Rain
in inches
125 inches and above
118-125
110-118
102-110
86-102
78-86
70-78
62-70
55-62
47-55
39-47
31-39
24-31
16-24
8-16
8 inches or less

C. Penrod
The amount of ocean water that evaporates varies with surface temperature. Cold ocean water evaporates more slowly than warm ocean water, forming less water vapor. Water vapor can condense into precipitation. Therefore, less water vapor leads to less precipitation. Ocean water that evaporates is carried in the direction of prevailing winds.

**Key: Sea Surface Temperature in Degrees Celsius**

<table>
<thead>
<tr>
<th>Temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-2</td>
</tr>
<tr>
<td>0</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>4</td>
</tr>
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</tr>
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<tr>
<td>32</td>
</tr>
<tr>
<td>34</td>
</tr>
<tr>
<td>36</td>
</tr>
</tbody>
</table>
Evidence Card C
Rain Shadow Effect

When winds carrying moist air move up the side of a high mountain range, the air cools as it rises. The water vapor in the air condenses and falls as precipitation. After the wind passes the top of the mountain range, it no longer has much water vapor. The way that high mountains block water vapor from getting to the opposite side of the mountain range is called the rain shadow effect.
### Student Science Performances

<table>
<thead>
<tr>
<th>Topic: Evidence for Dryness</th>
<th>Title: Now I Know Why... the Atacama is so Dry!</th>
</tr>
</thead>
</table>

### Overarching Performance Expectations (Standard) from State Standards or NGSS:
Develop and use a model to show how unequal heating of the Earth’s systems causes patterns of atmospheric and oceanic circulation that determine regional climates.

### Lesson Performance Expectations:
Develop a model to show how uneven heating of the Earth’s systems causes patterns of atmospheric and oceanic patterns that determine deserts (Atacama Desert).

<table>
<thead>
<tr>
<th>Students Will. . . To Construct Meaning</th>
<th>Teacher Will. . . To Support Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Putting it All Together</td>
<td>Putting It All Together</td>
</tr>
<tr>
<td>1. In your lab notebook, create a final model that explains WHY (the causes), using evidence gathered, the Atacama Desert is the driest desert in the world.</td>
<td>1. Make all maps and articles used in the storyline available for students.</td>
</tr>
<tr>
<td>2. Use all the resources available, including the Systems Model made earlier in the storyline.</td>
<td>2. Prompt students to create a final model for explain WHY (cause) the Atacama Desert is the driest desert in the world.</td>
</tr>
<tr>
<td>3. Include text (explanations) and drawings/illustrations of concepts presented, including. It should identify the parts of the system (atmosphere, hydrosphere, and geosphere) and how matter and energy interact to create this system. Focus thinking on causes and explaining each one.</td>
<td>3. Instruct them to use the evidence they have gathered in creating the model.</td>
</tr>
<tr>
<td>Management Strategy:</td>
<td>4. Also, encourage students to use any resources they need. Remind them that they have all the parts recorded in their lab notebook, they just need to pull it all together.</td>
</tr>
<tr>
<td>1. Remember the model is being used to explain WHY the Atacama Desert is so dry. This is not a model of the Atacama Desert. Also, this is a conceptual model so it is complex. This may take some time for your students to put all the evidence together. Be sure to refer students back to the Systems Model and the interactions. This is where the answer lies- in the interactions!</td>
<td>5. The model should focus on the causes and include text (explanations) and drawings/illustrations of concepts presented, including: the parts of the system (atmosphere, hydrosphere, and geosphere) and how matter and energy interact to create this system.</td>
</tr>
<tr>
<td>2. Develop you own conceptual model BEFORE you give you students this task. You will know where students may need support and will also better understand the phenomenon yourself.</td>
<td><strong>Materials:</strong></td>
</tr>
</tbody>
</table>

All maps and articles used in storyline

### Assessment of Student Learning

**Proficient:** Rain Shadow Effect (winds (atmosphere) carry moisture (hydrosphere-matter) toward mountains, then air loses energy (cools) and rains on the windward side of mountain; less water vapor in air (atmosphere) due to cooler ocean temperature (hydrosphere), and high elevation(geosphere) of the Atacama leads to dry air (atmosphere and hydrosphere). Bonus: The sun heats the ocean and the air over the ocean which causes the moisture to rise and move away from desert regions (convection).
**Strand: 6.4.1**

**Emphasis:** Resource availability affects populations

**Anticipated Time Required:**
- LE 0 - 15 minutes
- LE 1 - 60-75 minutes
- LE 2 - 60 minutes
- LE 3 - 30-40 minutes
- LE 4 - 30-45 minutes
- LE 5 - 60-75 minutes

**Dominant CCC:** Cause and effect

**Dominant SEP:** Analyzing and interpreting data; engaging in argument from evidence

**Management Strategies** to support equitable access to content:
- Discussion: Repeat, New Idea, Add-On
- Partner talk and individual written work: Sentence stems

**Shopping list:** none
### Anchor Phenomenon:
Over the past 40 years, the mountain plover population has declined by about 67%. ([http://www.iucnredlist.org/details/22693876/0](http://www.iucnredlist.org/details/22693876/0))

### Big question:
What is causing the decline in the mountain plover population?

### Student Performance Expectation:

**6.4.1** Analyze data to provide evidence for the effects of resource availability on organisms and populations in an ecosystem. Ask questions to predict how changes in resource availability affects organisms in those ecosystems. Examples could include water, food, and living space in Utah environments.


<table>
<thead>
<tr>
<th>Dominant DCI</th>
<th>Dominant CCC</th>
<th>Dominant SEP</th>
</tr>
</thead>
<tbody>
<tr>
<td>LS2.A: Interdependent Relationships in Ecosystems</td>
<td></td>
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<tr>
<td>● Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors.</td>
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<tr>
<td>● In any ecosystem, organisms and populations with similar requirements for food, water, oxygen or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction.</td>
<td></td>
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<tr>
<td>● Growth of organisms and population increased are limited by access to resources.</td>
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<td></td>
</tr>
<tr>
<td>Cause and effect</td>
<td>Analyzing and interpreting data, engaging in argument from evidence</td>
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</tr>
</tbody>
</table>

### Science Experiences

<table>
<thead>
<tr>
<th>CCC/SEP</th>
<th>What are students doing?</th>
<th>What Disciplinary Core Idea understandings should students get from this experience?</th>
<th>New questions students have to lead to the next science experience</th>
<th>Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>0: Introduction to plovers</td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>CCC: cause and effect</td>
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<td></td>
<td></td>
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<tr>
<td>SEP: asking questions</td>
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</table>
| *This is just an introduction to the phenomenon; it is not a complete lesson*

Students learn about the decline in the plover population and complete an assessment probe to propose an initial explanation for the decline.

Mountain plovers are birds that only live in a small region of the world, and their population has declined.

What is causing the decline in the plover population?

Formative: Students complete an assessment probe that will be handed in and saved until the end of the unit, when they will use it to reflect on how their thinking has changed.

| 1: Coral and urchins |
| CCC: cause and effect |
| SEP: analyze and interpret data; argue from evidence; ask questions |
| *Reason:* Students identify questions that could help lead to better understanding of Space/shelter is necessary for some species to survive. Some species provide resources that other species need (in this case, the urchins are providing space that the corals need) |
| Is something taking away the plover’s space or shelter? Is there another species that could provide a resource for the plovers? |

Formative: Students should be assessed on their ability to interpret data in a graph and generate questions; students who are struggling with these skills will need scaffolding throughout this unit until they develop these skills.
the relationship between the urchins and coral, then use evidence to make and support a claim regarding the relationship between the urchins and corals

*Communicate:* Class discussion:
- What resource do the urchins make available to the coral?
- How might this help us answer our question about the plovers?

Students record their ideas on their summary sheets.

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<thead>
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<tbody>
<tr>
<td>Reason I:</td>
<td>Students graph population size data; make inferences about what causes changes in population size; determine the relationships among resource availability, individual growth and population size.</td>
</tr>
<tr>
<td>Communicate I:</td>
<td>Students share their inferences with their partner and participate in a class discussion to summarize their inferences and the relationships among resource availability, individual growth and population size.</td>
</tr>
<tr>
<td>Reason II:</td>
<td>Students work in partners to infer effects of resource availability on individuals.</td>
</tr>
<tr>
<td>Communicate II:</td>
<td>Students share their inferences, along with supporting evidence, with the class.</td>
</tr>
</tbody>
</table>

Students record their ideas on their summary sheets.

<table>
<thead>
<tr>
<th>2: Oh Deer!</th>
<th>When resources are available, individuals can survive longer, grow larger, and reproduce. This causes the population to grow.</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>When resources are scarce, individuals die and the population shrinks.</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>2: Oh Deer!</th>
<th>Does lack of shelter really cause deer to die? What kind of shelter do the plovers need?</th>
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<tbody>
<tr>
<td></td>
<td>What causes there to be more or less food for the plovers? How much water do the plovers need?</td>
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</table>

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<tr>
<th>Formative:</th>
<th>Student CERs can be used as formative assessments of their ability to identify and use evidence to support a claim, and/or a summative assessment of their understanding of the relationship between the urchins and coral. These skills will be practiced throughout this storyline, so student ability should be assessed early to help provide sufficient scaffolding throughout the remaining lessons.</th>
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<tbody>
<tr>
<td></td>
<td>Student graphs and inferences can be used to assess their understanding; student participation in small and whole group discussion should be used to assess understanding and identify misconceptions</td>
</tr>
<tr>
<td>3: Predators</td>
<td><strong>Gather:</strong> Students gather data on the population sizes of the plover’s predators.</td>
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</tr>
<tr>
<td><strong>CCC:</strong> cause and effect, stability and change</td>
<td><strong>SEP:</strong> analyzing and interpreting data, arguing from evidence</td>
</tr>
<tr>
<td><strong>Reason:</strong> In groups, students use the data to infer how the predator populations are affecting the plovers.</td>
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<tr>
<td><strong>Communicate:</strong> Students create a written argument to support a claim about the effect of the predators on the plover populations.</td>
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<tr>
<td>Students record their ideas on their summary sheets.</td>
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<tr>
<td>4: Food and water resources</td>
<td><strong>Gather:</strong> Students use food webs and data set to collect information about precipitation and organisms in the plover’s ecosystem.</td>
</tr>
<tr>
<td><strong>CCC:</strong> cause and effect, stability and change</td>
<td><strong>SEP:</strong> analyzing and interpreting data, constructing explanations</td>
</tr>
<tr>
<td><strong>Reason:</strong> Students analyze the data to determine how precipitation is likely affecting populations in the system, including the plover populations.</td>
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<tr>
<td><strong>Communicate:</strong> Students post their explanations for the likelihood that precipitation is causing the decline in the plover population.</td>
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</tbody>
</table>
| 5: Prairie Dogs | **Gather:** Students gather information about prairie dogs and the relationship they have with the plovers. | Prairie dogs provide two services to the plovers:  
- They keep the grass short so that plovers can see predators  
- Their warning alarms alert the plovers if a predator is nearby  
When the prairie dog populations decline, so do the plover populations. | | Formative:  
Student discussions and group models should be used as formative assessments  
Summative: students use evidence to construct an argument about what is causing the decline in the plover population when they revisit the probe from the first lesson and in constructing their final argument |
| **CCC:** cause and effect, systems, stability and change | **SEP:** develop models, argue from evidence | | | |
would affect the mountain plovers.

*Communicate:* Students use evidence to construct a written argument that supports or refutes the claim that shrinking habitat is causing the decline in the plover population.
### 6.4.1 Learning Episode 0

#### Student Science Performance

| Topic: Ecosystem Resources | Title: Introduction to plovers |

#### Overarching Performance Expectations (Standard):
Analyze data to provide evidence for the effects of resource availability on organisms and populations in an ecosystem. Ask questions to predict how changes in resource availability affects organisms in those ecosystems. Examples could include water, food, and living space in Utah environments.

#### Lesson Performance Expectations:
Students will make a prediction about the causes of the decline in the plover population.

- **CCC:** Cause and effect
- **SEP:** Asking questions

#### Students Will... To Construct Meaning

_Engage with a phenomenon:_ Over the past 40 years, the mountain plover population has declined by about 67%.

Read through the conversation among friends probe with the class. Decide which friend’s idea you _most_ agree with. Circle the friend’s name and then explain why you agree with the friend’s idea.

#### Teacher Will... To Support Students

*Note: This is an introduction to the anchor phenomenon and unit, but is not a complete lesson!*

Introduce the anchor phenomenon to the students. Find a hook to help generate interest in the bird; possible hooks:

- Mountain plovers are called “prairie ghosts” because they camouflage so well and are often hard to see; adults, chicks, and eggs are all camouflage well in their environment. Introducing the birds by showing a picture of camouflaged birds and asking students to find them might be one way to help generate interest in the plovers.
- Show pictures of the downy chicks, which will generate plenty of, “cuuuute” from some students and help them care about the birds.
- Show a map with the bird’s territory, and emphasize that this is the only place on the planet where these birds are found. Point out places that students may have visited to help them connect with the plovers.

Once students know about the decline in the plover population, give them a few minutes to complete and turn in the probe. Students should only complete the front side; they will revisit the probe at the end of the lesson. Ask students what questions they could investigate that would help them explain why the plover population is declining. Allow the students time to write their questions on sticky notes and post them on the question board. You can have students work on this individually or discuss possible questions in groups. At some point, you can sort the questions into categories, and refer back to them each time students are investigating a category of questions throughout the unit.

Not every learning episode in this storyline focuses on the mountain
What questions could you investigate to help understand why the plover population is decreasing? Write each question that could help us understand this phenomenon on a sticky note, and post it on the question board.

Plovers, so intentionally tying concepts students are learning back to the phenomenon is important. One way to help facilitate this is to make a list of the factors that could be causing the decline. After this lesson, the list could include predators, humans, and other species, since those were the factors on the probe. As students identify additional factors that could be causing the decline during the next lessons, you can add each factor to the list. This can also serve as a way to quickly check in with students and emphasize that their ideas may be changing as they learn new information. At any point during the unit, you can ask which of the factors they think are causing the population decline.

Also set up a summary chart to use for this unit. An example of a summary chart is included with the lesson materials; additional resources for how and why to use summary charts:
- [https://drive.google.com/drive/folders/0B95bQ5hNDMc2bFE2TzBqWnhCRGs](https://drive.google.com/drive/folders/0B95bQ5hNDMc2bFE2TzBqWnhCRGs)

**Notes for setting up this unit:**
Using a class summary chart will be useful. Not every lesson in this storyline focuses on the plovers, so keeping a record of what students have learned and their ideas about how it relates to the anchor phenomenon will help keep things coherent. An example of a summary chart developed during this unit can be found at: [https://docs.google.com/document/d/1gLEDhGV4iacYqSZjZf5bkLfmDDEs4Tzu99JG937lnxc/edit?usp=sharing](https://docs.google.com/document/d/1gLEDhGV4iacYqSZjZf5bkLfmDDEs4Tzu99JG937lnxc/edit?usp=sharing)

If you have never used a summary chart, these are two great articles on how and why to use them:
- [https://drive.google.com/drive/folders/0B95bQ5hNDMc2bFE2TzBqWnhCRGs](https://drive.google.com/drive/folders/0B95bQ5hNDMc2bFE2TzBqWnhCRGs)

You may also want to consider having the students fill out individual summary sheets after each lesson. These summary sheets allow students to keep a record of what they’ve learned, making it easier to bring all the pieces together at the end of the unit. Individual summary sheet template can be found here:
- [https://docs.google.com/document/d/1Vn-05R-bs_U5HK5ZIjwcT3B3xccXsnVySVJ6NrxAtGc/edit?usp=sharing](https://docs.google.com/document/d/1Vn-05R-bs_U5HK5ZIjwcT3B3xccXsnVySVJ6NrxAtGc/edit?usp=sharing)
An example of an individual summary sheet completed for this unit can be found at:
- [https://docs.google.com/document/d/1n8kY4USODATZ-1E3ssd58KLEEx_gGM6rOVG2PxlXdxV4/edit?usp=sharing](https://docs.google.com/document/d/1n8kY4USODATZ-1E3ssd58KLEEx_gGM6rOVG2PxlXdxV4/edit?usp=sharing)

The assessment probe is a great way to promote metacognition. Students can look back at what they originally thought, and then reflect on how and why their thinking changed throughout the unit.

The probe can also be used to measure how the class’ ideas changed. It may be useful to provide a visual representation on what the students were thinking the first day of the unit, so they can compare it with what they are thinking of the last day of the unit. You could do this by writing each friend’s name along the bottom of the whiteboard, and instructing each student to place a sticky note above the name of the friend whose idea...
they most agreed with on the probe. The sticky notes can be placed in a way to create a bar graph, so students can see which friend’s idea got the most (or least) votes. This can be repeated at the end of the unit, and the graphs can be compared. An alternative is to use legos of different colors. Let the students “vote” by placing the lego color that represents their idea in the ballot box. They can then be quickly snapped into a bar graph. Again, the voting process can be repeated at the end of the unit and the graphs compared to see how the class’ ideas changed.

**Assessment of Student Learning**

*This is an introductory activity; assessment probes should be saved and used at the end of the unit for student reflection.*

Explanations on student probes should include a justification/reasoning that includes information that students learned about the plovers. Examples:

- “I agree with Oscar’s idea. The birds build their nests on the ground, so it would be easy for a fox or snake to get the eggs or the baby birds. If the foxes and snakes eat all the babies, the population will get smaller.”
- “I agree with Jackie’s idea. The birds eat insects and people try to kill all the insects. My mom sprays chemicals on the garden to kill the bugs. If we kill all the bugs, then the birds won’t have any food.”
Jamal, Maribel, Hazel, Will and Oscar are learning about a population of grassland birds that is declining. Hazel is not sure why a bird population would be declining over so many years. She says to her friends, “I get how a population might get smaller for a while, like maybe there wasn’t any food one year. But then shouldn’t the population start to get bigger again? Why would a population keep getting smaller for so long?”

This is how her friends responded:

Jamal: “I think that people are making the population get smaller. We add a lot of pollution to the environment and build houses and buildings, and I think that is what is making the population decrease.”

Maribel: “I think it’s because of climate change. The earth is getting hotter, and that might be making it so the birds can’t live as long.”

Will: “I think another species is affecting the birds. There are a lot of other species that live by the birds. Maybe one of those species helps the birds, and if that species was shrinking, it would make the bird population get smaller too.”

Oscar: “I agree with Will that it could be another species, but I think it is because of the bird’s predators. I think the predator species are getting bigger and eating more of the birds, so their population is getting smaller.”

Which friend’s idea do you most agree with? Circle one: Jamal  Maribel  Will  Oscar

Explain your reasoning. Why do you most agree with this idea?

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________
Mountain Plover Probe

Read through the information in the box on the front and decide which friend’s idea you most agree with now.
Circle one:  Jamal  Maribel  Will  Oscar

Explain your reasoning. Why do you most agree with this friend’s idea?
If your answer is different that it was at the beginning of the unit, explain why your thinking changed. What evidence do you have to support your new answer? Why isn’t your original answer as valid? If you didn’t change your answer, explain how your thinking has changed. What additional information do you have to support your answer? Why don’t you agree with one of the other friends’ ideas? If you need more space, you can continue your explanation on a separate sheet of paper.

<table>
<thead>
<tr>
<th>Grade Level</th>
<th>Description</th>
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</table>
| Surpasses proficiency | Your explanation meets the requirement for proficiency, PLUS:  
  - Valid counter arguments for at least one friend’s response are included |
| Proficient | Your explanation includes:  
  - Evidence from data that you collected and analyzed throughout the unit to support your answer  
  - Explanation of how the friend’s response that you chose relates to the evidence collected throughout the unit  
  - Description of how and why your thinking has changed since you first thought about this question |
| Approaching proficiency | Your explanation includes everything for proficiency, but contains errors or incomplete information |
| Below proficient | Your explanation is missing evidence to support it |
Phenomenon: Over the past 40 years, the mountain plover population has declined by about 67%.

Big Question: Why are the mountain plovers disappearing?

**SAMPLE Summary Chart**

<table>
<thead>
<tr>
<th>Activity</th>
<th>OBSERVATIONS What do we know?</th>
<th>INFERENCES What are we thinking?</th>
<th>How might this connect to the phenomenon or help us answer the big question?</th>
<th>What questions do we have now?</th>
</tr>
</thead>
</table>
| Corals and urchins | More urchins = more corals
Urchins eat algae | Corals grow better when there is no algae around
Corals will go extinct if there are no more urchins | Maybe there is a species that could help the plovers like the urchins help the corals | What do plovers need?
Are there other species that could help the plovers grow? |
| Oh Deer! | Deer that get the resources they need live
When there are enough resources, the deer population can grow
When there are not enough resources, the deer population will shrink | Deer that live longer will have more offspring
Deer that are faster will get the resources and live longer | Maybe the plover population got too big and used all the resources so now they don’t have enough resources
Maybe something else is taking the plover’s resources | What resources do the plovers need?
How big did the plover population get? |
| Predators | Foxes, snakes, hawks eat the plovers
Fox population is getting smaller
Hawk and snake populations are stable | Something else could be eating the plovers
Predators are not causing the decline in the plover population | Maybe something else is eating the plovers or there is a different thing causing their population to get smaller | Do the plovers have enough food and water and shelter? |
| Food and water | Plover’s eat bugs
Bugs eat other bugs or plants
The amount of precipitation has not changed very much | The amount of food and water that the plovers have is not causing their population to decrease | A different resource must be causing the decline in their population | How much shelter do the plovers need? Can’t they make nests for their shelter? |
| Prairie dogs | Prairie dogs cut down the grass
Plovers build their nests on the dirt
Prairie dogs warn when there is a predator | The plovers need the prairie dogs
If the prairie dog population decreases, so will the plovers | The prairie dog population could be causing the plovers to decline, because if there are not enough prairie dogs, there won’t be enough space for plovers to build their nests | Are the prairie dog populations getting smaller? |
As we investigate the decline in the plover population, you will be recording your ideas here. This will help you keep all the important information you’ve learned summarized in one place and help you see how your ideas about the bird’s population are changing.

<table>
<thead>
<tr>
<th>Activity</th>
<th>What do I know?</th>
<th>How do I know it?</th>
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</thead>
<tbody>
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<tr>
<td>Activity</td>
<td>What do I think?</td>
<td>Why do I think this?</td>
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6.4.1 Learning Episode 1

<table>
<thead>
<tr>
<th>Student Science Performance</th>
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<tbody>
<tr>
<td><strong>Topic:</strong> Ecosystem Resources</td>
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</tbody>
</table>

**Overarching Performance Expectations (Standard):**
6.4.1: Analyze data to provide evidence for the effects of resource availability on organisms and populations in an ecosystem. Ask questions to predict how changes in resource availability affects organisms in those ecosystems. Examples could include water, food, and living space in Utah environments.

**Lesson Performance Expectations:**
Students analyze data and use evidence to explain how sea urchins affect the growth of corals.

- **CCC:** Cause and effect
- **SEP:** Analyze and interpret data, argue from evidence; asking questions

**Students Will... To Construct Meaning**

*Engage with a Phenomenon: There tend to be more corals in areas where there are sea urchins.*

*Gather:* Look at the graph your teacher has given you. The first thing you will do is identify parts of the graph:
- Look for changes, patterns or trends you see in the graph.
- Draw an arrow to each feature you see.
- Label each arrow with a “what I see” statement.
- Only describe what you see; don’t try to explain anything yet!

Now use your “what I see” statements to interpret the graph:
- Interpret each “what I see” statement by writing a “what it means” statement.
- Don’t worry about trying to figure out what the whole graph means yet!

Use the “what I see” and “what it means” statements to write a caption for the graph:
- Start with a topic sentence. What is the main point the graph is communicating?
- Join the “what I see” and “what it means” statements to make complete sentences.

**Teacher Will... To Support Students**

*Note: This activity was modified from [http://datanuggets.org/wp-content/uploads/2017/07/Urchin_Student-A.pdf](http://datanuggets.org/wp-content/uploads/2017/07/Urchin_Student-A.pdf); screen shots of the relevant sections of this document are included in the lesson materials.*

Make copies of the graph from the data sheet with no other information, and distribute them to the students. Use the I² strategy from BSCS to help students start analyzing the graph (this strategy is outlined in the lesson materials). If this is new to students, either model the procedure for students or do an example of each part as a class before allowing students to work individually.

As students work, circulate through the class. If you notice that many students are struggling to interpret the graph, consider facilitating a class discussion to help model the process of analyzing and interpreting data for students.

Emphasize that students should read their captions, and explain that when their partners are reading, they should be listening for similarities and differences between their partners’ captions and their own.
- Use the sentences to write a paragraph that explains what the graph is showing.

Read your caption to your partner, and listen as your partner reads her caption to you. What similarities and differences are there in your captions?

What do you already know about corals and urchins? Share what you know, and also tell the class how you know that piece of information.

What questions could help us understand why the urchins affect the corals? Write down one question that we could investigate to help us understand this system better, and share it with the class.

After students read their captions to their partners, facilitate a class discussion to make sure that everyone understands that when urchins are present, there are more corals, and when urchins are absent, there are fewer corals.

Prepare a poster with the “big question” at the top: Why does the presence of urchins affect the coral populations? Below the question, make two columns and label them “what we know” and “questions.”

Make a list of what students know in the “what we know” column for display in the class during this lesson. This can be done as a whole group share out. Note: as students provide their knowledge about corals/urchins, ask them how they know that piece of information; if students aren’t sure how they know the information, consider adding a small question mark as you record it to indicate that we might not be sure about about that “fact.”

Before asking students for their questions, allow them time to discuss ideas with their partner and/or think of questions on their own; consider asking all students to record one question before asking students to share with the class. As you record questions from the students in the “questions” column, leave space around each question for students to write answers.

**Management Strategy:** Asking questions is fundamental to science, but many people have a hard time asking the right questions. Students often need guidance when learning how to ask questions that will lead them toward better understanding of a phenomenon. When a student suggests a question that doesn’t seem like it will help direct instruction, ask him to clarify how/why investigating his question will help understand the phenomenon under investigation. As students do this, they will sometimes realize that their questions aren’t really helpful in making sense of the phenomenon and withdraw the question. Sometimes it will be clear that the student had a valid idea in mind, but the question was not worded well. Once the student has a chance to explain what he was trying to get at, you can throw it back out to the class and ask for suggestions on how to reword the question to better fit the student’s purpose.
| Individually, read through the information about corals and urchins, and examine the data. Look for answers to the questions on the class poster, or new information about corals and urchins that could help us answer the big questions. When you find an answer, underline it. When you find a fact that will help us, circle it. |
| With your group, discuss the answers and/or facts you underlined. When your group agrees on an answer to a question or an important fact, you can add it to the class poster. |

**Reason:** Now that you have some additional information about the system where the corals and urchins live, make a claim to answer the big question. Your claim is a statement that tells us

You can also increase students’ ability to ask productive questions by modeling this process yourself. Anytime you ask students to investigate a question, you can tell them how/why investigating that question may help them to better understanding of the phenomenon they trying to make sense of. Alternately, you can ask the students to explain how/why a given question will be useful instead of explaining it yourself.

Distribute copies of the research background and data to the students. Allow them to read the material individually. As they examine the materials, they should be looking for answers to the class’ questions. When they find an answer to one of the questions, they should underline or circle it on their paper. Depending on the class, you may also want them to circle/underline facts they think are important to understanding the coral-urchin relationship (these tasks could also be divided, with half the students looking for facts and the other half looking for answers; this might also be a good way to differentiate, as facts may be easier for some students to identify than answers). After students have had a chance to examine the materials individually, put students in groups of three to discuss the answers and/or facts they found. Once a group agrees on an answer to a question or an important fact, they can go add it to the class poster. Revisions/additions can be made to the “what we know” column while answers should be written next to relevant questions in the “questions” column. Depending on the class, you may need to set norms for writing on the poster (a group can only write one answer/fact at a time; set a minimum and maximum number of answers/facts each group should write, etc.).

After students have added their answers and facts to the poster, facilitate a class discussion to make sure the class agrees on what has been written on the poster.

If students have not had much experience with the claim-evidence-reasoning model, they will need some guidance. Walking them through one piece at a time and providing a graphic organizer may be useful. Additional ideas for scaffolding a CER are in the lesson materials. In this lesson, students complete the claim and evidence, and then get feedback from peers before completing the reasoning section.
why the presence of urchins affects the coral population. After writing your claim, record the evidence you have to support your claim.

Communicate: When you and your partner are both done, compare your claims and the evidence each of you used to support your claims. When it is your turn to share, read your claim and then list the evidences you used to support your claim. When you finish, listen to the questions and feedback your partner gives you. When it is your turn to listen, show your partner you are listening by looking at him. You should not be reading or writing yourself. As your partner shares, think about his claim and evidences. You will need to give him at least one piece of feedback or a question:

- “What did you mean by ______?”
- “How does that evidence support your claim?”
- “I think your argument would be stronger if ______.”
- “I don’t think that evidence supports your claim because ______.”

Now that you have some feedback on your evidence, describe how and why the evidence supports your claim. Write your reasoning for using this evidence to support your claim in your lab book.

Now work with your partner to answer the following questions:

- What resource do the urchins make available to the coral?
- How might understanding the relationship between the coral and urchins help us answer our question about the grassland birds?

Share your ideas during the class discussion. Record your ideas on your summary sheet, and use these ideas to help the class fill out the summary chart.

As students work, circulate through the room and use questions to help students clarify their ideas. When students are done, review (and model, if needed) the expectations for their partner discussions and post questions/sentence stems on the board if needed.

While students discuss their claims and evidence, circulate through the room and listen to their ideas; compliment groups on good discussion skills (making eye contact, asking for clarification, providing effective feedback, etc.).

Post the two questions on the board and allow students a few minutes to discuss them. Listen to students’ ideas and make note of students you may want to call on to share with the whole group.

Facilitate a short whole group discussion to ensure that students have an idea or two regarding the second question (the urchins help make space for the coral; maybe there is another species that helps make space for the birds). Allow time for the students to record their ideas on their summary sheets. If displaying a list of factors that could be causing the plover population decline, you can add a factor or two from this lesson to the list, such as “no space” or “competition with another species.”

If using a summary chart for this unit, make sure you set aside time to complete it after this activity.
Assessment of Student Learning:
Written work as well as discussions should be used to help assess how well students are able to identify cause and effect relationships and interpret the data presented. Student responses (both written and oral) should be used to identify misconceptions and guide instruction throughout the rest of the unit.

The claims students make on the urchin/coral activity should be supported by evidence, and students’ reasoning should explain how the evidence supports the claim. An example of a CER is below, but please note that if this is new to students, their products will not be as detailed and probably won’t include as many pieces of evidence or reasoning. If time permits, consider allowing students time to workshop their CERs, and/or provide a quality example for them to compare their own to so they can identify what they could do to improve their CERs in the future.

<table>
<thead>
<tr>
<th>Question: How does the presence of urchins affect the coral populations?</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Claim:</strong> The corals grow better when there are urchins near them.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Evidence:</th>
</tr>
</thead>
<tbody>
<tr>
<td>● Average number of corals with urchins was 13.75</td>
</tr>
<tr>
<td>● Average number of corals without urchins was 5.25</td>
</tr>
<tr>
<td>● The most corals growing with urchins was 25</td>
</tr>
<tr>
<td>● The most corals growing without urchins as 11</td>
</tr>
<tr>
<td>● Corals contain algae</td>
</tr>
<tr>
<td>● Urchins eat algae</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Reasoning:</th>
</tr>
</thead>
<tbody>
<tr>
<td>The evidence shows us that the average number of corals growing in a system with urchins is 8.5 more than the average number of corals growing in a system without urchins. Also, the most corals that grew without urchins was 14 fewer than the most corals that grew with urchins. We can see that more corals grow when there are urchins. We also know that corals contain algae. These algae need resources to grow. There is other algae in the ocean that also need the resources. The algae in the coral have to compete with the other algae in the ocean for resources, just like the deer in our game had to compete for resources. In the game, deer who couldn’t get their resources died. We know that the urchins eat algae. If the urchins eat the algae in the ocean, the algae in the corals won’t have to compete as much for the resources, so the coral can grow better.</td>
</tr>
</tbody>
</table>

Claim, Evidence, Reasoning Scaffolding Ideas
Note: Students may be familiar with the term “argument” from writing arguments in their ELA classes. In many science lessons and teaching resources, the “reasoning” section is similar to the argument used in ELA. In the claim-evidence-reasoning (often referred to as CER or Cl-Ev-R) model, the reasoning section is where students construct an explanation for how or why the evidence they cited supports their claim. Differentiating between the evidence and reasoning is difficult for students and takes practice. The evidence consists of the data they collected and/or the observations they made, while the reasoning is an explanation of how or why the data supports the claim. In this case, students will be using data collected by Sarah W. Davies and available in the document [http://datanuggets.org/wp-content/uploads/2017/07/Urchin_Student-A.pdf](http://datanuggets.org/wp-content/uploads/2017/07/Urchin_Student-A.pdf) (screen shot is included with the student materials for this lesson). Students may use any of her data or observations as evidence, but
simply listing the numbers from the data table is not enough to support their claim. In the reasoning section, they must describe how the different pieces of evidence can be linked together to support the claim. The first few times students do a CER, they will need some scaffolding. Three different levels of scaffolding are included below, with level III providing the most scaffolding.

**Level I:** Provide students with possible claims and allow them to select the claim they have the most evidence to support. They can then use the evidence they generated to construct their argument. Possible claims:
- Sea urchins help the corals grow
- When there are sea urchins in the system, there will be more corals
- More corals grow in systems with less algae
- Coral growth is affected by the presence of sea urchins

Additionally, sentence stems could be provided to help students write their reasoning. This could be particularly helpful to ELL students.

**Level II:** Provide students with claims and evidences; allow them to determine which pieces of evidence could support each claim. Note that some of the evidences could be used to support multiple claims, and that all the claims could be supported by the evidence that students gathered. Students then select one claim and use the evidence to construct their argument. You could provide these in a list and allow students to draw lines from the evidence to the claim that it supports, or cut them into strips that students can sort. Possible claims/evidence:

<table>
<thead>
<tr>
<th>Claims</th>
<th>Evidences</th>
</tr>
</thead>
<tbody>
<tr>
<td>● Sea urchins help corals grow</td>
<td>● When urchins were present, the average number of corals was 13.75</td>
</tr>
<tr>
<td>● More corals grow in systems with less algae</td>
<td>● When sea urchins were not present, the average number of corals was 5.25</td>
</tr>
<tr>
<td>● Coral growth is affected by the presence of sea urchins</td>
<td>● Sea urchins eat algae</td>
</tr>
<tr>
<td>● When there are sea urchins in the system, there will be more corals</td>
<td>● Corals and algae compete for resources and space</td>
</tr>
<tr>
<td></td>
<td>● The most corals growing in a bin with sea urchins was 25</td>
</tr>
<tr>
<td></td>
<td>● The most corals growing in a bin without sea urchins was 11</td>
</tr>
<tr>
<td></td>
<td>● The fewest number of corals growing in a bin with urchins was 8</td>
</tr>
<tr>
<td></td>
<td>● The fewest number of corals growing in a bin without sea urchins was 1</td>
</tr>
</tbody>
</table>

**Level III:** Provide students with only one claim and a list of evidences (these could be from the examples in the table above). Students determine which of the evidences could be used to support the claim, and then use the evidences they selected to write their reasoning. If additional scaffolding is needed:
- Students could be given the claim and the evidence to support it, and then asked to write their reasoning. In this case, students would be responsible to explain why/how the evidence provided supports the claim given to them.
- Sentence stems could be provided to help students write their reasoning; this may be particularly helpful for ELL students.
Sea Urchins and Corals

Corals were grown in different bins in the ocean, and data was collected. Follow your teacher’s instructions to identify the parts of the graph, interpret what they mean, and write a caption for the graph.
Sea Urchins and Corals

Corals were grown in different bins in the ocean, and data was collected. Follow your teacher’s instructions to identify the parts of the graph, interpret what they mean, and write a caption for the graph.

Won't you be my urchin?
Featured scientist: Sarah W. Davies from University of Texas at Austin

Research Background:

Imagine you are snorkeling on a coral reef where you can see many species living together. Some animals, such as sharks, are predators and eat other animals. Other species, like anemones and the fish that live in them, are mutualists and protect each other from predators. There are also herbivores, such as urchins, that eat plants and algae on the reef. All of these species, and many more, need the coral reef to survive.

Corals are animals that build coral reefs. When you look at a coral you may see what looks like one large rock. In fact, corals are made up of thousands of tiny animals, called polyps. Coral polyps are white but look brown and green because microscopic plants, called zooxanthellae, live inside them. Corals provide the algae a safe home, and in return the algae make food for corals. Sadly, corals around the world are dying. Scientists want to figure out ways to save coral reef ecosystems by helping corals survive so they can continue to build reef habitats.

Corals are picky and only like to live in certain places. Corals compete with other types of algae, like seaweed, for space to grow. Sarah is a marine biologist who is interested in corals because they are such important animals on the reef. She wanted to understand how to help corals. She thought that if there were more herbivores eating algae on the reef then corals would have less competition. Then they would have more space to grow.
Sarah set up an experiment where she put tiles in bins out on the reef. Tiles provided space for animals to grow, including corals. Sarah also put sea urchins in half of the bins. Sea urchins are important herbivores and one of the species that like to eat algae. The other half of the bins had no urchins so the algae would be free to grow there. She had 4 bins with urchins and 4 bins with no urchins. After a few months, Sarah counted how many corals were growing on the tiles. She counted corals found in the bins with and without sea urchins. Because sea urchins eat algae, they should free up space for coral to grow. Sarah expected that more corals would grow on the tiles in sea urchin bins compared to the bins with no sea urchins.

<table>
<thead>
<tr>
<th>Treatment in the bin</th>
<th>Bin #</th>
<th>Number of corals on tile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sea urchins present</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>Sea urchins present</td>
<td>2</td>
<td>12</td>
</tr>
<tr>
<td>Sea urchins present</td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td>Sea urchins present</td>
<td>4</td>
<td>25</td>
</tr>
<tr>
<td>No sea urchins</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>No sea urchins</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>No sea urchins</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>No sea urchins</td>
<td>8</td>
<td>11</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Average number of corals on tile when urchins present</th>
</tr>
</thead>
<tbody>
<tr>
<td>11.5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Average number of corals on tile when there are no sea urchins</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.5</td>
</tr>
</tbody>
</table>
# Urchin and Coral CER

**Question:** How does the presence of urchins affect the coral populations?

<table>
<thead>
<tr>
<th>Claim:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Evidence:</th>
<th>Reasoning:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
I Can Use the Identify and Interpret (I²) Strategy

Have you ever looked at a graph or figure and felt overwhelmed by it? Often there is a lot of information on graphs and in figures. The Identify and Interpret (I²) strategy helps you make sense of graphs, figures, sketches, and other ways to represent data. This strategy helps you break down the information into smaller parts. To do this, you first identify what you see in the graph or figure. Then you interpret each of those observations by deciding what they mean.

Once you have determined what the smaller parts of the graph or figure mean, you are ready to put all the information together. To do this, you write a caption. You have probably seen captions under figures in textbooks or magazines. Captions are a summary of the information in the graph or figure. They are written in complete sentences. Captions help you show your understanding of the material you are studying.

To help you understand how to use the I² strategy, look at the following example. This example will help you make sense of a graph. This graph shows the average monthly temperatures in one US city.

<table>
<thead>
<tr>
<th>I² step</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1: Identify</strong> (“What I see” comments)</td>
<td>a</td>
</tr>
<tr>
<td>▪ Identify any changes, trends, or differences you see in the graph or figure.</td>
<td>What I see: a downward slope between July and December</td>
</tr>
<tr>
<td>▪ Draw arrows and write a “What I see” comment for each arrow.</td>
<td>5</td>
</tr>
<tr>
<td>▪ Be concise in your comments. These should be just what you can observe.</td>
<td>0</td>
</tr>
<tr>
<td>▪ Do not try to explain the meaning at this point.</td>
<td>month</td>
</tr>
</tbody>
</table>

For this example, there are arrows drawn that point to the two trends and the change. Notice that the arrows point to the general upward and downward trends, not to each data point. A “What I see” comment describes what each arrow points to on the graph.
### Example

**Step 2: Interpret**

<table>
<thead>
<tr>
<th>What I see: a peak in July</th>
<th>What it means: the hottest average temperatures in the city happen in July.</th>
</tr>
</thead>
<tbody>
<tr>
<td>The graph shows a peak in July, indicating the hottest average temperatures in the city occur in July.</td>
<td></td>
</tr>
</tbody>
</table>

**Step 3: Caption**

<table>
<thead>
<tr>
<th>What I see: a peak in July</th>
<th>What it means: The hottest average temperatures in the city happen in July.</th>
</tr>
</thead>
<tbody>
<tr>
<td>The graph shows a peak in July, indicating the hottest average temperatures in the city occur in July.</td>
<td></td>
</tr>
</tbody>
</table>

In this example, “What it means” comments were added to each “What I see” comment. The “What it means” comments explain the changes, trends, and differences that were identified in Step 1.
# 6.4.1 Learning Episode 2

## Student Science Performance

<table>
<thead>
<tr>
<th>Topic: Ecosystem Resources</th>
<th>Title: Oh Deer!</th>
</tr>
</thead>
</table>

## Overarching Performance Expectations (Standard):

6.4.1: Analyze data to provide evidence for the effects of resource availability on organisms and populations in an ecosystem. Ask questions to predict how changes in resource availability affects organisms in those ecosystems. Examples could include water, food, and living space in Utah environments.

## Lesson Performance Expectations:

Collect and analyze data to support the claim that availability of food, water and shelter resources affect the growth of individuals and as well as population size.

**CCC:** cause and effect, stability and change

**SEP:** analyze and interpret data, constructing explanations

## Students Will... To Construct Meaning

*Engage with a Phenomenon: Deer populations change size.*


*Reason I:* Analyze the data you collected during the game and construct an explanation about what caused the deer population to change size throughout the game. Start by graphing the population size data that we generated during the game on a piece of graph paper. On your graph, identify when the population was growing and when it was in decline.

On each part of the graph, write a description of what caused the population to change.

## Teacher Will... To Support Students

Clearly explain how to play the *Oh Deer!* game (instructions included in the lesson materials).

Students may need reminders about how to set up the axes on their graphs so that they can graph the data; you may also need to review types of graphs and make sure the students realize they should be making a line graph. As students create their graphs, circulate throughout the room to guide students who are having trouble or who have questions. Although each student needs to create his own graph, you can encourage students to ask their peers for help if they are having trouble. Make the data available by projecting it on the screen (if time and resources permit, provide each student with a copy of the data; having a hard copy next to you makes it easier to complete the graph quickly).

Once students have completed their graphs, model how they should write their descriptions on their graphs. Emphasize that this is an individual activity. Students should write their ideas directly on their graphs. You may want to remind students that they can think of factors that they observed affecting the population during the game, but could also include other factors that could affect a real deer population. As students work on their explanations, circulate throughout the room and use questions to help guide students who may be stuck:

- “How was the deer population changing here? What could have caused the deer population to change that way?”
- “If there was enough food for all the deer, what do you think would happen to their population? What would this look like on the graph?”
**Communicate I:** Share the descriptions you wrote on your graph with your partner.

- As you talk to your partner, show him your graph and point to the descriptions you wrote as you explain your thinking. Watch your partner for signs of confusion. If your partner doesn’t understand your ideas, try explaining it in a different way.
- As you listen to your partner, look at him and at his graph and descriptions. If you are confused about something he says, wait for him to get to a good stopping point and then ask him to explain it again. You may need to ask a specific question so your partner knows what you are confused about. Once you think you understand your partner’s ideas, summarize them in one sentence.

Switch roles so that you both have time to share your ideas. You have two minutes each to share; if you finish early, work together to summarize the similarities and differences in your explanations.

As a class, summarize your ideas about what causes changes in the size of the deer population.

**Reason II:** With your partner, consider the question: “How do the resources affect individual deer?” With your partner, generate an inference that answers the question. Your inference should be supported by evidence.

Display the description of what each partner should be doing during the conversation, and/or model the type of conversation students are expected to have with their partners. Emphasize what active listening looks like and model the types of questions that would be appropriate. If needed for your class, provide sentence stems to help students; examples are included in the lesson materials.

Give the students a time limit (four minutes total); use a timer or signal so that students know when to switch roles and when they should be done.

As students work with their partners, circulate through the room and listen to their ideas. Make note of misconceptions that may need to be addressed and/or ask students questions to help resolve misconceptions.

Facilitate a short class discussion to summarize factors that affect the population size.

Pose the question to students and give them a few minutes to work with their partner to form an inference that can be supported by evidence. You may want to instruct students to record their inference and the evidence in their lab books as well as writing it on a sticky note, so they have their ideas in front of them for the class discussion.

**Management Strategy:** As students are working, circulate through the room with a clipboard, and read over their shoulders and listen to their conversations. Make note of students whose ideas will help drive the class discussion. Consider giving these students a heads-up, so they know that they will be called on to share. You can tell the student when she’ll share (“I’m going to call on you first”), what you want her to share (“I’m going to read your inference and ask you to share evidence to support it”) and why you want her to share (“I want you to share because the way you worded your inference makes your idea very clear”).

Use student inferences to facilitate a class discussion. Be intentional about which students you call on to share to help start the discussion, (see management strategy above), but allow as many students as possible to participate. Consider using the
Communicate II: Write your inference on a sticky note and post it on the board. Be ready to use evidence to support your inference during the class discussion.

Participate in the class discussion to examine how resource availability affects individuals in a population.

With the other students in the class, decide which of the inferences you made about the deer could also be true for the mountain plover population. Are there things that caused a decline in the deer population that could also be causing a decline in the plover population?

Record your ideas from today’s lesson on your summary sheet.

**Discussion Strategy: Repeat, New Idea, Add On**

This discussion strategy allows all students to participate in class discussions, helps them understand that there are different ways to participate in discussion, and encourages students to consider how their comments relate to the comments and ideas shared by others in the discussion.

Before sharing, a student considers if the comment he’ll be sharing is a repeat of someone else’s idea, a new idea, or an add on to someone else’s idea. When a student forgets to do this, wait until he is done sharing, and then ask the class to categorize the student’s comment. Some students who don’t usually participate in discussions can be invited to talk in a relatively safe way by asking, “who can repeat _____’s idea?” or “ _____, could you repeat _____’s idea for us?”

Finally, you can have the students categorize the sticky notes with their inferences. Read each sticky note, and have the class decide if the inference about the deer could also be true for the mountain plovers. Once the class has decided, move the sticky note so that all the inferences the students think also apply to the plovers are together. Let students know that they will be investigating these inferences to determine what factors might be causing the decline in the plovers.

If using a summary chart, allow time to fill it in; inferences from the class discussion can be added to the chart.

---

Repeat, New Idea, Add On Strategy described below. If you need to pose specific questions to steer the discussion, consider the following:

- How do the available resources affect individuals in the population? What evidence can you use to support your idea?
- How does an individual’s ability to grow bigger or live longer affect the rest of the population?
- What resources might be affecting individual birds and the entire grassland bird population?

By the end of the discussion, students should understand that resource availability affects an individual’s ability to grow and reproduce, which in turn affects the population’s ability to grow.
Assessment of Student Learning

This is an introductory activity; assessments of the students’ graphs/explanations should help the teacher identify misconceptions and guide instruction throughout the unit.

Student graphs should be an accurate representation of the change in population size recorded during the game.

Explanation (written on graphs) should show student understanding of when the population was growing, shrinking or staying the same.

Explanation (written on graphs) may show student understanding of cause and effect relationship between availability of resources and population size (when there were more resources available, fewer deer died and the population grew; when there were fewer resources available, more deer died and the population shrank).

Explanation (written on graphs) may show student understanding of cause and effect relationship between speed of the deer and its chance of survival (faster deer were more likely to get to the resource first; slower deer were less likely to make it to the resource before another deer got to it first).

Example graph with explanations:

Examples of inferences:

- The longer a deer lives, the more offspring it has
- The faster a deer is, the longer it will live
- When there are more resources, the deer population grows faster
- When the deer population is smaller, fewer deer die trying to get resources
- When the deer population is larger, more deer can’t get the resources they need

Students should be able to recognize that their inferences could also apply to the bird population.
Oh Deer!

This activity is from http://www.beaconlearningcenter.com/documents/313_01.pdf

During this game, students investigate how population size and resource availability affect each other.

Tell the students that you’ll be playing a game outside and that some of them will be starting out as deer. Before leaving the classroom, explain where the deer will be starting out, including the direction they will facing. You may want to make a map of the area where you’ll be playing on the board to help show the students exactly where they should go if they are assigned to be deer.

Next, ask the students what deer need to survive. Students will come up with many answers, but you’ll just use three of them for this game: shelter, food and water. When a student comes up with one of these answers, teach the whole class the symbol they’ll be using for that resource. Have the students quickly practice making the symbols before you go outside to play the game. For shelter, students use their hands to make a tent over their heads. For water, students pretend they are holding a glass of water by their mouths. For food, students place both hands on their abdomen.

Explain that the students who do not start out as deer will be starting out as these resources. They will line up across from the deer (when students are lined up correctly, it will look like they are ready to play red-­rover, except they won’t be holding hands). Explain that when you yell “get ready” all the students turn so their backs are facing the middle of the field. They all pick a symbol and must keep it the entire round. When you yell “go,” all students turn to face the middle of the field. Students who represent resources must stay where they are; students who represent deer must run to their matching resource (if a deer chose the symbol for water, he needs to run to a student with the water symbol in the resource line). If a deer is the first one to its resource, the deer survives, and the resource now becomes a deer. Both students return to the deer starting line. If a deer doesn’t get to the resource it needs, it dies and becomes part of the resources. The student stays on the resource line for the next round.

Make sure students understand the expectations for the game (as well as walking through the halls, etc.) before leaving the classroom. Also ask for two students who would like to record data (there are often students who do not want to participate in the game; this is a way for them to make a meaningful contribution). Provide these students with a clipboard and data sheet. Explain that they will need to record how many deer there are at the beginning of each round. After a few rounds, the students recording data are often able to get a count of the deer as they walk back to the starting line so you don’t have to wait to take a headcount before starting the next round.

Students should play 10-15 rounds. The data can be projected on the board so that students can start making a graph as soon as they come back in.
Partner Talk

<table>
<thead>
<tr>
<th>Partner A</th>
<th>Partner B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Show your partner your graph.</td>
<td>As your partner explains his graph, look at him and his graph to show that you are listening.</td>
</tr>
<tr>
<td>Point to the descriptions you wrote and the parts of the graph you are referring to as you explain your thinking to your partner.</td>
<td></td>
</tr>
<tr>
<td>“This shows where____________.”</td>
<td>If you are confused about something your partner says, wait for him to get to a good stopping point and then ask him to explain it again.</td>
</tr>
<tr>
<td>“I think the population __________ because____________.”</td>
<td>“Did you mean________?&quot;</td>
</tr>
<tr>
<td>Watch your partner for signs of confusion.</td>
<td>“I didn’t understand what you meant when you said____________.”</td>
</tr>
<tr>
<td>If your partner doesn’t understand one of your ideas, try explaining it in a different way.</td>
<td>Once you think you understand your partner’s ideas, summarize them back to your partner in one sentence.</td>
</tr>
<tr>
<td>When you are finished, your partner will summarize your ideas back to you. Listen to what your partner says, and if it sounds like he misunderstood your idea, clarify what you meant.</td>
<td>“So you’re saying that ______________.”</td>
</tr>
<tr>
<td></td>
<td>“If I understand, you think that ____.”</td>
</tr>
</tbody>
</table>

Once you are done, switch roles. You have four minutes total; listen for the signal so you know when to switch. If you get done early, work together to summarize the similarities and differences in your explanations.
# 6.4.1 Learning Episode 3

## Student Science Performance

<table>
<thead>
<tr>
<th>Topic: Ecosystem Resources</th>
<th>Title: Predators</th>
</tr>
</thead>
</table>

## Overarching Performance Expectations (Standard):

6.4.1: Analyze data to provide evidence for the effects of resource availability on organisms and populations in an ecosystem. Ask questions to predict how changes in resource availability affects organisms in those ecosystems. Examples could include water, food, and living space in Utah environments.

## Lesson Performance Expectations:

Analyze data to gather evidence to support a claim about the effects of the predator populations on the bird population.

- **CCC:** cause and effect; stability and change
- **SEP:** analyzing and interpreting data; arguing from evidence

## Students Will... To Construct Meaning

*Engage with a Phenomenon: The plover population is decreasing.*

*Gather:* Use the food web and the reading to learn about the mountain plover’s predators. In your lab book, write down three predators that could be responsible for causing the plover population to decline.

## Teacher Will... To Support Students

*Note: During the first lesson, students may have predicted that predators were causing the decline in the plover population. This lesson addresses predators. If no or very few students in the class predicted that predators could be causing the decline, you could choose to exclude this lesson and go to LE 3.*

Review the prediction (from the probe in the first lesson or the list of factors that you are keeping posted) that predators could be causing the decline in the plover population. Tell students that today we’ll be investigating this factor. If needed, introduce/review the role of predators to make sure all students understand what a predator is. If students are having a hard time understanding why predators could possibly be causing the decline in the plover population, conduct a thought experiment with them. Ask the students how the deer population (from the Oh Deer! game) would have been affected if during each round, a few students were able to act as predators by chasing and tagging the deer. If any deer were tagged before reaching their resource, they would “die.” Depending on the class, you could have students discuss the possible outcomes, write down what they think would have happened, and/or graph how they think the deer population would have been affected. Before moving on, ensure that students understand how a predator population can affect the prey population.

Distribute the food webs and readings, and allow students a few minutes to identify three of the plover’s predators. Explain that to start out, they will pick just one predator species to think about.
Select ONE of the predator species you listed to focus on. If that species has been causing the decline in the plover population over the past 40 years, how do you think its population has been changing? Write your idea in your lab book. You can use the following sentence stem if needed:
“I think the ______ population is ______ because______.”
Once you have written your idea, create a graph that shows how you think the predator population has changed.

Discuss your idea and your graph with your partner. When it is your turn to share, show your graph and read your sentence. When it is your turn to listen, check to see if your partner’s written prediction and graph match, and tell him if they match or not. For example, if your partner’s sentence says that the predator population stayed the same size but the graph shows that the population got smaller, point this out. If your partner needs help fixing his graph, help him revise his graph to match the sentence he wrote.

For classes/individual students who need some scaffolding to make their predictions, you can provide three options to choose from:
● The predator population could be growing
● The predator population could be getting smaller
● The predator population could be stable
They should select one of these options and explain why that could cause a decline in the predator population.

Before students begin their graphs, you can use the deer population graphs they constructed during the last lesson as a reminder of how to set up the graph, and what the trendline of declining or growing populations looks like. Tell students that the graph should show the trend, but doesn’t need to show the exact number of predators.

Explain and/or model what the conversation between partners should look like. If there are students who need scaffolding, you could prepare a cheat sheet that shows the graphs of increasing, decreasing, and stable populations that students can use to determine if their partner’s graph and sentence match.

After students have a chance revise their graphs, do a quick check in with the whole class to see what students are thinking. If there are students who think that a decreasing predator population could cause a decline in the plover, facilitate a short discussion to allow other students to help explain why an increasing predator population is more likely to cause a decline in the plovers.

Distribute copies of the predator population data (for the fox, snake and hawk populations). There are several options for setting up this piece:
● Give a data set on one predator to each student, allow them time to analyze the data individually and then group them with students who analyzed data on the other species to discuss their findings
● Put students in groups of three and give each group a complete data set to review together; depending on the class, discussion norms may need to be established
● Set it up as a jigsaw
Reason: Analyze the predator data set that you have been given. Determine if the population is changing or stable, and identify evidence to support your idea. Record the pattern or trend of the population size and your inference in your lab book.

Discuss the following questions with your group:
- Are the predators causing the decline in the bird population? What evidence do you have to support your answer?
- How do the patterns in the predator populations compare to the prediction you made at the beginning of the lesson? What inferences can you make from the patterns in the predator populations?

Communicate: Select the claim that you most agree with:
- The predators are causing the decline in the bird population.
- The predators are not causing the decline in the bird population.
Write the claim you agree with, and then construct a written argument using the evidence to support your claim.

Share your ideas during the class discussion.

Record what you are thinking on your summary sheet.

Note that the data for each species is presented in a different way, allowing for differentiation; some students may have an easier time using the graph of the hawks because it is similar to the deer graph that they created, while other students might be better equipped to generate a graph or make inferences from the population data.

After students have had a chance to analyze the data, allow them time to discuss the possible effects of the predators on the plovers.

Display the discussion questions; if needed, assign roles and/or provide sentence stems to help students analyze, interpret and discuss the data. As students work with their groups, circulate through the room and listen to their discussions. Make note of ideas that you may want to have shared with the whole class. If needed, before the communicate portion, facilitate a whole group discussion to make sure that all students have a chance to hear/see strong supporting evidence.

Provide students with the two claims and explain that they should select the one they most agree with. You can have students record the claim and supporting evidence in their lab books or provide a graphic organizer for them to use.

As students work, circulate through the room and read what they are writing.

If needed, facilitate a whole group discussion to allow students to hear each other’s ideas; you may want to encourage students to add to their list of evidences during the discussion as they listen to their peers.

If using a summary chart, allow time for the class to determine what to add to the chart after they have had time to complete their own summary sheets.
Assessment of Student Learning

Students’ graphs, explanations, discussions, and the evidence they use to support their claim should be used as formative assessments.

Students’ prediction graphs can be used to assess their graphing ability as well as their ability to identify patterns/trends related to the population sizes.

The arguments students construct should include evidence; examples of evidence the students cite include:

- The swift foxes are found in fewer places now than they used to be found
- The snake population is not changing
- The raptor populations go up and down

Examples of arguments that students could construct:

- Since the foxes are found in fewer places, their population is likely shrinking. If their population is shrinking, or they are not found in places where the birds still live, they can’t be responsible for killing enough of the birds over a long period of time to cause the population decline.
- If the snake population is staying the same, they are likely not eating more of the birds than they used to be eating, so they wouldn’t be causing the decline in the bird population.
- If the raptor population was having a large effect on the plover population, the plover population should be going up and down instead of just down. When the raptor population goes up, the plover population might go down, but when there are fewer raptors, there should be more plovers.
The diagram below shows some of the species that are part of the mountain plover’s ecosystem. The arrows show what each species eats. For example, badgers eat the prairie dogs.
Mountain plovers live in grasslands areas of the Great Plains in the United States. This is the only place on the whole planet where these birds can be found. Snakes, foxes, coyotes, and even other birds like to eat mountain plovers. Since the mountain plovers build their nests on the ground, these predators can easily hunt their eggs and chicks. Their defense is good camouflage. The adults, chicks and eggs all blend into the ground where the nests are. In fact, these birds blend into their environment so well that they are hard to see and sometimes called “prairie ghosts.” The birds can also get away when they hear prairie dogs sounding an alarm that there are predators in the area.

Mountain Plovers

Mountain plovers live in grasslands areas of the Great Plains in the United States. This is the only place on the whole planet where these birds can be found. Snakes, foxes, coyotes, and even other birds like to eat mountain plovers. Since the mountain plovers build their nests on the ground, these predators can easily hunt their eggs and chicks. Their defense is good camouflage. The adults, chicks and eggs all blend into the ground where the nests are. In fact, these birds blend into their environment so well that they are hard to see and sometimes called “prairie ghosts.” The birds can also get away when they hear prairie dogs sounding an alarm that there are predators in the area.
The swift fox is native to the Great Plains. These foxes are only about as big as a housecat, which is small for a fox. We don’t know exactly how many swift foxes live in the wild, but we do know where they live. How does the area the foxes used to live in compare to the area the foxes currently live in? What inferences can you make from this data? “Extinct” means a species has disappeared from an area where it used to live and can no longer be found there. “Extant” means a species can still be found in the area.

PredatorData
Great Plains Rat Snake

See [http://www.iucnredlist.org/details/63861/0](http://www.iucnredlist.org/details/63861/0) for additional information

Great Plains Rat Snakes eat birds, mammals, reptiles and amphibians. They can bite, but they do not have venom. Although the population size is not known, there are probably more than 100,000 great plains rat snakes. Over the past 10 years, the population has remained about the same. It may be declining, but the decline is thought to be less than 10%.

On the graph below, represent the size of the snake population if it has not changed over the past 10 years. Also represent the population size of the population if it has declined less than 10% over the past 10 years. Remember to label the axes and include a key!

Image source: [https://commons.wikimedia.org/wiki/File:Pantherophis_guttatus_emoryi.jpg](https://commons.wikimedia.org/wiki/File:Pantherophis_guttatus_emoryi.jpg)
Hawks

Red-tailed hawks, Rough-legged hawks and Ferruginous hawks

The graph below shows the total number of three species of hawks migrating through different routes in Colorado, where plovers also live. The data was collected by the Boulder County Nature Association.

![Graph showing the total number of three species of hawks migrating through different routes in Colorado.](http://bcna.org/winrapt7.html)

Image source: http://bcna.org/winrapt7.html

Red-tailed Hawk: [https://www.flickr.com/photos/mikebaird/323660913](https://www.flickr.com/photos/mikebaird/323660913)

Rough-legged Hawk: [https://www.flickr.com/photos/usfwsmtnprairie/2298829524](https://www.flickr.com/photos/usfwsmtnprairie/2298829524)

Ferruginous Hawk: [https://commons.wikimedia.org/wiki/File:Ferruginous_Hawk_Flying.jpg](https://commons.wikimedia.org/wiki/File:Ferruginous_Hawk_Flying.jpg)

Name ____________________________________________
Predator Prediction

What are three predators that could be causing the decline in the plover population?


Pick ONE of the predator species that you listed above. If this species has been causing the decline in the plover population for the past 40 years, how do you think the predator species has been changing? Why would this change cause the plover population to decline?

Make a graph that shows your prediction. Don’t forget to title the graph and label the axes!
As you discuss the predator data with your group, look for patterns in the population sizes. How is each population changing (or not changing)? Then use the patterns to make inferences about how the predator population might be affecting the plover population.

<table>
<thead>
<tr>
<th>How is the predator population changing?</th>
<th>Inference: based on what you know about the predator population, how do you think this population will affect the plovers?</th>
</tr>
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<tbody>
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</table>

My claim: __________________________________________________________

My argument to support the claim (make sure you include evidence in your argument!): __________________________

__________________________________________________________________________________________

__________________________________________________________________________________________

__________________________________________________________________________________________

__________________________________________________________________________________________

__________________________________________________________________________________________
### 6.4.1 Learning Episode 4

**Student Science Performance**

| Topic: Ecosystem Resources | Title: Food and water resources |

#### Overarching Performance Expectations (Standard):
6.4.1: Analyze data to provide evidence for the effects of resource availability on organisms and populations in an ecosystem. Ask questions to predict how changes in resource availability affects organisms in those ecosystems. Examples could include water, food, and living space in Utah environments.

#### Lesson Performance Expectations:
Students will use information from a food web to determine how the amount of precipitation affects different organisms in the system, including the insects that serve as the plover’s food. They will then analyze precipitation data and use their analysis to determine if they think precipitation could be causing the decline in the plover population.

- **CCC:** cause and effect, stability and change, patterns
- **SEP:** Analyzing and interpreting data, constructing explanations

#### Students Will . . . To Construct Meaning

*Engage with a Phenomenon: Plover populations are decreasing*

**Gather:** The plovers live in an area of the United States where there is a lot of grass and other plants or vegetation. The vegetation needs water to grow. In your lab book, write the cause and effect relationship between the amount of water and the plants.

Look at the food web. If the water affected the vegetation in the way you described, how do you think the animals in the system will be affected? Pick two animals from the system, and write a cause and effect relationship among the amount of water, plants, and the animal.

#### Teacher Will . . . To Support Students

Facilitate a short discussion to review what the grasslands look like, and use questions to help students identify the needs of the grass/plants, including water. Point out the factors that are listed on the board (from previous lessons) and tell students that they will be investigating food and water today. (You could also take a minute and review what students learned about predators in the previous lesson.) Emphasize that the grass and plants need water to grow. Ask students to write a cause and effect relationship between the water and grass; they will be writing a few of these statements during this lesson, so you may want to consider writing the first one together as a class. Provide a sentence structure for students to fill in. (“Water causes ______,” or “More water causes ______.”) Make sure that each student has a complete sentence, such as “Water causes the vegetation to grow,” or “More water causes more plants to grow.”

Distribute the food webs that students used during the last lesson. Remind students that more water would result in more vegetation, and ask students to predict how more vegetation would affect the animal species. Tell them to pick two animals, and write cause and effect relationships between the water, vegetation, and the animal. You may want to provide sentence structures and/or do an example with the class:
Reason: How do you think the plovers will be affected if the amount of water changes? In your lab book, describe changes in the water that would cause the plover population to decline. Make sure you support your idea.

Share your sentence with your partner. Identify similarities and differences in your sentences. If your ideas were very different, refer back to the food web and see if you can come to consensus.

- “More water will cause more vegetation, which will cause ________.”
- “Increasing the amount of plants will cause the ________ population to ________ because ________.”

You also have the option to assign which animals students should use, or assign specific animals to different students and then let them share their cause and effect sentences with each other. For this piece, you may want to focus on the animals that eat the grass, particularly for struggling students. As students work, circulate through the room to assess how well they understand the cause and effect relationships among the organisms. If needed, provide a way for students to share their ideas (short small group or whole group discussion).

Ask the students to consider how changing the amount of water in the system will affect the plover population. If students are struggling, facilitate a class discussion about how the birds would be affected by increasing the amount of water before giving them the question. Emphasize that they are predicting how the water would need to change to cause a decline in the plover population. Again, you can provide a sentence stem to help struggling students:
- “_______ the amount of water will cause the plover population to change because ________.”

If some students need further scaffolding, you can provide them with word choices (increasing or decreasing) for the first blank in the sentence.

Pair students and explain/model the expectations for their sentence-share. Model strategies they can use to come to consensus if their answers are different. This is a good time to remind students how to discuss different ideas in a productive way. Suggestions could include:
- Comparing their sentences about the other animals from earlier in the lesson to see if they are the same; if they agree on those animals, they can start exploring why their ideas about the plovers are different.
- Both partners crossing off their answers, and then starting from the beginning by looking at the vegetation on the food web and following the cause and effect relationships up to the plovers.
Once you and your partner agree, look over the precipitation data. Look for patterns in the precipitation. Does the data show that the precipitation changed in a way that would cause the plover population to decline over the last 40 years?

Communicate: With your partner, determine how likely you think it is that precipitation is causing a decline in the plover population. Use this scale:

1 = we think it is not likely at all that precipitation is causing the decline in the plover population
2 = we think that it is probably not likely that precipitation is causing the decline in the plover population
3 = we think that precipitation may or may not be causing the decline in the plover population
4 = we think that precipitation probably is

• Asking each other questions with the goal to understand the other student’s idea:
  ○ “I’m not sure what you meant by _____.”
  ○ “I had a different idea about _____; can you tell me how you came to your conclusion?”
  ○ “I agree with you about _____; Could you explain to me how that relates to _____?”

As students discuss their ideas, circulate through the room, paying attention to partnerships that may be having trouble coming to consensus. If needed, use questions to help guide students in their discussions so that they can better understand each other.

Distribute the precipitation data or instruct students to pick it up once they have come to consensus with their partner. Allow them time to discuss the data and determine if the data supports the claim that water resources are responsible for the decline in the plover population. Depending on the class, you may want to provide a graphic organizer or specific question to help focus and guide their thinking (example guiding questions are included in the lesson materials). If students are having a hard time analyzing the data, help guide them by:

• Suggesting they use the I² strategy (from the coral-urchin lesson) to understand the data better.
• Asking them to compare the data to their prediction; for example, if they predicted a decrease in precipitation would result in fewer plovers, does the graph show declining precipitation?
• Helping them look for averages; for any given area, the yearly amount of precipitation changed, but has the average changed over the past 30 years?

Set up a horizontal axis on the board with numbers 1-5 written across it. Students will be posting sticky notes on the number they choose, creating a visual representation of what the class is thinking about the possibility that precipitation is causing the decline in the plover population.

After students have had a chance to analyze the data,
causing the decline in the plover population

- 5 = we think that precipitation is the main factor causing the decline in the plover population

Once you determine your number, write your explanation for choosing that number on a sticky note. Write your names on the back of the sticky note. Post the note on the corresponding number on the class graph.

Record your ideas on your summary sheet.

tell them they will work with their partner to determine how likely they think it is that water resources are causing the decline in the plover population. Model how where they should write their explanation/names on the sticky note, and where they should post it.

As students post their sticky notes, read through their explanations and make note of things that you can use to facilitate a class discussion:

- Similarities and differences in explanations for the same number
- Stronger and weaker pieces of evidence

Use the completed sticky note graph to facilitate a class discussion. There are several ways you can use the notes to help students share their ideas with the class:

- Ask the students what patterns they see in the graph; did most students select the same number? Were their votes for all the numbers?
- Look through the explanations for any individual number. Read a few to the class. Are all the explanations in the “2” column the same? How are they different?
- Compare the explanation across different numbers. Did students who chose one number have stronger evidence than students who chose other numbers?

Lastly, if the link between water and food have not been made explicit, make sure this happens during this final discussion. Students should understand that the amount of food available to the plovers is indirectly affected by the amount of water available. By the end of this lesson, it should be clear to students that they have been discussing both water and food resources.

If using a summary chart, allow time for the class to complete it. Also use the cards or list of factors to review which factors students have investigated and what they are thinking about those factors.
Assessment of Student Learning:

*Student ability to analyze the precipitation data, construct cause and effect relationships, and construct explanations should be used as formative assessments.*

When identifying cause and effect relationships, students should:

- Understand that the amount of precipitation affects the amount of vegetation (more water causes more vegetation)
- The amount of vegetation affects the amount of insects (more vegetation causes more insects)
- The amount of insects affects the amount of plovers (more insects cause more plovers)
- Students may also recognize that additional factors can affect populations. For example, more insects could also cause a decline in the vegetation, because they are eating it.

When analyzing the precipitation data, students should recognize that the amount of precipitation goes up and down, but there is no significant long-term trend in either direction.

When constructing explanations (on the sticky notes), students should be able to use evidence from the food web and precipitation data to support their idea. For example, a student might recognize that the amount of water has not declined over the past 40 years, and relate this back to the food chain to conclude that the plover’s food has not been in decline over the past 40 years as a result of changes in precipitation.
Four locations in the Great Plains region where the plovers live are shown on the graph above. Scientists measured how much rain fell each month in each of the locations. The graph shows how much rain fell during the month of May in each place.

Look at the data for Bateman, New Mexico. Describe the patterns you see in precipitation from 1981-2017:

Is there an overall trend of decreasing precipitation in Bateman over the past 35 years?

Look at the data for Niwot, Colorado. Use a ruler to draw in a straight line that represents the average. Does this line slope up or down? What does this tell you about how the amount of precipitation has changed in Niwot over the past 35 years?

How does the amount of precipitation affect the plover’s food source?

After analyzing the precipitation data, how do you think the plover’s food source has been affected by the amount of precipitation over the past 35 years?
### 6.4.1 Learning Episode 5

**Student Science Performance**

<table>
<thead>
<tr>
<th>Topic: Ecosystem Resources</th>
<th>Title: Enter . . . the prairie dogs!</th>
</tr>
</thead>
</table>

**Overarching Performance Expectations (Standard):**

6.4.1: Analyze data to provide evidence for the effects of resource availability on organisms and populations in an ecosystem. Ask questions to predict how changes in resource availability affects organisms in those ecosystems. Examples could include water, food, and living space in Utah environments.

**Lesson Performance Expectations:**

Identify cause and effect relationships among the parts of the plover’s ecosystem; use evidence to develop a model that explains how prairie dogs affect the plover population. Use evidence to support a claim regarding how changes in habitat space affect plover populations.

- **CCC:** Cause and effect, stability and change, systems
- **SEP:** Develop and use models; argue from evidence

**Students Will . . . To Construct Meaning**

*Engage with a Phenomenon: Plover populations are decreasing*

-Gather: Meet with your expert group, and prepare to present the information to your expert group. You should be able to summarize the important points for your jigsaw group.

When you are with your jigsaw group, take turns sharing the important points you summarized. When it is your turn to listen to the other members of your group, record the information they give you on your sheet.

**Teacher Will . . . To Support Students**

*Note: When introducing this lesson, make sure to tell students that they will be investigating prairie dogs, which live in the same system as the plovers. It is important for the students to understand that the plovers and prairie dogs live in the same areas.*

- Set up a jigsaw for students to gather information about the nesting behavior of plovers and various prairie dog behaviors (three expert groups). Allow students time to work with their expert groups. Students should discuss the information and determine which pieces of the information are most important. Encourage them to use the pictures as well as the text to find important information. They will be summarizing the most important pieces of information to their jigsaw group. Providing specific questions and/or requiring students to record the information can help students be more prepared when they meet with their jigsaw groups.

- Instruct students to sit with their jigsaw groups; if needed, model how they should share their information and record what they learn from their group members.

- Before students start developing their models, you may want to show one or both of the following videos to give additional information to the groups. These
Reason: With your jigsaw group, create a model that shows how the different parts of the system are related. You can use the information you just learned about prairie dogs and any other information you’ve learned during this unit. Your model should include:

- Vegetation
- Prairie dogs
- Plovers
- Insects
- Predators
- Bison/antelope
- Water

Your model should show how these things are related, including:

- What eats what
- Cause and effect relationships

You will be reviewing another group’s model and providing three pieces of information:

- Keeper: What is something this group did really well? Look for pieces of information that are accurate, and that the group did a nice job communicating. Write the keeper, and why you like it, on a sticky note and stick it to the model.
- Polisher: What is something that needs some revision? Look for information that may not

Management Strategy: As students work on their models, circulate through the class. Listen to what the students are saying, and look at how they are representing information in their model. If you see problems/misconceptions, use questions to better understand what students are thinking and help them clarify their own ideas:

- “What does this symbol represent? Why did you choose that symbol to represent _______?”
- “How will _______ affect _______?”
- “How does _______ relate to _______? How will you represent that relationship in your model?”
- “Have you thought about where/how you will include _______?”
- “What evidence do you have to support _______?”
- “Can you tell me more about what this part means?”

Instruct the students on how they will be giving feedback; one option is to give each group three sticky notes of different colors and assigning one
be complete, evidence that could be strengthened, or something that is not communicated well. Write the polisher, and why it needs revision, on a sticky note and stick it to the model.

- **Question** What is one question that you still have after looking at the model? This could be a question about the information, or about the model itself. Write the question on a sticky note and stick it to the poster.

When you get your model back, look over the feedback the group gave you. What could you do to improve your model?

With your group, discuss the following question: “Would a decline in the prairie dog population cause a decline in the plover population? If so, how or why? If not, why not?” Record any evidence you could use to answer this question.

Management Strategy: If students have not had a lot of practice giving feedback on models, only ask them to do the keeper or the keeper and polisher. Once they’ve had more practice, start introducing more ways (such as asking questions) that students can give feedback on models.

When all groups have their models, tell them to look over the feedback they received. If needed, facilitate a short class discussion to review some of the important relationships in the system.

Pose the question to the students, and explain that they will be working with their groups to record evidence they can use to answer the question. Depending on the class, you may want to provide a graphic organizer to help them record what they talk about. One choice would be to create a T chart with the question at the top, and the columns labeled “yes” and “no.” In each column, students can write evidence to support each answer. Providing each student (instead of each group) with a graphic organizer to fill out will increase accountability and allow each student to have a copy of her own notes to use for the assessment.

Management Strategy: As students discuss the question, circulate through the room with a clipboard and make note of student ideas that will be useful in facilitating a class discussion. The class discussion should help students explore the different ways the plovers could be affected by the decline in the prairie dog population (or not affected), and should allow students the opportunity to engage in arguing from evidence. When you hear a student communicate an idea that you would like...
Fill in your summary sheet.

Communicate: Revisit the probe from the beginning of class. Which friend’s idea do you most agree with now? Look over your initial response, and explain how your thinking has changed.

Individually, examine the prairie dog population data. You will be using the data, along with other data and information collected during this unit, to support or refute the following claim:

Loss of habitat space is causing the decline in the plover population

1. List all the evidence that you have to support the claim.

Facilitate a class discussion to allow students to discuss some of their ideas (see management strategy above). During the discussion, make sure students have a chance to talk/hear about how the space plovers need for their nests is affected by the prairie dogs. It may be useful to draw an analogy with the corals and urchins from the first lesson (the urchins make space for the corals to grow; the prairie dogs make space/habitat for the plovers to build nests). Allow students a few minutes to fill out their summary sheets for this lesson, and if using a class summary chart, complete it as well.

to come out during the discussion, you may want to consider giving the student a heads-up that you will be calling on her to share a particular idea so she is prepared. Some ideas to listen for as students are discussing with their groups:

- Prairie dogs trim the vegetation, creating more desirable space for plovers to make nests; a decline in the prairie dog population could cause there to be less space for plover nests. A decline in the prairie dog population could cause a decline in the plover population.
- Prairie dogs warn each other when a predator is near; the prairie dogs are eaten by the same predators as the plovers. Prairie dog alarms could also help the plovers avoid predators. Declines in the prairie dog population could cause a decline in the plover population, because they are not so easily warned about predators.
- Prairie dogs don’t eat the same food as the plovers or live in the same space. The prairie dogs are not competing with the plovers for resources, so they are not causing the decline in the population. A decline in the prairie dog population would not affect the plover population.
- Prairie dogs don’t prey on the plovers, and they are not eaten by the plovers. A decline in the prairie dog population would not affect the plover population.
2. List all the evidence that you have to refute the claim.
3. Look over your evidence. Which side has stronger evidence to support it? Write down if the claim should be supported or refuted.
4. Use the evidence to explain your reasoning for supporting or refuting the claim.

Review the resources from the list you have been keeping during the unit, and use them as a final review of what students have learned.

Give students the assessment probe they completed at the beginning of the unit and allow them time to think about how and why their thinking has changed. Take time to collect class data (whose idea do they agree with now?) and compare it with their initial responses? Allow students to share how and why their ideas have changed. Emphasize that even though they may still agree with the same idea, their reasons for agreeing may have changed.

Final assessment: provide the prairie dog population information to the students, along with the claim. Instruct students to:
- List evidence to support and evidence to refute the claim
- Use the evidence listed to determine if they support the claim or not
- Use the evidence to explain their reasoning for supporting the claim or not
- This is the final assessment and should be done individually.

Using a graphic organizer can help students know how/where to record their evidences/reasoning, and can make it easier for you to quickly read and assess their ideas. Distribute graphic organizers or show how you would like students to record the information in their lab books. Depending on the class, you may want to review what information to record in each section of the organizer.

Additional scaffolding may be needed for some students; for example, you may provide evidence statements to some students and have them sort the evidences into supporting or refuting categories before explaining their reasoning. You could also provide evidence to support the claim, and then ask a student to explain why the evidence supports the claim.

**Assessment of Student Learning:**

Student participation in discussions with their expert and jigsaw groups, as well as the models and their ability to argue from evidence should be used as formative assessments. Students should not be asked to do the final assessment until they have shown on the formative assessments that they understand the cause and effect relationships in the system. They should have also demonstrated that they can identify evidence and use it to support (or refute) a claim.
Rubric for final assessment:

| Surpasses proficiency | ● At least three relevant evidences to support the claim are included  
|                       | ● At least two relevant evidences to refute the claim are included  
|                       | In addition to meeting the requirements for proficiency, student reasoning may include:  
|                       | ● Explanation of why the opposing evidence is not as strong (if they said that the supporting evidence was stronger, they included reasons that the refuting evidence was not as strong)  
|                       | ● Explanation includes relationships, predictions beyond what was discussed in class  
|                       | ● Recognition that more than one factor could be causing the decline in the population  
| Proficient            | ● At least three relevant evidences to support the claim are included  
|                       | ● At least two relevant evidences to refute the claim are included  
|                       | Student reasoning:  
|                       | ● Includes relevant evidence  
|                       | ● Includes explanation of how/why the evidence supports or refutes the claim  
|                       | ● At least two lines of evidence are used to support or refute the claim  
| Approaching proficiency | All requirements to meet proficiency are included (for example, the student included three relevant evidences to support the claim); however, some information may be incomplete or incorrect.  
| Below proficiency      | Requirements to meet proficiency are not included.  

Example of final assessment:

<table>
<thead>
<tr>
<th>Claim: Loss of habitat is causing the decline in the mountain plover population</th>
<th>Evidence that supports the claim</th>
<th>Evidence that refutes the claim</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evidence that supports the claim</td>
<td>Predator populations are not increasing</td>
<td>Prairie dogs eat plants, not plovers</td>
</tr>
<tr>
<td>Predator populations are not increasing</td>
<td>Prairie dogs help make space for plovers to live</td>
<td>Plovers don’t eat prairie dogs</td>
</tr>
<tr>
<td>Prairie dogs help make space for plovers to live</td>
<td>Average precipitation has not changed</td>
<td>Lady bird beetles eat the same food as plovers</td>
</tr>
<tr>
<td>Average precipitation has not changed</td>
<td>Plovers build their nests where there are not many plants</td>
<td></td>
</tr>
</tbody>
</table>

Which side has stronger evidence? Supporting evidence

Explain your reasoning for supporting or refuting the claim:
Mountain plovers have many predators, but the predator populations are not increasing.
Since the predator populations are mostly stable or declining, it is unlikely that predators are eating more and more of the plovers and causing their populations to get smaller. We know that the prairie dog populations are also decreasing, but they are not a food source for the plovers. If they were, the decline in the prairie dog populations might cause a decline in the plovers. Even though the prairie dogs aren’t food for the plovers, they do help them. The prairie dogs keep the grass short, and plovers like to build their nests where there are not as many plants. If there are fewer prairie dogs to trim the grass, there will be less space for plovers to build their nests. If plovers build their nests in more vegetation, they will not blend in as well and it could be easier for their predators to see them. This could cause more plovers to be eaten and their population could decline. The prairie dogs create living space for the plovers, so a decline in the prairie dog population will affect how much living space the birds have. Less living space will cause the bird population to decline.
Expert Group: Plover Nesting Behavior

Mountain plovers build their nests on the ground. They like to build their nests in areas where there is little to no vegetation. The adult birds, chicks and eggs blend in with short, dried vegetation and dirt better than with green plants. It might also be easier for them to spot insects to eat on the dirt than when there are a lot of plants around.

Image source: https://commons.wikimedia.org/wiki/File:Birds_that_hunt_and_are_hunted_(1905)_(14727209126).jpg

Image source: https://abcbirds.org/bird/mountain-plover/ (image from the Rocky Mountain Bird Observatory)

Image source: http://www.waderquest.org/2014/08/guest-blog-mountain-plover-nest.html (image from the Rocky Mountain Bird Observatory)
Prairie Dogs live in family groups. They make many changes in their habitat. One way they change their environment is by digging tunnels. The tunnels they dig provide a place for them to live. They can also hide from predators by going into the tunnels. When prairie dogs see a predator in the area, they will use an alarm call to warn other prairie dogs. If a prairie dog begins to sound an alarm, the other prairie dogs will hide in the tunnels. Other animals, like the mountain plovers, can also hear the alarm calls. This may help them avoid the predators also.

Image source: https://commons.wikimedia.org/wiki/File:Pr%C3%A4riehund_P1010308.JPG

Prairie Dog Tunnel System

Prairie dogs keep the vegetation around their homes trimmed short. They cut the grasses to eat them. Keeping the vegetation short also makes it easier to see long distances. When the prairie dogs can see longer distances, it is easier for them to spot predators approaching from far away. When the prairie dogs cut the grasses, other plants have more room to grow. These other plants attract bison and antelope, who like to eat them.
Prairie Dogs and Mountain Plovers

Work with your expert groups to identify the most important information from the words and pictures on your topic. Record the most important information in the correct box below.

<table>
<thead>
<tr>
<th>Mountain Plover Nesting Behavior</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prairie Dogs and Tunnels</td>
</tr>
<tr>
<td>Prairie Dogs and Vegetation</td>
</tr>
</tbody>
</table>
Would a decline in the prairie dog population cause a decline in the plover population? If so, how or why will the plover population change? If not, why won’t the plover population change?

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The area covered by prairie dog towns has decreased by about 98% since the 1850’s. Farming is one of the reasons that the prairie dog towns are more scarce now than they used to be.

The Great Plains region is flat and the soil is good for growing plants. This makes it good for prairie dogs, but it also makes it good for farms. People have plowed some of the land in the Great Plains to grow crops. Prairie dogs can no longer live in these areas.

Prairie dogs are also affected by a bacteria that causes them to get sick. This bacteria causes prairie dogs to get sylvatic plague. Prairie dogs who get sylvatic plague usually die, and this disease can spread quickly through a prairie dog population, causing most of the animals to die.

Claim: Loss of habitat space is causing the decline in the plover population.

<table>
<thead>
<tr>
<th>Evidence that could be used to support the claim</th>
<th>Evidence that could be used to refute the claim</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Which side has stronger evidence? Do you think the claim should be supported or refuted? ________________

Use the evidence to explain your reasoning for supporting or refuting the claim. Use the back of this paper to continue your explanation.
Explanation continued:
As we investigate the decline in the plover population, you will be recording your ideas here. This will help you keep all the important information you’ve learned summarized in one place and help you see how your ideas about the bird’s population are changing.

<table>
<thead>
<tr>
<th>Activity</th>
<th>What do I know?</th>
<th>How do I know it?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corals and urchins</td>
<td>When there are more urchins around, there are usually more corals. The urchins eat the algae in the water.</td>
<td>I learned that there are more corals with the algae from analyzing the data. I learned the urchins eat algae from the reading.</td>
</tr>
<tr>
<td>Oh Deer!</td>
<td>If the deer got to its resource first, it lived, but if not, it died. Deer need food, water and shelter to survive. When there were a lot of deer, most of them died.</td>
<td>I know all of this from the game! If you didn’t get to the resource fast enough, you would die. The resources we had to get were food, water and shelter. During one round, almost everyone in the class was a deer, but then they all died at the end of the round.</td>
</tr>
<tr>
<td>Predators</td>
<td>Foxes, badgers and hawks eat mountain plovers. The fox population is shrinking and the snake and hawk populations are stable.</td>
<td>I know that those things eat plovers from looking at the food web. I know that their populations are shrinking or staying the same from the data we looked at.</td>
</tr>
<tr>
<td>Precipitation</td>
<td>More water helps grow more plants; more plants help the insects. Plovers eat insects.</td>
<td>I already knew that more water helps plants to grow. I know that more plants can help insects and that plovers eat insects from the food web.</td>
</tr>
<tr>
<td>Prairie dogs</td>
<td>Prairie dogs get rid of the plants. Prairie dogs alarm everyone when a predator is coming. Plovers like to build their nests on the dirt.</td>
<td>I know this from reading about it and from my group.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Activity</th>
<th>What do I think?</th>
<th>Why do I think this?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corals and urchins</td>
<td>I think the urchins are eating the algae, so the coral can get more stuff to grow. The corals have algae in them too, so if there is no other algae, the corals can</td>
<td>I think this because when the urchins are there, the corals grow more.</td>
</tr>
<tr>
<td>Category</td>
<td>Explanation</td>
<td>Notes</td>
</tr>
<tr>
<td>----------------</td>
<td>-----------------------------------------------------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Oh Deer!</td>
<td>I think that the deer that are the fastest will always survive because they can get to the resource first. I think that deer who get more resources or live longer can get bigger.</td>
<td>I think this because when there was someone faster than me, they would get to the resources first and I would die. I think that deer who live longer can get bigger, because if they didn’t die and kept eating, they would gain weight.</td>
</tr>
<tr>
<td>Predators</td>
<td>I think that maybe a new predator has moved in and is eating the plovers.</td>
<td>The places where the fox live are getting smaller, so maybe there is room for another species to live, like how there is more room for the corals when the algae is gone. The new species could be eating the plovers.</td>
</tr>
<tr>
<td>Precipitation</td>
<td>I think that water and food are not causing the decline.</td>
<td>The amount of water hasn’t changed very much. If the amount of water had really gone down, there could be less grass and that would make it so there weren’t as many bugs for the plovers to eat.</td>
</tr>
<tr>
<td>Prairie dogs</td>
<td>I think that the plovers need the prairie dogs to live. I think that if the prairie dog population gets smaller, the plovers will die too.</td>
<td>The prairie dogs help make space or shelter for the plovers. Even though the prairie dogs don’t make the plover’s nests for them, they make a space for them to build a nest by eating the plants. They also warn the plovers if there is a predator.</td>
</tr>
</tbody>
</table>
**Strands: 6.4.3 and 6.4.4**

**Emphasis:** In 1850, there were 13 species of fish in Utah Lake. Now there are four species of fish.

**Standard 6.4.3** Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem. Emphasize food webs and the role of producers, consumers, and decomposers in various ecosystems.

**Standard 6.4.4** Construct an argument supported by evidence that the stability of populations is affected by changes to an ecosystem. Emphasize how changes to living and nonliving components in an ecosystem affect populations in that ecosystem.

**Anticipated Time Required:**
LE 1 - One to two 50 minute class periods  
LE 2 - Two to three 50 minute class periods  
LE 3 - Two to three 50 minute class periods  
LE 4 - Three to four 50 minute class periods  
Optional Extension - Twelve to fifteen 50 minute class periods

**Dominant CCC:** Stability and Change  
**Dominant SEP:** Developing and Using Models

**Management Strategies to support equitable access to content:**
- Build an inclusive and fair classroom community that encourages and respects diverse thinking and discussion by keeping close proximity and listening to student conversations. Emphasize the everyone’s contributions by paying attention to students’ ideas that you can highlight in front of the whole class.
- Encourage students to take risks, and embrace mistakes as learning opportunities by making it the norm that students’ ask questions and challenge each other’s ideas and viewpoints in a respectful manner.
- Give students time to think about and discuss ideas, predictions, findings, etc.
- Actively manage participation levels of students.

**Shopping list:**
- 8.5 X 11 white or colored paper  
- Sticky/Post-it notes  
- Black markers  
- Highlighters (optional)  
- Colored pencils (optional)

**Additional materials for the optional extension:**
- Clear 2 liter soda bottle for each student or group  
- Pea gravel  
- Activated charcoal  
- Plants or seeds  
- Sphagnum moss (optional)  
- Rich topsoil (not potting soil)
6.4.3 and 6.4.4 Ecosystem Interactions Storyline Overview

Anchor Phenomenon: In 1850, there were 13 species of fish in Utah lake. Now there are four species of fish.

Student Performance Expectation:

**6.4.3:** Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem. Emphasize food webs and the role of producers, consumers, and decomposers in various ecosystems.

**6.4.4:** Construct an argument supported by evidence that the stability of populations is affected by changes to an ecosystem. Emphasize how changes to living and nonliving components in an ecosystem affect populations in that ecosystem.


<table>
<thead>
<tr>
<th>Dominant DCI</th>
<th>Dominant CCC</th>
<th>Dominant SEP</th>
</tr>
</thead>
<tbody>
<tr>
<td>LS2.B: Cycle of Matter and Energy Transfer in Ecosystems</td>
<td>Cause and effect</td>
<td>Developing and using models</td>
</tr>
<tr>
<td>● Food webs are models that demonstrate how matter and energy is transferred between producers, consumers and decomposers as the three groups interact within an ecosystem.</td>
<td>Matter and energy</td>
<td>Arguing from evidence</td>
</tr>
<tr>
<td>LS2.C: Ecosystem Dynamics, Functioning and Resilience</td>
<td>Systems and system models</td>
<td></td>
</tr>
<tr>
<td>● Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations</td>
<td>Stability and change</td>
<td></td>
</tr>
</tbody>
</table>

Science Experiences

<table>
<thead>
<tr>
<th>CCC/SEP</th>
<th>What are students doing? (This should match your SEP!)</th>
<th>What specific understandings should students get from this experience? (What pieces of the performance expectation does the experience provide?)</th>
<th>New questions students have to propel us to the next science experience</th>
<th>Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1: Introduction to fish populations in Utah Lake</td>
<td>Gather: Students use data to gather information about the fish populations in Utah Lake.</td>
<td>Some species of fish (including trout) have decreased to the point of extinction, while the populations of other species have increased.</td>
<td>Why would some populations shrink and others grow? What is causing these changes?</td>
<td>Formative: Student questions and predictions should be used to plan for instruction throughout the rest of the unit.</td>
</tr>
<tr>
<td>CCC: Patterns</td>
<td>Reason: Students generate questions to investigate and categorize the questions.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SEP: Analyzing and interpreting data</td>
<td>Communicate: Students predict the causes of the population changes they observed.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2: Food webs</td>
<td>Gather: Students learn about the different parts of a food web.</td>
<td>Producers can use energy from the sun, consumers must eat another organism to obtain energy, decomposers get energy from eating dead/decaying matter.</td>
<td>How are populations of the producers in Utah Lake changing? How are populations of the trout and carp’s predators changing?</td>
<td>Formative: Students ability to identify parts of a food web and generate possible investigation questions should be used to assess their understanding of how the components of the system interact with each other.</td>
</tr>
<tr>
<td>---</td>
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<td>---</td>
</tr>
<tr>
<td>CCC: Cause and effect</td>
<td><strong>Reason:</strong> Starting with a familiar food web, students determine the role of each organism and then do the same for less familiar food webs.</td>
<td><strong>Communicate:</strong> Students generate additional investigation questions using the food web terms they have learned.</td>
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<tr>
<td>SEP: Developing and using models</td>
<td><strong>Gather:</strong> Students learn about the different parts of a food web.</td>
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</tr>
<tr>
<td>3: What do the arrows mean?</td>
<td><strong>Gather:</strong> Students use food web models to identify factors that all food webs have in common.</td>
<td>Energy flows through all food webs, and the energy flow is represented by arrows. Arrows should point from the sun to the plants to the herbivores, etc.</td>
<td>Did the energy flow in the Utah Lake ecosystem change? Is there not enough energy for the trout?</td>
<td>Formative: Students should be able to identify parts of the food web model that represent energy and matter.</td>
</tr>
<tr>
<td>CCC: Energy and matter</td>
<td><strong>Reason:</strong> Students predict what the arrows in a food web represent.</td>
<td><strong>Communicate:</strong> Students share and justify their predictions.</td>
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<td><strong>Formative:</strong> Students should be able to identify parts of the food web model that represent energy and matter.</td>
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<tr>
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<td><strong>Formative:</strong> Students should be able to identify parts of the food web model that represent energy and matter.</td>
</tr>
<tr>
<td>4: Take my advice</td>
<td><strong>Gather:</strong> Students analyze population data for trout, carp and humans and read information about human impacts on Utah Lake.</td>
<td>Several factors, including overfishing and invasive species, have played a role in the decline of the trout population. Human choices (to fish, to introduce carp) are responsible for the changes to the ecosystem.</td>
<td>Why did people make those choices? What would have happened if we hadn’t introduced carp or overfished the trout?</td>
<td><strong>Formative:</strong> Initial student explanations should be used to assess their understanding of the changes in the ecosystem before they complete the summative assessment. <strong>Summative:</strong> Evidence should be used to support written explanation of how and why the ecosystem changed.</td>
</tr>
<tr>
<td>CCC: Cause and effect; stability and change</td>
<td><strong>Reason:</strong> Students construct explanations, supported by evidence, for the decline in the trout population in Utah Lake.</td>
<td><strong>Communicate:</strong> Students share their explanations with each other and make revisions, then use their revised ideas to construct a final written explanation.</td>
<td>Why did people make those choices? What would have happened if we hadn’t introduced carp or overfished the trout?</td>
<td><strong>Formative:</strong> Initial student explanations should be used to assess their understanding of the changes in the ecosystem before they complete the summative assessment. <strong>Summative:</strong> Evidence should be used to support written explanation of how and why the ecosystem changed.</td>
</tr>
<tr>
<td>SEP: Analyzing and interpreting data; argue from evidence</td>
<td><strong>Communicate:</strong> Students share their explanations with each other and make revisions, then use their revised ideas to construct a final written explanation.</td>
<td>Why did people make those choices? What would have happened if we hadn’t introduced carp or overfished the trout?</td>
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</tr>
</tbody>
</table>
### Student Science Performance

<table>
<thead>
<tr>
<th>Topic: Interactions Between Organisms and Environment in an Ecosystem</th>
<th>Title: Introduction to fish populations in Utah Lake</th>
</tr>
</thead>
</table>

### Overarching Performance Expectations (Standard):

6.4.3: Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem. Emphasize food webs and the role of producers, consumers, and decomposers in various ecosystems.

6.4.4: Construct an argument supported by evidence that the stability of populations is affected by changes to an ecosystem. Emphasize how changes to living and nonliving components in an ecosystem affect populations in that ecosystem.

### Lesson Performance Expectations:

Students will analyze data to identify patterns in the population sizes of native and introduced fish in Utah lake, and generate questions about the causes of the changes in population size.

**CCC:** Patterns

**SEP:** Analyzing and interpreting data

### Students Will... To Construct Meaning

*Engage with a phenomenon:* In 1850, there were 13 species of fish in Utah lake. Now there are four species of fish.

**Gather:**

Student prompt:

Use the fish population data to identify at least two patterns.

Write at least three questions that could help us investigate what caused these patterns (one question per sticky note).

**Reason:**

Student prompt:

Listen to questions that are similar to yours, and hold your question up when you hear a similar question. Be prepared to describe similarities and differences in your questions.

### Teacher Will... To Support Students

Teacher gives students initial Native/Carp data table. Instruct students to keep the data table for future reference. Students work with partners or small groups to look for patterns and formulate questions.

Provide sticky notes for student questions.

**Management Strategy:** Walk around the room and listen to student conversations, paying attention to students’ ideas that you can highlight in front of the whole class. Prepare students ahead of time that you would like them to share their questions.

Sort the students’ questions into categories. Possible strategies you could use:

- Model sorting the questions by asking the students to post their sticky notes on the board. As you sort them into groups, narrate the thinking that motivates your decisions.
- While partners/groups still have their questions in front of them, have one group read their question to the class and then ask, “Who else wrote a similar question?” Ask students to group the similar questions together on the board.

**Categories of questions may include:**

- Questions about what the fish eat
- Questions about other animals in the lake
Communicate:
Student prompt:
Predict the cause of the change in the fish population that you explored. Record your prediction in your lab book.

Consider facilitating a short small group or whole group discussion to allow students to share their predictions.

Assessment of Student Learning
Formative: Students’ predictions and questions are the basis for assessment. At this point, student responses should not be graded, but should be used to assess their prior knowledge of ecosystem interactions and identify misconceptions that may need to be addressed in future lessons.

Students can begin to construct an explanation that predicts patterns of interactions among organisms in an ecosystem. Students who got it will see patterns and make predictions that are based on the data in the table. Students whose patterns and predictions do not need scaffolding to get them on track.

Student questions and predictions can be used to assess their prior knowledge of ecosystem interactions and identify misconceptions that may need to be addressed in future lessons. For example, student questions/predictions may indicate that the student understands that the fish’s food source, as well as the fish’s predators, or temperature of the water could be causing a change in the fish’s population size.

- Questions about temperature or weather Throughout the following lessons, refer back to these questions. When a lesson addresses a group of questions, make it clear to the class that they will be working to answer their own questions.
### Overarching Performance Expectations (Standard):

6.4.3: Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem. Emphasize food webs and the role of producers, consumers, and decomposers in various ecosystems.

6.4.4: Construct an argument supported by evidence that the stability of populations is affected by changes to an ecosystem. Emphasize how changes to living and nonliving components in an ecosystem affect populations in that ecosystem.

### Lesson Performance Expectations:

Identify patterns to develop a model that identifies key food web roles and explains that there are consistent interactions among organisms in an food web.

- **CCC:** Cause and effect
- **SEP:** Developing and Using Models

### Students Will... To Construct Meaning

*Engage with a phenomenon: Models of food webs all include arrows.*

**Gather:**
As we discuss the parts of a food web, record the part, its role in the food web, and an example.

**Student prompt:**
Use the vocabulary we’ve just learned to label the plover food web from earlier in the year.

**Reason:**
Using the two aquatic ecosystem models as examples, label your freshwater ecosystem. Then circle one food chain within the freshwater ecosystem.

### Teacher Will... To Support Students

Direct instruction: Teach students basic food web vocab (producer, consumer, decomposer, predator/predation, food web, food chain). Consider providing a graphic organizer where they can organize the parts of the food web with definitions and examples that will be useful to them later.

Allow students time to determine the roles of the organisms in the plover food web. As students work, walk around the room and look for places where they are struggling. If needed, facilitate a short discussion to make sure the students have correct answers on their plover food webs.

Give students a food web and written description of two ecosystems: an estuary and oceanic ecosystem.

Students will also need a blank freshwater food chain diagram with description to label; distribute now or allow students to pick it up after they have completed the estuary and oceanic food webs. Note that the freshwater ecosystem reading contains a lot of information. Scaffolding may be needed for struggling readers and ELL students.

Instruct students on how you would like them to label the parts.
Communicate:

On sticky notes, write down 3 more questions about the original fish data sheet using the vocabulary words producer and consumer.

of the estuary and oceanic food webs. When they finish, they should have labeled all organisms with their role (for example, the seal is a consumer). Options for facilitating this activity may depend on how well students are prepared to complete the task on their own:

- I do, we do, you do: Select either the estuary or oceanic food web to demonstrate how to determine the role of each organism, work as a class to complete the other one together, and then let students do the fresh water web individually
- Partners: Allow students to work in partners to complete the estuary and oceanic webs before completing the fresh water web individually
- Hint cards: Work through the estuary or oceanic web as a class, and then ask students to do the other on their own, with the option to check “hint cards” which you have set up around the room. If a student gets stuck, he can go to where a hint card is, silently read it to himself, and then return to the web. Examples of hints:
  - Plankton get energy from the sun
  - Worms eat dead animals
  - Crabs cannot use energy from the sun
  - There are ___ decomposers in the food web

Students then complete the fresh water web individually with no hints. This strategy can be useful because students can use the hints instead of interrupting as you work with students who need more direct instruction

- Level up/fast finishers: ask students who need an extra challenge to identify the herbivores, carnivores and omnivores in the food webs, or to add in arrows that are missing from the estuary and oceanic food web diagrams (for example, there are no arrows going to the decomposers in the oceanic food web; students should recognize that the decomposers can eat any of the organisms in the web)

When students finish, ask them to circle one food chain within the food web. Observe their work; if needed, facilitate a short class discussion to make sure everyone recognizes that several intertwined food chains make a food web.

Instruct the students on how you would like them to develop their new questions (individually or in partners). Allow students to determine where their new questions should be categorized on the board; the class may determine that a new category or two are needed. If students have answered any questions, any time you revisit the question board, you can ask students to offer answers they’ve encountered.
Assessment of Student Learning
A properly-labeled aquatic food web is important for this lesson - note students’ answers to formatively assess understanding of food web relationships. Asking questions about why a student labeled the food web the way she did can also be used as an assessment of student understanding. Circle one food chain in their food web and use the words producer and consumer to explain why their food chain is a food chain, and not a food web.

Example of labeled food web (note that the student may not have every arrow represented in the reading, but should be able to trace a few different pathways from the heron or fish back to the sun). The food chain circled in this example is: sun → algae → mayfly → frog → heron.
Estuary Food Webs

An estuary is a place where a river meets the ocean. The river contains fresh water, meaning that it is not salty. The water in the ocean is salty. Sometimes the water in the estuary is more salty from the ocean water, and sometimes there is more fresh water from the river. The organisms that live in the estuary must be able to survive in different types of water. In an estuary, there are worms and shrimp that eat decaying matter in the water. The shrimp also eat plankton. Small insects, called stonefly larva, eat plants growing around the water.

Estuary food web url -
https://www.google.com/url?sa=i&rct=j&q=&esrc=s&source=images&cd=&cad=rja&uact=8&ved=0ahUKEwi bwub_947VAhUQ3GjKHQ5MCecQiwIwIBw&url
Oceanic Food Web

All of the organisms in an oceanic food web must be able to survive in the salty water that is in the ocean. If an animal dies without being eaten by something else, it will sink to the ocean floor and be eaten by decomposers.

Oceanic food web url:
Plants and algae that live in fresh water get energy from the sun. Some animals that live in the water, like shrimp, will eat decaying matter. Other animals in or near the water, like the trout and frogs, eat insects and shrimp. The carp can eat insects and shrimp too, but it mostly eats plants and algae growing in the water. Herons and other birds may not live in the water, but they can catch and eat many of the animals living in the water, including frogs and fish. Mayflies and dragonflies are both insects that change in appearance as they grow. Young mayflies eat algae. When the mayflies turn into adults, they live for such a short time that they don’t eat anything at all. In fact, as adults, they don’t even have a functional mouth! When dragonflies are young, they are called nymphs. Both the nymphs and the adult dragonflies eat other insects. The nymphs live in the water and will eat any insects or small animals they can catch. Sometimes they even eat small fish! The adults can eat mosquitoes, butterflies, or even smaller dragonflies.
### Overarching Performance Expectations (Standard):

6.4.3: Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem. Emphasize food webs and the role of producers, consumers, and decomposers in various ecosystems.

6.4.4: Construct an argument supported by evidence that the stability of populations is affected by changes to an ecosystem. Emphasize how changes to living and nonliving components in an ecosystem affect populations in that ecosystem.

### Lesson Performance Expectations:

Individually, students will use models to construct sound predictions concerning energy and matter. Predictions will be refined through effective communication with others. A separate model will be developed with the evidence based findings.

- **CCC:** Energy and matter
- **SEP:** Developing and using models

### Students Will . . . To Construct Meaning

*Engage with a phenomenon: All food chains/webs contain arrows.*

**Gather:**
What do all the food webs we looked at during the last lesson have in common?

Ask students, “What do the arrows in a food web mean?”

**Reason:**
Predict what the arrows in a food web mean and be prepared to explain your reasons for your prediction. Record your prediction and your reasoning in your lab book.

**Communicate:**
Share your prediction and reasoning during the Inside-Outside Circle activity. You can revise your prediction after listening to your peers’ ideas, but make sure you also revise your reasoning.

With your group, discuss your predictions and reasoning. Formulate your final conclusions about what the arrows represent.

### Teacher Will . . . To Support Students

To introduce the idea of arrows, ask students to pull out the four food webs they used during the last lesson, and determine what they have in common. Students should recognize that all the food webs contain arrows and the sun.

When students say the arrows show “what eats what,” ask them if that definition works for the arrow that goes from the sun to the vegetation.

Allow students time to record their prediction. Encourage them to look at their food webs and use the information in the food webs and text to support their predictions.

**Inside-Outside Circle Strategy:** Students make an inside and outside circle so they can pair up and share their predictions.

Use small group discussions/whole group discussion to tease out concept that arrows represent energy. Some groups will need some scaffolding to come to the correct
Using the freshwater food web sheet from the previous learning episode, students circle matter, label arrows as energy, and be prepared explain the difference between the two.

In your science notebook, make a table and write down two producers and two consumers from each food web.

Assessment of Student Learning
Use students’ initial predictions about what the arrows represent to formatively assess their understanding and to help determine how much time needs to be spent learning about/discussing energy flow through the ecosystem. Common misconceptions include: “the arrows represent what eats what” or “the arrows show that ____ eats ____.” Students will rarely come up with the correct answer (arrows represent the movement of energy) on their first try.

Use student ideas during the Inside-Outside Circle and small group discussions to formatively assess their understanding of the concepts of energy and matter, and how these are represented in models of food webs/chains. By the end of the lesson, students should understand that energy flows through the ecosystem and is represented by arrows. The matter is contained in the organisms (and abiotic factors, such as water) in the ecosystem.

Walk around the room to observe students’ level of participation. Make certain students have equity within their groups. Intervene, if necessary, and ask questions of the quieter students to increase their involvement in the group discussion. Depending on the students in the class, consider providing a discussion format, such as Ten Coins in a Hat (described below) to allow all students to participate.

Ten Coins in a Hat
Students are placed in groups of five, and each student is given two “coins” (slips of paper, tokens, etc.). When a student shares an idea with the group, she must place one of her “coins” in the middle of the table. Once a student has used both of her coins, she can’t share again until everyone else has used both of their coins.

As students work on this, walk around the room and make note of their work. If students are struggling with the concept of matter, consider stopping the class and facilitating a short discussion to review what matter is and how it compares to energy before allowing the students to finish circling matter and labeling energy.
### Table example for science notebook

<table>
<thead>
<tr>
<th>Producers</th>
<th>Consumers</th>
</tr>
</thead>
<tbody>
<tr>
<td>pond weed</td>
<td>heron</td>
</tr>
<tr>
<td>phytoplankton</td>
<td>shrimp</td>
</tr>
</tbody>
</table>

Example of food chain with matter/energy labeled (note that although every arrow represents the movement of energy, not every arrow in the food web below has been labeled; it is important for students to recognize that the sun is the energy source for the food web, that plants can use energy from the sun, and then the energy can be used by other organisms in the food web):
### Student Science Performance 4

<table>
<thead>
<tr>
<th>Topic: Human impacts on ecosystems</th>
<th>Title: Take My Advice</th>
</tr>
</thead>
</table>

#### Overarching Performance Expectations (Standard):

6.4.3: Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem. Emphasize food webs and the role of producers, consumers, and decomposers in various ecosystems.

6.4.4: Construct an argument supported by evidence that the stability of populations is affected by changes to an ecosystem. Emphasize how changes to living and nonliving components in an ecosystem affect populations in that ecosystem.

#### Lesson Performance Expectations:

Students will analyze data to identify patterns in the populations of trout, humans and carp. They will use evidence to construct an explanation for the decline in the trout population of Utah Lake, and communicate their explanations and offer advice to a past policy-maker in a letter.

**CCC:** Cause and effect; stability and change  
**SEP:** Analyzing and interpreting data

#### Students Will . . . To Construct Meaning

**Engage with a phenomenon:** In 1875, there were approximately 580,000 trout in Utah Lake; by 1825, there were none.

**Gather:**

Student prompt:  
Review the fish population data and compare it with the human population data. On the graph of the human population, add the trout and carp populations.

Read the information about humans and Utah Lake.

#### Teacher Will . . . To Support Students

Provide students with the human population data and allow them time to graph the carp and trout data. Students may need some direct instruction to get started; the human population numbers are on the left axis and the carp and trout population numbers are on the right axis. This could also be a good time to talk about scale and proportion; students should understand that two different scales are needed because the carp population is so much larger than the human population. As students work on their graphs, circulate through the room and check on their progress.

Encourage students to ask their neighbors for a hint on how to construct the graph if they are stuck. Remind students to finish the key. Consider facilitating a short class discussion to allow students to explain the patterns in the data. Distribute the readings about humans and Utah Lake (or hand readings to students as they finish their graphs). You could give each student both readings, or give each student only one reading, and then later pair students who got different readings together (during the CCCR) so they can teach their partner the information they learned.
Reason:
Student prompt:
Reflect on everything we’ve learned, including information about food webs. What do you think caused the decline in the trout population? You will be using the consider-contribute-consult-revise strategy to construct an explanation to this question.

Consider: Consider the question, “What caused the decline in the trout population?” Record your best ideas about the question in your lab book. You should record your ideas about how and why the trout population declined, and should include evidence that supports your ideas. You can use both words and pictures to record your ideas.

Contribute and Consult: Share your ideas with your partner. Read what you wrote, word for word. If you used pictures, explain the pictures to your partner. Answer your partner’s questions. If your partner gives you feedback that you have questions about, ask her. Record the feedback in your lab book.

When it is not your turn to share, show your partner you are listening. As your partner explains her ideas, ask any questions that might help you understand her ideas better. When she finishes, provide feedback that your partner could use to revise and improve her ideas. To do this, ask yourself the following questions:

- “Was everything correct?”
- “Was everything clear?”
- “Would an example, more evidence, or a diagram help?”

Revise: After you have consulted with your partner, revise your ideas. Decide which pieces of your partner’s feedback is useful and will improve your explanation. You can make revisions by drawing a line through items you don’t want to include, and adding items that will help improve and clarify your ideas.

During the class discussion, you can make further revisions to your ideas.

Review each step of the CCCR strategy with students before they start it. Set time limits for each step of the CCCR. Students do not need to write in complete sentences/paragraphs, but should represent their ideas and the evidence to support them in any way they would like. They will be using the ideas to construct a written argument, in the form of a letter, at the end of the lesson.

Before students start the contribute-consult step, consider modeling what the partner discussion should look and sound like. You may also want to provide sentence stems to facilitate student engagement. As students work, it is important for you to circulate through the class and listen to their ideas. Make note of student ideas that will be useful in facilitating the class discussion, and consider giving individual students a heads-up that you will be asking them to share a particular idea during the discussion.

A complete description of the CCCR strategy can be found at:

After students have time to complete the CCCR and have revised their ideas, facilitate a class discussion. Students should understand that the decline in the trout population does not have only one cause. Overfishing by humans reduced the population. Changes to the food web caused by the introduction of the carp also contributed to a decline in the trout population. Allow students to share their ideas and drive the discussion, but use questions to guide the discussion in a way that helps students see the various causes of the decline in the trout population. Encourage students to revise their ideas during the class discussion.
**Communicate:**

**Student prompt:**
You will be using your ideas about what caused the decline in the trout population to write a letter to one of the following people:

- A. Milton Musser (head of the fishing commission when carp were introduced to the lake)
- Brigham Young (governor of the Utah Territory who brought the settlers to the area)
- John S. Higbee (helped establish the first settlement of European Americans near Utah Lake)

All of these people lived in the 1800’s and made decisions that affected Utah Lake. A short biography has been prepared for each person. Read through them, and decide who you would like to write your letter to. Your letter needs to include the following:

- A comparison of the Utah Lake they knew (in the 1800’s) and the Utah Lake that exists now
- An explanation of why the Utah Lake ecosystem is so different now
- Advice about what choices they should make concerning Utah Lake, and why they should follow your advice

**Assessment of Student Learning**

Formative: Student graphs and the patterns they identify, as well as their ability to construct and support an explanation during the CCCR activity should be used as formative assessments. Students should already have constructed reasonable explanations with evidence before they are expected to assimilate those ideas into their letter. Examples of student products are below.

Sample graph:

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**Explain the letter-writing activity to the students, and provide the bios for students to determine who they would like to write to. Also provide a grading rubric and/or list of expectations for the letter. Review the requirements before students start their letters. Consider reviewing the decisions each man made that affected the lake, so students know where to focus their advice.**

Consider allowing students to share their letters. Some ideas:

- Have one or two students read their letters to the class every day until everyone has had a chance to share, or read a letter or two yourself to the class each day
- Allow students to read their letters in small groups, and instruct each group to select one letter from the group that they want to read for the class
- Hang the letters in a place where students can read them and allow time/structure for students to read the letters
Patterns identified could include: as the human population gets larger, the trout population gets smaller, or as the carp population gets larger from 1935 to 1955, the trout population gets smaller, etc.

Sample CCCR ideas and evidence:

| My idea is that the carp populations are caused the trout population to get smaller and then go extinct. Some evidence for this is that from 1875 to 1955, the trout population went from 580,000 to 0. At the same time, the carp population went from 0 to 7,200,000. We read that the carp eat the plants. If there are carp eating all the plants, there won’t be enough food for the insects that the trout eat. On our food web, it shows that the mayflies eat the plants and the trout eat the mayflies. Without any plants, the trout won’t have mayflies to eat. Also, the carp can eat the insects too, so the trout won’t have as much food. |
| I think that people fishing is what caused the trout to disappear from Utah Lake. Even though it said in the reading that the Native Americans fished in the Lake, there weren’t very many of them, so they didn’t take as many fish. When the settlers came, the population got really big and it said that they were catching thousands of fish. The graph also shows that when the human population got bigger, the trout population got smaller. This shows that when there are more people, they will take more fish from the lake and the trout can go extinct. |

Summative assessment:
Letters can be assessed using the following rubric as a guide:

<table>
<thead>
<tr>
<th>Surpasses proficiency</th>
<th>Your letter meets the requirements for proficiency, and includes additional informations. For example:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Your letter includes more than two factors that have caused changes in the lake ecosystem.</td>
</tr>
<tr>
<td></td>
<td>Your letter includes predictions about what the lake would be like today if the person had followed your advice, including evidence to support your prediction.</td>
</tr>
<tr>
<td></td>
<td>Your letter includes predictions about the conditions of the lake in the future if the person does not follow your advice, including evidence to support your prediction.</td>
</tr>
<tr>
<td></td>
<td>Your letter outlines a solution for restoring the lake that we will have to implement.</td>
</tr>
<tr>
<td>Proficiency</td>
<td>Advice and Information Required</td>
</tr>
<tr>
<td>-------------</td>
<td>---------------------------------</td>
</tr>
</tbody>
</table>
| **Proficient** | - Your letter describes the similarities and differences in conditions of the lake in the 1850’s and now (this could include describing parts of the food web that are the same or different or how the area around the lake looks the same or different)  
- Your letter explains how and why the ecosystem of the lake changed  
- Your letter includes at least two factors that have caused changes in the lake ecosystem  
- Your letter includes advice about decisions that the person makes about the lake (for example, advice given to Brigham Young might focus on his decision to send settlers to the area to fish, advice given to A. Milton Musser might focus on his decision to put carp into the lake, advice given to John S. Higbee might focus on his decision to catch fish from the lake)  
- The advice you give includes an explanation that is supported by evidence (you include an explanation of why the person you are writing to should follow your advice) |
| **Approaching proficiency** | Your letter contains all elements required to meet proficiency, but some of the information is incorrect or incomplete. For example, only one factor that caused a change the the lake ecosystem is included. |
| **Below proficiency** | Your letter is missing elements required to meet proficiency; elements that are included may be incorrect or incomplete. |

**Student samples:**
**Proficient (high):**
Mr. Young,

In school we learned about you. We are in the future and learned about that you sent people to live by Utah Lake and get the fish to eat. This was not a good choice because it took the trout out of the lake and now in the future there are no more trout. The food web is different now because there are carp and they eat different food than the trout. The carp eat all of the plants but the trout were eating the insects.

I will give you the advice to tell people that they should not fish in Utah Lake. When you sent the settlers to live by the lake and catch the fish maybe you didn't know they would catch all the fish. But that's what happened, so you shouldn't send them to catch the fish. I think you did some good things, like making roads, but telling more people to live by Utah Lake was not a smart choice. You should listen to my advice because I am in the future so I know what happened. I know you are busy because you are the governor. So thanks for reading this.
Humans and Utah Lake


Using large nets, pioneer fishermen caught thousands of pounds of Bonneville cutthroat trout, June sucker, Utah sucker, and chub. In 1848, fishing companies were organized to collect fish for desperate settlers who were without provisions. That year, frost killed early sprouting crops. Then came the crickets. Swarms of crickets destroyed many crops, and hundreds of the valley’s early residents stared starvation in the face. Were it not for the plentiful fish in Utah Lake, hundreds of settlers would have suffered severely. Several families were fortunate to have friends who were also skilled fishermen. More crickets and other insects would destroy pioneer crops in years to come. They gobbled up wheat, corn, oats, barley, clover, grass – even clothing. At times like these, when all the crops were eaten by insects, the only thing left to do was fish. Motivated by hunger, settlers fished frequently and recklessly. Soon, laws were written to control the number of fish being taken from the lake. But these laws were ignored by many locals, who used nets to fish night and day.

Very often, change is good. But in the 1880s, when carp were introduced to Utah Lake, the results weren’t good at all. The intent was to replace the dwindling number of trout and to provide locals with a hardy fish that was also a very popular dish in other areas of the world. Yet, the newly integrated carp had long-lasting, negative impacts on the lake’s native fish population. The carp’s aggressive foraging habits eventually destroyed the pondweed on the surface and the plant life on the lake floor. This directly impacted the native fish population.
A. Milton Musser

Amos Milton Musser was born in 1830 in Pennsylvania. He traveled to the Utah Territory in 1851. Musser worked on many different projects throughout his life. He brought the telephone to Salt Lake, and helped promote railroad building across areas that would become part of Utah. Before Utah became a state, Musser was the fish and game commissioner for the territory. While he was in this position, he helped make the decision to introduce fish into many different lakes and rivers in Utah. In 1883, he helped make the decision to stock Utah Lake with carp.

Brigham Young

Brigham Young was born in 1801 in Vermont. He helped bring the first settlers to Utah in 1847, and became the first governor of the Utah Territory before Utah became a state. While he was governor, he helped many more settlers come to the area. By 1860, there were 40,000 new settlers in the territory. Young directed the building of roads, bridges, schools, and a mail service. He also directed irrigation projects that helped move water from lakes and rivers so that the settlers could use it to grow crops. Young wanted to use the fish from Utah Lake to help feed the settlers. In 1849, he sent a team to Utah Lake with instructions to find the best places to catch fish. Young was the governor from 1851-1858.

John S. Higbee

In 1849, John S. Higbee brought the first group of Mormon settlers to the Utah Lake area. Two years earlier, Higbee had visited Utah Lake with a few other settlers to see how easy it might be to catch fish in the lake. They fished in a place that does not usually have many fish, and only caught a few trout. When Higbee returned with a group to settle the area, they observed the Native Americans catching fish from the lake, and learned where and when to catch fish. There were so many fish that they could even catch them by hand. In June of 1849, the Native Americans and settlers caught thousands of fish from the lake. The fish they caught were a mixture of different species.
Human, Carp and Trout Populations

The graph below shows the population of humans living in Utah County, near Utah Lake. The graph shows the population of humans from 1855 to 1955. Remember that before 1847, there were only Native Americans and various mountain men and trappers living in the area, and the human population was relatively small. The first large settlements of European Americans began in 1847.

Use the fish population data to add carp and trout populations to the graph. Then identify at least one pattern in the population sizes.

![Graph showing human, carp, and trout population sizes from 1855 to 1955.]

Describe at least one pattern in the data:
Human, Carp and Trout Populations cont.

Consider: What do you think caused the decline in the trout population in Utah Lake? As you think about this, reflect on what you know about the other species (including humans) in the area and food webs. You can use pictures and/or words to record your ideas below. Don’t forget to include your evidence!
Pen Pal From The Past
Directions and Checklist

Now that you have a better understanding of the role that humans played in the decline of the trout population in Utah Lake, what advice would you give to the early settlers in the area? Do you think they understood how their decisions would affect the lake? How would you explain to them how their choices impacted the lake?

You will be writing a letter to A. Milton Musser, Brigham Young, or John S. Higbee. You will be telling him about the changes to the lake and giving him some advice. Before you turn in your letter, make sure it has:

- The similarities and differences in the lake from the 1800’s and the lake now
- Explanation of how and why the lake ecosystem changed
- Advice about the choices the recipient made about the lake
- Evidence to convince him to follow your advice
Strand: 6.4.5

**Emphasis:** Standard 6.4.5 *Evaluate competing design solutions* for preserving ecosystem services that protect resources and biodiversity based on how well the solutions maintain stability within the ecosystem. Emphasize *obtaining, evaluating, and communicating* information of differing design solutions. Examples could include policies affecting ecosystems, responding to invasive species, or solutions for the preservation of ecosystem resources specific to Utah, such as air and water quality and prevention of soil erosion.

**Anticipated Time Required** (assuming 50 minute class periods): 2.5 weeks
- LE 1: 30 minutes
- LE 2: 50 minutes
- LE 3: 75 minutes
- LE 4: 75 minutes
- LE 5: 75 minutes
- LE 6: 100 minutes
- LE 7: 100 minutes

**Dominant CCC:** Stability and Change
**Dominant SEP:** Obtaining, Evaluating, and Communicating Information

**Management Strategies** to support equitable access to content:
Jigsaw, think/pair/share, grouping students, managing stations, arguing ideas and not each other

**Shopping list:**
Flowers to dissect (one for every 2 students)
- Tissue paper
- Construction paper
- Pipe cleaners
- Pom poms (multiple sizes)
- Glue
- Tape
- Scissors
## Standard 6.4.5 Biodiversity

**Anchor Phenomenon:** Why are huge populations of bees disappearing?

**Student Performance Expectation:**

Standard 6.4.5 *Evaluate competing design solutions* for preserving ecosystem services that protect resources and biodiversity based on how well the solutions maintain *stability* within the ecosystem. Emphasize *obtaining, evaluating, and communicating* information of differing design solutions. Examples could include policies affecting ecosystems, responding to invasive species, or solutions for the preservation of ecosystem resources specific to Utah, such as air and water quality and prevention of soil erosion.

<table>
<thead>
<tr>
<th>Dominant DCI</th>
<th>Dominant CCC</th>
<th>Dominant SEP</th>
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<tbody>
<tr>
<td>Biodiversity</td>
<td>Stability and Change</td>
<td>Obtaining, Evaluating, and Communicating Information Designing Solutions</td>
</tr>
</tbody>
</table>

### Science Experiences

<table>
<thead>
<tr>
<th>CCC/SEP</th>
<th>What are students doing? (This should match your SEP!)</th>
<th>What specific understandings should students get from this experience? (What pieces of the performance expectation does the experience provide?)</th>
<th>New questions students have to propel us to the next science experience</th>
<th>Assessment</th>
</tr>
</thead>
</table>
| **1** CCC Cause and Effect SEP Analyzing and interpreting data | **Snapshot**  
*Gather*  
Students will be provided with data regarding human populations and bee populations. They will start to brainstorm ideas as to why these numbers are changing.  
*Reason*  
In small groups, students will use a sentence stem to format their response to what they think is happening.  
*Communicate*  
Students will share their claims with the rest of the class and there will be discussion of the anchor phenomenon. | **Students should understand**  
Students will understand that although human populations are rising, there is a drastic decline in bee colony populations. Students should consider as many possible causes for this. | **Questions**  
- What is causing the number of colonies to decrease?  
- Are humans playing a factor in the loss of colonies? | **Assessment**  
Teacher will analyze student claims about what they think is happening with this data. Teacher will ensure the proper use of a sentence stem, and meet with small groups to check for understanding. |
<table>
<thead>
<tr>
<th>2</th>
<th>CCC Cause and Effect</th>
<th><strong>Snapshot</strong></th>
<th><strong>Students should understand</strong></th>
<th><strong>Questions</strong></th>
<th><strong>Assessment</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SEP Structure and function</td>
<td><em>Gather 1:</em> Students will be given sorting cards and asked to come up with possible categories. Students will record their ideas in their science notebooks.</td>
<td>That pollination is a large part of why we get our food (70%). That each structure in a plant has a particular function that helps attract pollinators. Plants and flowers have adaptations that allow them to attract pollinators.</td>
<td>• What adaptations does a flower have to attract bees? • What will happen to our food supply if the bees disappear?</td>
<td>Formative: Assess the student paragraphs on the importance of pollination and bees in an ecosystem.</td>
</tr>
<tr>
<td></td>
<td>SEP Analyzing and interpreting data</td>
<td><em>Gather 2:</em> Students will be invited to share what they already know about the importance of bees in an ecosystem. They will brainstorm ideas as small groups then together as a class.</td>
<td>Communication Students will write a paragraph communicating why bees are important in an ecosystem.</td>
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<td>SEP Developing and using models</td>
<td><em>Gather 3:</em> Students will gather information and data from specified web pages (Michigan State University) about the importance of bees in an ecosystem--namely pollination.</td>
<td>Reason Students will be asked to re-sort their food cards to determine which foods are a result of pollination.</td>
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<tr>
<th>3</th>
<th>CCC Cause and Effect</th>
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<th><strong>Students should understand</strong></th>
<th><strong>Questions</strong></th>
<th><strong>Assessment</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SEP Structure and function</td>
<td><em>Gather:</em> Students will be given materials to complete flower dissection. Students will draw a model of what they see when they open up the flower.</td>
<td>Flowers have different adaptations to attract pollinators. Flowers are unable to pollinate on their own. Flowers and plants have different structures that each serve an important function.</td>
<td>• What adaptations do all flowers have in common? • Why are some flowers pollinated by insects, while</td>
<td>Teacher will formatively assess student paragraphs and diagrams. Paragraph should include</td>
</tr>
</tbody>
</table>
### Models

**Reason:**
Students will describe each structure using their senses in their science notebooks.

**Communicate:**
Students will examine their diagram and descriptions and write a short paragraph on ways in which the flower has adapted to attract pollinators.

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<tr>
<th>CCC</th>
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<tr>
<td>SEp</td>
<td>Gather</td>
<td>Bees are attracted to certain flowers. These flowers have adapted to have traits that are attractive to bees and other pollinators. Without pollinators, flowers are unable to reproduce.</td>
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</table>

**Questions**
- What happens to the flowers if the bees disappear?
- Why do we care about bees?
- What effects will there be worldwide?

**Assessment**
Teacher will formatively assess student science notebook and flower models.
<table>
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<tr>
<th></th>
<th><strong>biodiversity.</strong></th>
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<tr>
<td>5</td>
<td><strong>CCC</strong>&lt;br&gt;Stability and Change&lt;br&gt;SEP Developing and using models</td>
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<td>6</td>
<td><strong>CCC</strong>&lt;br&gt;Stability and Change&lt;br&gt;SEP Designing solutions Obtaining, evaluating, and communicating information</td>
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<tr>
<td>Snapshot</td>
<td>Students should understand</td>
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<tr>
<td><strong>Gather</strong>&lt;br&gt;Students will gather information and research to begin to build a possible solution to the problem.</td>
<td><strong>Students should understand</strong>&lt;br&gt;There are groups and organizations that are working to save the bees. Students are able to have a voice and work toward helping save the bees.</td>
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<tr>
<td><strong>Reason</strong>&lt;br&gt;Students will discuss their research with others, to ensure it is reliable and relevant to preserving biodiversity of bees in an ecosystem.</td>
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<tr>
<td><strong>Communicate</strong>&lt;br&gt;Students will write an argumentative essay to a legislator on the importance of bees and what we can do to protect them.</td>
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**Standard 6.4.5 Learning Episode 1**

<table>
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<td><strong>Topic:</strong> Biodiversity</td>
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**Overarching Performance Expectations (Standard) from State Standards or NGSS:**
Standard 6.4.5 *Evaluate competing design solutions* for preserving ecosystem services that protect resources and biodiversity based on how well the solutions maintain stability within the ecosystem. Emphasize *obtaining, evaluating, and communicating* information of differing design solutions. Examples could include policies affecting ecosystems, responding to invasive species, or solutions for the preservation of ecosystem resources specific to Utah, such as air and water quality and prevention of soil erosion.

**Lesson Performance Expectations:** Students will construct a claim that populations of bees are declining, while human populations are increasing. This will present the phenomenon.

**Students Will. . . To Construct Meaning**

*Engage with a Phenomenon: Students will discover the phenomenon during this learning episode.*

*Gather*
Students will be provided with data regarding human populations and bee populations. They will start to brainstorm ideas as to why these numbers are changing.

*Reason*
In small groups, students will use a sentence stem to format their response to what they think is happening.
Possible sentence stems:
- I observed _____________ when _____________.
- I compared _____________ and _____________.
- Bee colonies are __________, because __________.
- Human populations are __________ because __________.

*Communicate*
Students will share their claims with the rest of the class and have a discussion on what they think this information means.

**Teacher Will. . . To Support Students**

Pass out the data sheets. Have students work as small groups of 3-4 to see if they can find patterns in the numbers.
Link to PDF of data sheets (pages 16-17):
[https://www.nextgenscience.org/sites/default/files/H5-LS_Bee_Colony_version2.pdf](https://www.nextgenscience.org/sites/default/files/H5-LS_Bee_Colony_version2.pdf)

Teacher will walk around to each small group and check for understanding. Possible prompts could include:
What do you notice about the number of bee colonies in the United States between 1950 and 2013?
What do you notice about the human population in the United States between 1950 and 2013?
What do you think could be causing these changes in population?
Teacher writes claims and evidence on the board. This will allow students to argue ideas rather than with each other.

### Assessment of Student Learning

Data from the United States Department of Agriculture National Agricultural Statistics Service's "Honey Production" (1940s-1980s) and "Honey" (1970's-2010's) reports:


#### Table: Number of Honey Bee Colonies in the United States, California, South Dakota, and United States (1939-2013)

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- Possible answer: Bee populations are getting smaller because the number of bee colonies in the United States in 1939 was 4422, and in 2013 it was only 2640. All students should come to the same conclusion: human populations are increasing over time while bee colony numbers are decreasing. Students should think about what is causing this decline in bee populations. What are humans doing that is causing colonies to decrease in number? If students are struggling, give them specific years to focus on. They could use highlighters to highlight every 5 years worth of data if this is overwhelming.

### Management Strategy

- Teacher will analyze student claims about what they think is happening with this data. Teacher will ensure the proper use of a sentence stem, and meet with small groups to check for understanding. Students should think about what is causing this decline in bee populations.
## Attachment 2. Human Population for the United States, California, and South Dakota (1939-2012)

<table>
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US Historical Population Data was compiled from: https://www.census.gov/popest/data/historical/
# Standard 6.4.5 Learning Episode 2

<table>
<thead>
<tr>
<th>Student Science Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Topic:</strong> Biodiversity</td>
</tr>
</tbody>
</table>

**Overarching Performance Expectations (Standard) from State Standards or NGSS:**
Standard 6.4.5 *Evaluate competing design solutions* for preserving ecosystem services that protect resources and biodiversity based on how well the solutions maintain stability within the ecosystem. Emphasize *obtaining, evaluating, and communicating* information of differing design solutions. Examples could include policies affecting ecosystems, responding to invasive species, or solutions for the preservation of ecosystem resources specific to Utah, such as air and water quality and prevention of soil erosion.

**Lesson Performance Expectations:** Students will understand that bees have an important role in our ecosystem. Without pollinators, we lose our food supply.

<table>
<thead>
<tr>
<th>Students Will. . . To Construct Meaning</th>
<th>Teacher Will. . . To Support Students</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Engage with a Phenomenon:</strong></td>
<td><strong>Management Strategy:</strong></td>
</tr>
<tr>
<td><em>Where does our food come from?</em></td>
<td>Placing students in effective partners can be tricky. For the purpose of these lessons, be mindful of your student personalities. You may place them into smaller groups if necessary. Partners are a good way to ensure accountability for learners. All students will be required to record their ideas in their science notebooks. Ideas on how to pair students:</td>
</tr>
<tr>
<td><strong>Gather 1:</strong></td>
<td>● Cards: Give students one card each and they will need to find their partner based on suite, color, or number.</td>
</tr>
<tr>
<td>Students will be provided with sorting cards.</td>
<td>● Elbow partner: Work with the person sitting closest to you.</td>
</tr>
<tr>
<td>Students will be placed into partners.</td>
<td>● Popsicle sticks: Random draw of popsicle sticks with student names written on them.</td>
</tr>
<tr>
<td>Upon direction of teacher, students will sort cards and record their ideas in their science notebooks. For example: fruits, vegetables, grains.</td>
<td>● Partner of the day: Students will have a new partner each day.</td>
</tr>
<tr>
<td>Students should have specific reasons as to why they chose these categories. For example: “We chose fruits because all of these would be found in the fruit section of the grocery store.”</td>
<td>Teacher will ask students to sort the food cards into different categories based on similarities and differences. The students will decide on the categories</td>
</tr>
<tr>
<td>Students will be invited to share what they already know about the importance of bees in an ecosystem.</td>
<td></td>
</tr>
</tbody>
</table>
They will brainstorm ideas as small groups then together as a class.

Focus questions:
● What do you know about what bees do?
● Based on what bees do, why might they be important to an ecosystem?

Gather 3:
Students will gather information and data from specified web pages (Michigan State University) about the importance of bees in an ecosystem—namely pollination.

Reason:
Students will be asked to re-sort their food cards to determine which foods are a result of pollination.

Communicate
Students will write a paragraph communicating why bees are important in an ecosystem.

for the initial sort:
● I want you to sort these cards into different categories. In order to do so, you will need to look for similarities and differences. If you are unsure of what some of these items are, you can choose to have an “other” category.
● Please write down your categories that you and your partner came up with in your science notebooks.
● Be prepared to share your ideas with other groups and justify your reasoning.
Teacher will walk around to different partners and ask them to explain their thinking.
Possible questions:
● Why did you choose to sort this way?
● What is your thinking?
Teacher will have partners share with the class their categories, and write them down on the board.

Management Strategy: Have students write their ideas down on a whiteboard individually. Students will then share in small groups (5-6 students). Teacher can see student responses on the whiteboard, and allow all students the opportunity to participate. The goal of sharing with small groups is to look for ways their ideas are similar and different. They should be identifying where their ideas are similar, as well as gather new ideas from their peers.

Possible ways to include all learners:
I noticed ____and ______have _____ written down. I had not thought of that!

Teacher will set up stations regarding pollination. These station cards can be printed on cardstock and laminated for durability. I suggest cutting them into half-size by section. This can also be used as a double-sided handout.

Management Strategy: Teacher may choose how to present this information. Some ideas:
● Station cards with specified time limit (2-3
Teacher will have students get out their science notebooks and card sorts. “Based on the information you have learned about the importance of bees, I want you to re-sort the food cards. I want you to discuss with your partner which foods are a result of crops pollinated by bees. Scientists often revisit initial ideas when they have more information.”

**Assessment of Student Learning**

Teacher will formatively assess student explanations. Things to look for:
- Basic understanding of the role of bees in pollination
- Many crops are a result of pollination by bees
- Possible Misconceptions (teacher will need to be mindful of these misconceptions and look for them in student work):
  - All pollination requires a flower.
  - All pollination is done by bees.
Name:

Directions:
Sort 1: Think about how each of these is similar or different. Sort the cards into different categories of your choosing based on similarities or differences.

<table>
<thead>
<tr>
<th>watermelon</th>
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<th>sweet potatoes</th>
<th>sunflowers</th>
<th>strawberries</th>
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<tbody>
<tr>
<td>pumpkins</td>
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<td>rhubarb</td>
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<td>almonds</td>
<td>apples</td>
<td>asparagus</td>
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Pollination


Pollination Facts

Pollination in plants is the process where pollen is transferred from the anther, the male part of a flower, to the stigma, the female part of a flower. Pollen can be transferred to one plant or even a nearby plant so that they can make more flowers.

The word ‘pollen’, was used in science writing since 1760 and means “the producing part of flowers.” Earlier in history it meant “dust or fine flour.”

Why is pollination important to the life cycle?

Pollination is a very important part of the life cycle of plants and they cannot produce fruit or even seeds unless they are pollinated. Pollen is transferred by pollinators, which can be the wind, or other ways. Once pollination takes place, seeds begin to grow. Pollination is an important part of a plant’s life cycle, from flowering plants to non-flowering ones.

Pollination usually occurs naturally and most often it is due to insects, birds, and small mammals. The sticky pollen from flowering plants clings to their bodies, where it is carried from one plant to another. Honeybees do more pollination than any other insect, which includes ants, beetles, butterflies and moths. Birds are also responsible for pollination, especially hummingbirds. Small mammals, such as bats, are pollinators as well.
The color or markings on a flower helps attract and guide insects to them for pollination. Bees are often attracted to bright blue and violet colors. Hummingbirds like red, pink, fuchsia, or purple flowers. Butterflies enjoy bright colors like yellow, orange, pink and red as well as fragrant ones.

A flower’s fragrance is another way that animals are attracted to plants, especially at night when moths and bats are out.

The way in which a flower is shaped also attracts pollinators. Butterflies prefer flowers with flat petals that act like a landing strip for them to sit on. Long, tubular flowers attract hummingbirds as their long beaks can easily fit into the flower when gathering nectar.

**What are the two ways in which pollination happens?**

There are two methods of pollination. Cross-pollination is the most common and occurs when the pollen goes from the stamen of one flower to the pistil of another flower. Self-pollination takes place when pollen is transferred from the stamen of one flower to the pistil of the same flower or plant.

**What are the other ways pollination happens?**

Pollination happens via the wind. Wind-blown pollen is normally dry and dust-like. Wind-pollinated plants are often plainer looking with feathery-looking flowers. Many trees and grasses rely on wind for pollination too. Pollination can occur by other means for example, water can carry pollen from one plant to another. This often takes place with pond plants. Even people transfer pollen as they handle flowers in the garden.

**More information on pollination**

Bees have always been recognized as the main pollinators but some plants like tomatoes are best pollinated by bumblebees as bees can’t shake the plant like a bumblebee does. The anther of the tomato flower will only release its pollen if it is vibrated. This is called buzz pollination and requires bumblebees to shake it in a certain way.

Every species of fig tree depends on its own specific wasp variety for pollination. Figs have no visible flowers – the flowers hide inside the fruit. Female wasps squeeze into the fruit through a tiny hole, feast on the secret flowers’ nectar and lay their eggs. As they feed they pollinate the flowers then fly to another fig tree, carrying some of the first tree’s pollen, which helps the trees’ to survive and thrive.
Standard 6.4.5 Learning Episode 3

Student Science Performance

<table>
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<tr>
<th>Topic: Biodiversity</th>
<th>Title: Dissecting a Flower</th>
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**Overarching Performance Expectations (Standard) from State Standards or NGSS:**
Standard 6.4.5 *Evaluate competing design solutions* for preserving ecosystem services that protect resources and biodiversity based on how well the solutions maintain stability within the ecosystem. Emphasize *obtaining, evaluating, and communicating* information of differing design solutions. Examples could include policies affecting ecosystems, responding to invasive species, or solutions for the preservation of ecosystem resources specific to Utah, such as air and water quality and prevention of soil erosion.

**Lesson Performance Expectations:** Students will understand that each structure in a flower is to allow the process of pollination to take place. Knowing that each structure has a function, they will be able to then construct their own model (in the next learning episode).

**Students Will. . . To Construct Meaning**

*Engage with a Phenomenon:*
*Flowers have adapted to attract pollinators.*

*Gather:*
Students will be given materials to complete flower dissection. They will need to remove a few of the petals to reveal what is inside. Students will draw a diagram of what they see when they open up the flower. As they investigate, they will need to describe each component using their senses (except taste).

- What does it look like?
- What does it smell like?
- What does it feel like?

**Teacher Will. . . To Support Students**

Teacher will need to explain that plants are unable to move around to look for ways to attract pollinators. In order for them to reproduce, they need pollinators to carry pollen to other flowers (cross-pollination). The purpose of this activity is to investigate what parts of the flower attract pollinators to ensure that pollination takes place.

The most important part of this activity is that the students have a working model of a flower using their own descriptions (an example of the drawn model can be found below assessment portion of the lesson plan).

The role of the teacher is to facilitate the dissection. Students will be taking apart their flower and looking for different structures. The teacher will ask guiding questions (more specific questions listed below):

- What shape are the petals?
- Why do you think the flowers are this color?
- What do you expect to find when cutting open that structure?

In the next learning episode, students will be asked to build upon their learning by constructing a 3D model of a flower that they drew. Vocabulary is not necessarily important--it could be included, but it is most important that students know what adaptations
**Reason:**
Students will describe each structure using their senses in their science notebooks. At this point, they will need to have a diagram of what they see, and be adding descriptions. Example: I noticed this was sticky. The petals are brightly colored purple.

**Communicate:**
Students will examine their diagram and descriptions and write a short paragraph on ways in which the flower’s forms help it to to attract and be helped by pollinators.

| flowers have in order to attract pollinators. Ex: brightly colored petals, a good spot for landing, sweet smells, etc. |
| Provide each pair of students (or individual students) with a flower, scissors, magnifying glass, and reiterate the importance of drawing and recording what you experience with your senses. Teacher will walk around the room asking questions: |
| ● What do you notice about the inside of the flower? |
| ● Why do you think this structure is “sticky”? |
| ● What are some characteristics of this flower that would make it attractive to pollinators and bees in particular? |

Teacher will need to remind students that they are looking to add more descriptions to their diagrams. **Management Strategy:** Encourage students by using examples from the class. “I noticed Alex is describing each structure using his senses! Nice work.”

Teacher will again remind students that flowers cannot move around and look for ways to attract pollinators. What do they do in order to make sure to attract pollinators? Explain that flowers adapt to attract what they need. They need pollinators, so they have specific adaptations to attract them.

**Assessment of Student Learning**

Teacher will formatively assess student paragraphs and diagrams. Paragraph should include explanations of how their flower attracts bees using their senses.

**Ideal answer:**
Flowers are unable to move around and attract pollinators. In order for pollination to take place, they need adaptations that allow them to attract insects or birds to move pollen for them. Our flower has brightly colored petals to attract bees and a solid spot for the bees to land. It is sweet-smelling to attract bees to the nectar. There are structures that are sticky to help collect some of the pollen from the bee that lands on it. Provide feedback or pose questions to garner student thinking. The goal is to have students being as descriptive as possible.
This was a quick model sketch with notes using the senses.

This is the original flower I dissected.
This dissection guide is not used in the lesson, but rather a resource if teachers need more information, or if students are struggling.

Flower Dissection

Name __________________________ Date __________________

Background Information:

Flowers are the reproductive parts of many plants. It may surprise you to know that flowers have female and male parts. The female part of the plant is called the pistil. It includes the stigma, style, and ovary (which contains the eggs). The male part is called the stamen. It includes the anther and filament. The anther holds the pollen (sperm) of the plant.

Using the flower provided by your teacher, take time to look for all the parts of the flower shown in the picture. If you are unsure of the parts, verify with your teacher before starting your dissection. After his/her approval, you may start the dissection. You will be color coding the flower parts with the boxes as you examine them. As you find the parts, carefully cut them off and set aside. OPTION: Tape either one or all parts next to the box with the parts' name, how many there are, and the function. Textbooks or other source of information (internet access) will be provided for students to look up the functions of the different flower parts.

Materials: Flowers, Scissors, Magnifying Glass, Resource Materials (textbook, internet), Tape (optional)

Directions for Dissection: On the back side of this sheet, fill in a box with the name, how many, and function of each part. Color code the box to match the flower part.

1. Find and count the sepals at the base of your flower. Why is the sepal important to the development of the flower?

2. Find and count the petals of your flower. Why are petal usually brightly colored?

3. Find both parts of the stamen on your plant (the male part—anther and filament). Why is it important for the anthers to be towards the top of the flower?

4. Find all three parts of the pistil on your plant (the female part—stigma, style, and ovary). Cut open the ovary. How many eggs are inside the ovary?
## Standard 6.4.5 Learning Episode 4

### Student Science Performance

<table>
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<tr>
<th>Topic: Biodiversity</th>
<th>Title: Bee Ecosystem Dynamics</th>
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### Overarching Performance Expectations (Standard) from State Standards or NGSS:

Standard 6.4.5 *Evaluate competing design solutions* for preserving ecosystem services that protect resources and biodiversity based on how well the solutions maintain stability within the ecosystem. Emphasize **obtaining, evaluating, and communicating** information of differing design solutions. Examples could include policies affecting ecosystems, responding to invasive species, or solutions for the preservation of ecosystem resources specific to Utah, such as air and water quality and prevention of soil erosion.

### Lesson Performance Expectations: Students will investigate the adaptations a flower has to attract pollinators.

#### Students Will... To Construct Meaning

*Engage with a Phenomenon:*

*Bees are often observed hanging out in and on flowers.*

Gather

Students will be given the Flower Seeking Pollinator Data Sheet. They will read over this information in partners.

Students are looking for what characteristics the flowers have in common that attract the most bees.

Students will record patterns found between flower traits that attract bees in their science notebooks.

**Reason**

Students will then come together in partners to construct a model that represents the adaptations of a flower/plant. They will need to label their structures using their descriptions from the previous learning episode, as well as information learned from the data sheet from this episode’s gather section.

#### Teacher Will... To Support Students

Remind students that they have been working on a hand drawn model of what adaptations a flower has to attract bees. They will be building upon the initial model by constructing a 3D version with more detail and labels that explain in more detail the adaptations of that flower.

Link to data sheet: [https://www.calacademy.org/sites/default/files/assets/docs/pdf/297_pollinatordatasheet_updated.pdf](https://www.calacademy.org/sites/default/files/assets/docs/pdf/297_pollinatordatasheet_updated.pdf)

*What patterns do you notice?*

What characteristics do the flowers have in common that attract the most bees?

Teacher will provide materials for 3D model construction:

Construction paper, tissue paper, pom poms (various sizes), pipe cleaners.

This model should be an extension of the hand-drawn model from learning episode 3. They should be adding information found in the patterns from the data sheet in their new labels on their 3D model.
**Communicate**  
Students will label their flower model with short descriptions on how it is attractive to bees.

Remind students that this should include information found in the *gather* section.

**Communicate II:**  
Students will work together to break down the work into different parts *bio/diverse/ity*.  

Teacher will introduce the topic of biodiversity by having students break down the word into its parts. Have them brainstorm other words that have the same parts. They should then be able to see a pattern based on the meanings of words.  
*bio*=life, *diverse*=different, *ity*=the condition of being  

Have students watch the video, and have a short discussion on how biodiversity relates to the topic of bees and pollination.

**Potential extension:**  
Find pictures of diverse ecosystems and ecosystems that are not diverse. Have students sort them into which they believe to be healthy ecosystems vs. not so healthy.

---

**Assessment of Student Learning**

Teacher will formatively assess student science notebook and flower models. Students should have:  
- Patterns seen between flower data written in their science notebooks  
- Flower model with important parts (they do not need to be able to name the parts, but rather describe the parts in their own word)  
- Descriptions of how this flower attracts bees  
   Examples: These petals are brightly colored to attract bees. This is a flat surface for the bee to land. Sweet smells coming from here.
### Flower Seeking Pollinator DATA SHEET

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<th>Flower Traits</th>
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<tr>
<td>Flower 2</td>
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<tr>
<td>Flower 3</td>
<td>7</td>
</tr>
<tr>
<td>Flower 4</td>
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<td>Flower 5</td>
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<td>Flower 6</td>
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<td>Flower 7</td>
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This is the initial hand-drawn model from the previous learning episode. In this learning episode, students will create a 3D version of their hand-drawn model. In the descriptions of the parts, they will describe exactly how that flower attracts pollinators.

Example: The petals are large and brightly colored. This means that the bees can easily see it from far away, and are able to land on it easily.
Standard 6.4.5 Learning Episode 5

<table>
<thead>
<tr>
<th>Student Science Performance</th>
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<tr>
<td><strong>Topic:</strong> Biodiversity</td>
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**Overarching Performance Expectations (Standard) from State Standards or NGSS:**

Standard 6.4.5 *Evaluate competing design solutions* for preserving ecosystem services that protect resources and biodiversity based on how well the solutions maintain *stability* within the ecosystem. Emphasize *obtaining, evaluating, and communicating* information of differing design solutions. Examples could include policies affecting ecosystems, responding to invasive species, or solutions for the preservation of ecosystem resources specific to Utah, such as air and water quality and prevention of soil erosion.

**Lesson Performance Expectations:** Students will understand that there are consequences to humans if the bees disappear—loss of our food production and/or supply, and a negative impact to our economy.

<table>
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<tr>
<th>Students Will... To Construct Meaning</th>
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<tr>
<td><strong>Engage with a Phenomenon:</strong> There are consequences if bees continue to disappear.</td>
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<tr>
<td><strong>Gather</strong> Students will brainstorm the possible consequences of a continuous decline in bee populations and fill out a graphic organizer to help them communicate consequences on a local, national, and global level.</td>
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</table>

Students will create this graphic organizer in their science notebooks to record their ideas (a more detailed version found below the assessment section):

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<tr>
<th>Local (within our city or state)</th>
<th>National (within our country)</th>
<th>Global (within the world)</th>
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**Reason**

Students will visit stations that share several things that may be affected if bees continue to lose colony populations.

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<tr>
<th>Teacher Will... To Support Students</th>
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<tr>
<td>Remind students that they already understand that without bees, our food supply is cut to 70%. They may not attach this understanding to a monetary value, so they may need prompting. Some probing questions: If our food supply shrinks to 70% of what it currently is, how will that affect our economy? What jobs are there that relate to food production? How might these jobs be negatively impacted?</td>
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</table>

Have students recreate graphic organizer in their science notebooks (or print it out and have them glue it in). They will be thinking about consequences of the loss of bee colonies on a local, national, and global level.

Prepare video and have students add ideas to their graphic organizer as they watch the video. Introductory video:

https://utahpbslearningmedia.org/resource/vtl07.la.r
y.text.beesdisap/disappearance-of-the-bees-whats-the-impact/#.WWd-NNPYu8
**Communicate**
Students will share potential negative impacts of a loss of bee populations in a slideshow format. Students should have a minimum of 5 slides:
- One title slide
- Local impact slide
- National impact slide
- Global impact slide
- Summary slide

*This may also be done as a brochure or poster if technology is unavailable.*

**Teacher will set up stations with the 4 articles and one video.**

**Management Strategy:** Teacher may choose how to present this information. Some ideas:
- Station cards with specified time limit (5-6 minutes per station)
- Station cards with free movement (give students reminders on time, but allow them to move on when needed)—give specified number of students per station
- Have students rotate the articles by table and watch the video as a class
- Print as a handouts and have students read together
- Jigsaw the information

The articles can be found below the assessment section of this lesson plan.

**Assessment of Student Learning**

*Short description of the evidence the teacher is willing to accept that a student is proficient with the performance expectations. This may be a rubric, narrative or other set of descriptors that are useful for distinguishing proficient from nonproficient performances.*

Teacher will formally assess slideshow presentations. Students should have a minimum of 5 slides:
- One title slide
- Local impact slide
- National impact slide
- Global impact slide
- Summary slide
<table>
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<tr>
<th>Slideshow Assessment Rubric</th>
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<td><strong>Local Consequences</strong></td>
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<td><strong>2</strong></td>
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<tr>
<td><strong>1</strong></td>
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</table>
Article #1
U.S. bees could be facing colony collapse, but what does that mean?
by Meredith Kile


WHAT ARE THE CONSEQUENCES OF COLONY COLLAPSE?

Honey bees pollinate plants that produce many of America’s favorite fruits, vegetables, seeds, and nuts. Without bees, the U.S. would lose up to $15 billion in crops, and eliminate important produce and field crops from the The National Resources Defense Council puts it simply on their “Vanishing Bees” homepage, with a list of plants that could be affected by the loss of these pollinators and a fact sheet on why we need bees.

“They have a symbiotic relationship – the flower needs the bee to pollinate it and the bee needs the nectar and pollen from the flower to provide protein and energy for itself and the baby bees. If the bee dies out, that flower will soon follow and the ecosystems fall apart.”
The Western honeybee is the world's premier managed pollinator species. Demand for its services has soared from fruit, nut (especially almonds) and vegetable growers. That represents almost 100 crop species, making up one-third of the average diet. Bee pollination is worth $15 billion to the U.S. farming industry. Disruption of the honeybee supply raised prices for domestically grown nuts, fruits and vegetables. In California, it tripled pollination fees. Beekeepers charged almond growers $51.99 per hive in 2003. By 2009 that rose to $157.03 a hive. In 2016, that fee increased to between $180 to $200 a hive.

Over the last six years, the bee industry spent $2 billion to replace 10 million hives. That's for an industry that's makes $500 million a year. These high costs force beekeepers to charge more to replace hives when they collapse. Higher fees cost almond growers an extra $83 million a year. They pass those costs on as higher prices for almonds.

Colony collapse disorder also affects the beef and dairy industries. Bees pollinate clover, hay and other forage crops. As they die off, it raises the cost of feedstock. That increases beef and milk prices at the grocery store.

The Disorder will lead to increased imports of produce from foreign countries, which will raise the U.S. trade deficit.
Article #3

Loss of honey bees and other pollinators could mean malnutrition for millions around the world
BY ADELYN BAXTER January 28, 2015 at 9:59 AM EDT

New research from scientists at the University of Vermont and Harvard University demonstrates the devastating impact the continued loss of pollinators like honeybees could have on millions of people in the developing world. Since honey bees play such a critical role in pollination of various plants and crops, their decline across the globe means a growing risk to the nutrition of people living in areas most dependent upon those foods. The study, published in the January issue of the scientific journal PLOS ONE, combines dietary and nutritional data with pollination rates and finds potential for severe health effects in such regions.

“The take-home is: pollinator declines can really matter to human health, with quite scary numbers for vitamin A deficiencies, for example, which can lead to blindness and increase death rates for some diseases, including malaria,” UVM scientist Taylor Ricketts, who co-led the study, said in a press release.

Those at particular risk include mothers and children in countries like Mozambique, where as much as 56 percent of the population could be at risk of malnutrition if pollinators disappear.

“Ecosystem damage can damage human health,” Ricketts said. “Conservation can be thought of as an investment in public health.”
The decline of honeybees seen in many countries may be caused by reduced plant diversity, research suggests.

Bees fed pollen from a range of plants showed signs of having a healthier immune system than those eating pollen from a single type, scientists found. Writing in the journal Biology Letters, the French team says that bees need a fully functional immune system in order to sterilise food for the colony. Other research has shown that bees and wildflowers are declining in step. Two years ago, scientists in the UK and The Netherlands reported that the diversity of bees and other insects was falling alongside the diversity of plants they fed on and pollinated. Now, Cedric Alaux and colleagues from the French National Institute for Agricultural Research (INRA) in Avignon have traced a possible link between the diversity of bee diets and the strength of their immune systems. "We found that bees fed with a mix of five different pollens had higher levels of glucose oxidase compared to bees fed with pollen from one single type of flower, even if that single flower had a higher protein content," he told BBC News. Other new research, from the University of Reading, suggests that bee numbers are falling twice as fast in the UK as in the rest of Europe.

Forage fall

With the commercial value of bees' pollination estimated at £200m per year in the UK and $15 billion in the US, governments have recently started investing resources in finding out what is behind the decline. In various countries it has been blamed on diseases such as Israeli Acute Paralysis Virus (IAPV), infestation with varroa mite, pesticide use, loss of genetic diversity among commercial bee populations, and the changing climate. The most spectacular losses have been seen in the US where entire colonies have been wiped out, leading to the term colony collapse disorder. However, the exact cause has remained elusive.
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<th>Article</th>
<th>Local (within our city and state)</th>
<th>National (within our country)</th>
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<td>Brainstorm</td>
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<td>Article 1</td>
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### Standard 6.4.5 Learning Episode 6

**Student Science Performance**

<table>
<thead>
<tr>
<th>Topic: Biodiversity</th>
<th>Title: What is happening to the bees?</th>
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**Overarching Performance Expectations (Standard) from State Standards or NGSS:**

Standard 6.4.5 *Evaluate competing design solutions* for preserving ecosystem services that protect resources and biodiversity based on how well the solutions maintain stability within the ecosystem. Emphasize obtaining, evaluating, and communicating information of differing design solutions. Examples could include policies affecting ecosystems, responding to invasive species, or solutions for the preservation of ecosystem resources specific to Utah, such as air and water quality and prevention of soil erosion.

**Lesson Performance Expectations:** Students will understand that there are many ideas as to what causes Colony Collapse Disorder (CCD), but that scientists are unsure of what causes this to take place.

**Students Will... To Construct Meaning**

*Engage with a Phenomenon:*

*Bees are disappearing at an alarming rate.*

*Gather*

Students will watch the 30 second “Silence of the Bees” video. 
[Video link](http://www.pbs.org/wnet/nature/silence-of-the-bees-introduction/38/)

Students will then read about one of the several possible contributors to Colony Collapse Disorder (CCD).

*Reason*

Students meet with other members of the same factor (pesticides, mites, etc.) and discuss what they believe to be the most important information then record the information they will share on their graphic organizer.

*Communicate*

Students will then share in “expert groups” about their potential CCD factor and students will keep track of notes on their graphic organizer.

**Teacher Will... To Support Students**

*Management Strategy:* This learning episode requires a lot of reading. To prevent this lesson from becoming overwhelming, this will be laid out in a jigsaw format. Students will read about *one* possible factor contributing to CCD. They will then meet with the other students that read about that same factor. They will discuss what information will be most important for others to know. They will write this down on their graphic organizer. Students will then be given a number which will place them into a new group. This new group will have one expert from each factor. For example, when all the mites meet together, they will be given a number (1-7 depending on how big your class is). They will then meet with the other students that have the same number.

*Management Strategy:* Teacher will want to give time limits for each person that shares. This will ensure that groups stay on track and are mindful of how much time they have to share. Students will also need to keep track of notes in their graphic organizer. You may print this for students (found below assessment section), or have them copy it into their science notebooks.
**Articles on CCD Factors:**
Many of these are linked for teacher information. I have listed one article from each factor under the assessment section.

**Overview of CCD:**
1. [https://www.nrde.org/sites/default/files/bees.pdf](https://www.nrde.org/sites/default/files/bees.pdf)
2. [http://www.beesfree.biz/The%20Buzz/Bees-Dying](http://www.beesfree.biz/The%20Buzz/Bees-Dying)

**Mites:**
1. [https://entomology.ca.uky.edu/ef608](https://entomology.ca.uky.edu/ef608)
2. [https://www.sciencedaily.com/releases/2005/05/050517110843.htm](https://www.sciencedaily.com/releases/2005/05/050517110843.htm)

**Disease:**

**Human Populations or Contributions to CCD:**
1. [http://www.spiegel.de/international/world/collapsing-colonies-are-gm-crops-killing-bees-a-473166.html](http://www.spiegel.de/international/world/collapsing-colonies-are-gm-crops-killing-bees-a-473166.html)

**Pesticides:**
1. [https://www.sciencedaily.com/releases/2016/06/160624135849.htm](https://www.sciencedaily.com/releases/2016/06/160624135849.htm)

**Climate Change:**
2. [https://beependent.wordpress.com/climate-change/](https://beependent.wordpress.com/climate-change/)
Assessment of Student Learning

Formative: Check student graphic organizers for understanding. Have a short journaling session for students to write about what factors are causing Colony Collapse Disorder.
Follow with this prompt:
Write a short summary of what factors may cause CCD. Knowing what might cause CCD, what ways can you potentially help solve the problem?
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<th>Pesticides:</th>
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<th>Climate Change:</th>
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Why We Need Bees: 
Nature’s Tiny Workers Put Food on Our Tables

Many people think of bees simply as a summertime nuisance. But these small and hard-working insects actually make it possible for many of your favorite foods to reach your table. From apples to almonds to the pumpkin in our pumpkin pies, we have bees to thank. Now, a condition known as Colony Collapse Disorder is causing bee populations to plummet, which means these foods are also at risk. In the United States alone, more than 25 percent of the managed honey bee population has disappeared since 1990.1

Bees are one of a myriad of other animals, including birds, bats, beetles, and butterflies, called pollinators. Pollinators transfer pollen and seeds from one flower to another, fertilizing the plant so it can grow and produce food. Cross-pollination helps at least 30 percent of the world’s crops and 90 percent of our wild plants to thrive.2 Without bees to spread seeds, many plants—including food crops—would die off.

Bees Keep Our Economy Humming
More than $15 billion a year in U.S. crops are pollinated by bees, including apples, berries, cantaloupes, cucumbers, alfalfa, and almonds. U.S. honey bees also produce about $150 million in honey annually. But fewer bees means the economy takes a hit. The global economic cost of bee decline, including lower crop yields and increased production costs, has been estimated at as high as $5.7 billion per year.3 Keeping bee populations safe is critical for keeping American tables stocked with high-quality produce and our agriculture sector running smoothly.
Bees Are Disappearing Around the World

Beekeepers first sounded the alarm about disappearing bees in the United States in 2006. Seemingly healthy bees were simply abandoning their hives en masse, never to return. Researchers are calling the mass disappearance Colony Collapse Disorder, and they estimate that nearly one-third of all honey bee colonies in the United States have vanished. The number of lives in the United States is now at its lowest point in the past 30 years.

What’s Causing Colony Collapse Disorder

Researchers think this Colony Collapse Disorder may be caused by a number of interwoven factors:

- **Global warming**, which has caused flowers to bloom earlier or later than usual. When pollinators come out of hibernation, the flowers that provide the food they need to start the season have already bloomed.
- **Pesticide use** on farms. Some toxic pesticides meant to kill pests can harm the honey bees needed for pollination. Many pesticides banned by other countries because they harm bees are still available in the United States.
- **Habitat loss** brought about by development, abandoned farms, growing crops without leaving habitat for wildlife, and growing gardens with flowers that are not friendly to pollinators.
- **Parasites** such as harmful mites.

How We Can Protect Bees

Policy makers must take action to protect the bees and other pollinators that help keep fresh food on our table. This means:

- Farmers must be rewarded for practices that help wild bee populations thrive, such as leaving habitat for bees in their surrounding fields, alternating crops so bees have food all year long, and not using harmful pesticides. Assistance should be provided to farmers who plan to support a wider variety of pollinators beyond just bees.
- **Bee research** by the U.S. Department of Agriculture (USDA) and the Environmental Protection Agency (EPA) must be strengthened, and must also be broadened to include research on pollinators besides honey bees.
- **Integrated Pest Management (IPM)** techniques should be used to minimize pesticide use and risk to bees. By promoting beneficial insects to prey on pests, disrupting pest’s habitat and using least-toxic products when necessary, IPM methods can provide effective, cost-effective pest control while reducing risks to pollinators. NRDC research finds that USDA is missing critical opportunities to promote IPM when allocating billions of dollars through Farm Bill conservation programs.
- **City dwellers** can also practice IPM where they live, work, and play to protect our health, water quality, and pollinators. See the Green Shield Certified website (www.greenshieldcertified.org) to find out how you can contract for a certified IPM service provider for your home, school, or business.
- **Trouble in the hive?** Help the EPA investigate and document bee kill incidents. Report suspected pesticide problems at: http://nnpic.epa.gov/reportprob.html. Or by mail: beekill@epa.gov.

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Read more on bees:

See “The Vanishing Bee: a cover story in NRDC’s OnEarth Magazine” at http://www.nrdc.org/onearth/00sun/bees1.asp

Bee blogs on NRDC’s Switchboard website, such as the posts by bloggers Josh Mogerman and Melissa Waiger: http://switchboard.nrdc.org
Honey Bees Dying
What’s Going on in Honey Bee Colonies Worldwide?

Honey bees are continually exposed to numerous threats: pests and parasites (such as the Varroa mite or Nosema), bacterial diseases (foulbrood), fungal diseases (chalkbrood), viral diseases (invertebrate iridescent virus – IIV), and pesticides. Now honey bees are facing an even greater risk: Colony Collapse Disorder (or CCD), a little understood phenomenon in which worker bees from a colony abruptly disappear. Today, the disappearance of honey bees has transformed into a global epidemic, negatively affecting ecosystems in a multitude of environments. Since 2006, North American migratory beekeepers have seen an annual 30 percent to 90 percent loss in their colonies; non-migratory beekeepers noted an annual loss of over 50 percent. Similar losses were reported in Canada, as well as several countries in Europe, Asia, and Central and South America.

Why Are Bees Dying & What is Causing this Epidemic?

Because there are no bee bodies to examine, scientists are unable to determine the exact cause of death. Initial hypotheses were wildly different including environmental change-related stresses, malnutrition, pathogens (i.e., disease including Israel acute paralysis virus), mites, pesticides such as neonicotinoids or imidacloprid, radiation from cellular phones or other man-made devices, and genetically modified crops with pest control characteristics such as transgenic maize. Now most scientists believe that CCD is the result of an unfortunate combination of many factors all of which work to increase the honey bee’s stress and reduce its immune system.
**Why Should We Care?**

The impact honeybees have on the human population and the environment is far more crucial than we may think. Agricultural crops rely on honeybees worldwide to provide them with life and guarantee their reproduction. Bees facilitate pollination for most plant life, including well over 100 different vegetable and fruit crops. Without bees, there would be significantly less pollination, which would result in limited plant growth and lower food supplies. According to Dr. Albert Einstein, "If the bee disappears from the surface of the earth, man would have no more than four years to live. No more bees, no more pollination…no more men”. Bees’ eradication affects us more than we may think.

**What Are Scientists Doing to Help?**

Because a honey bee population collapse would mean an agricultural catastrophe, scientists have been working overtime in an attempt to determine the cause of CCD. Scientists have linked CCD to many factors including the Varroa mite and Nosema. Recently, a Harvard biologist published a study directly linking the pesticide imidacloprid. Still the consensus is that multiple factors are to blame which is why many scientists are looking at ways to improve a honey bees health as the potential solution.

**How Can We Help?**

One of the easiest ways to help rejuvenate the honeybee population is to respect honeybees. Learning to preserve beehives and embrace bees’ roles in our ecosystem can be challenging, but the bees have a job to do and threatening their quality of life will
consequently threaten everyone’s. There are also proactive ways to encourage the regrowth of honeybee colonies. Plant bee-attracting flowers, sponsor honeybee research, or even become a beekeeper. Join a local beekeepers’ association to become better informed about the care and keeping of honeybees and other steps you can take to stimulate colony growth and combat CCD.
Mites

**Bee Mites Suppress Bee Immunity, Open Door For Viruses And Bacteria**

A non-native bee mite is causing the dramatic and sudden collapse of bee colonies across the country, but Penn State researchers believe they have found the combination of factors that triggers colony deaths which includes suppression of the bee immune system by the mites.

The Varroa destructor mite is a honey bee parasite that feeds much like a tick on the body of a bee. The mites are about the size of a pin head, dark brown in color and visible on close inspection.

This bee mite probably arose in the Eastern or Chinese Honey Bee population and hopped over to the United States in 1987. They quickly infested western or European honey bees. One sign of infection is the presence of bees with deformed wings. Also, sometimes seemingly healthy colonies become ill and the complete hive collapses in about two weeks.

"The native Chinese bees do not have the same problems," says Dr. Xiaolong Yang, post doctoral researcher in entomology and plant pathology, who raised bees in China. "I do not recall seeing deformed wing bees in the Chinese bee. Chinese honey bees have grooming behavior which can remove the mites from the bees. They get rid of the mites."

While researchers know that the Varroa mite is behind the death of bee colonies, the mechanism causing the deaths is still unknown. Yang and Dr. Diana L. Cox-Foster, Penn State professor of entomology, now believe that a combination of bee mites, deformed wing virus and bacteria is causing the problems occurring in hives across the country.

"Once one mite begins to feed on a developing bee, all the subsequent mites will use the same feeding location," says Cox-Foster "Yang has seen as many as 11 adult mites feeding off of one
Deformed wing virus is endemic among honey bees in the U.S., although when the European bees became historically infested with this virus, is unknown. However, simply having deformed wing virus does not cause bees to emerge from the pupa state with deformed wings, nor does it cause colony deaths.

"A group of Japanese researchers found that a virus that is 99 percent the same as deformed wing, appears in in the brains of aggressive guard bees," says Cox-Foster. "Guard bees that are aggressive better protect the hive, so there may be some positive effect in this virus that allows it to persist in a colony."

The combination of bee mite infestation and deformed wing virus does cause deformed wings in about a quarter of the emerging bees. This, however, does not lead to sudden hive collapse. Something else is involved that makes bee mites so harmful to bee colonies.

The Penn State researchers report their findings in today's (May 17) online version of the Proceedings of the National Academy of Science.

Yang and Cox-Foster looked at how bee mites affect the bee immune system. They injected heat-killed E. coli bacteria into virus-infected bees that were either infested with bee mites or mite free. The dead bacteria was used to trigger an immune response in the bees in the same way human vaccines cause our bodies to produce an immune response. They checked the bees for production of chemicals that disinfect the honey and for other immunity related chemicals.

They also measured the amount of virus in each bee. Surprisingly, they found that the virus in mite-infested bees rapidly increased to extremely high levels when the bee was exposed to the bacteria. The virus levels in mite-free bees did not change when the bee was injected with bacteria.

One chemical, GOX or glucose oxidase, is put into the honey by worker bees and sterilizes the honey and all their food. If bees have mites, their production of GOX decreases.
"As mites build up, we suspect that not as much GOX is found in the honey and the honey has more bacteria," says Cox-Foster. "It is likely that the combination of increased mite infestation, virus infection and bacteria is the cause of the two-week death collapse of hives."

The mites suppressed other immune responses in the bees, leaving the bees and the colonies more vulnerable to infection. The bee mites transfer from adult bees to late stage larva. The virus can be transferred through many different pathways.

"This system is important not only because of what the mites are doing to honey bee populations in the U.S., but because it can be used as a model system for exploring what happens to viruses in animal or human populations," says Cox-Foster. "If we view the colony as a city, then we have a variety of infection modes -- queen to eggs, workers to food supply, bee to bee, and parasite to bee."
Scientists sifting genetic material from thriving and ailing bee colonies say a virus appears to be a prime suspect — but is unlikely to be the only culprit — in the mass die-offs of honeybees reported last fall and winter.

The die-offs, in which adult bees typically vanished without returning to hives, were reported by about a fourth of the nation’s commercial beekeepers. The
losses captured public attention as rumors swirled about causes, like climate change, cellphone signals and genetically-modified crops. Scientists have rejected those theories.

Now, one bee disease, called Israeli acute paralysis virus, seems strongly associated with the beekeeping operations that experienced big losses, a large research group has concluded, although members of the team emphasized that they had not proved the virus caused the die-offs.

“I hope no one goes away with the idea that we’ve actually solved the problem,” said Jeffrey S. Pettis, an entomologist with the Department of Agriculture and co-director of a national group working on the puzzle, which has been given the name colony collapse disorder.

The project involved an unusual partnership between entomologists and scientists working at the leading edge of human genetic research. It employed the same technology being used to decode Neanderthal DNA and the personal genome of James Watson, a co-discoverer of the structure of DNA.

The research was described yesterday in Science Express, the online edition of the journal Science. Details are available at eurekalert.org/bees.

Even with the caveats, the possible identification of a virus involved in large bee die-offs is “exceptionally important,” said May Berenbaum, who heads the entomology department at the University of Illinois, Urbana-Champaign, and was not involved in the study. “Among other things, figuring out where this one came from will help us prevent future problems.”
Dr. Berenbaum, who led a 2006 National Academies study of problems with bees and other pollinators, said that finding ways to swiftly home in on novel diseases is ever more important in a globally linked economy. She noted that the first reports of the latest bee die-offs in the United States came in 2004, the first year the country allowed the import of honeybees — from Australia in this case — since 1922.

The new study found evidence of the virus in some Australian bee samples, although that country has not reported die-offs like those seen in the United States.

Dr. Pettis said that even if the virus was involved, it was likely that more than one factor had to align for a hive to collapse, with another possible influence being poor nutrition. Most of the colonies that had big losses last winter were in areas that experienced drought a few months beforehand, and thus a lack of nectar in flowers, he said.

Another factor, Dr. Pettis said, could be the stress that comes from the increasingly industrial-style beekeeping operations in the United States, in which truckloads of hives crisscross the country to pollinate California almonds or Florida orchards each season.

But the virus stands out as a top suspect. While seven viruses and a host of bacteria and parasites were identified in the genetic screening, only the Israeli bee virus, first identified in 2004, was strongly tied to the samples taken from keepers who reported the collapse disorder.
A new study has suggested that cell phone radiation may be contributing to declines in bee populations in some areas of the world.

Bee populations dropped 17 percent in the UK last year, according to the British Bee Association, and nearly 30 percent in the United States says the U.S. Department of Agriculture. Parasitic mites called varroa, agricultural pesticides and the effects of climate change have all been implicated in what has been dubbed "colony collapse disorder" (CCD).

But researchers in India believe cell phones could also be to blame for some of the losses. In a study at Panjab University in Chandigarh, northern India, researchers fitted cell phones to a hive and powered them up for two fifteen-minute periods each day. After three months, they found the bees stopped producing honey, egg production by the queen bee halved, and the size of the hive dramatically reduced.

It's not just the honey that will be lost if populations plummet further. Bees are estimated to pollinate 90 commercial crops worldwide. Their economic value in the UK is estimated to be $290 million per year and around $12 billion in the U.S.

Andrew Goldsworthy, a biologist from the UK's Imperial College, London, has studied the biological effects of electromagnetic fields. He thinks it's possible bees could be affected by cell phone radiation.

The reason, Goldsworthy says, could hinge on a pigment in bees called cryptochrome. "Animals, including insects, use cryptochrome for navigation," Goldsworthy told CNN. "They use it to sense the direction of the earth's magnetic field and their ability to do this is compromised by radiation from [cell] phones and their base stations. So basically bees do not find their way back to the hive."

Goldsworthy has written to the UK communications regulator OFCOM suggesting a change of phone frequencies would stop the bees being confused. "It's possible to modify the signal coming from the [cell] phones and the base station in such a way that it doesn't produce the frequencies that disturb the cryptochrome molecules," Goldsworthy said. "So they could do this without the signal losing its ability to transmit information."

But the UK's Mobile Operators Association -- which represents the UK's five mobile network operators -- told CNN: "Research scientists have already considered possible factors involved in CCD and have identified the areas for research into the causes of CCD which do not include exposure to radio waves."

Norman Carreck, Scientific director of the International Bee research Association at the UK's University of Sussex says it's still not clear how much radio waves affect bees. "We know they are sensitive to magnetic fields. What we don't know is what use they actually make of them. And no one has yet demonstrated that honey bees use the earth's magnetic field when navigating," Carreck said.
The large-scale, long-term decline in wild bees across England has been linked to the use of neonicotinoid insecticides by a new study.

Over 18 years, researchers analysed bees who forage heavily on oilseed, a crop widely treated with "neonics".

The scientists attribute half of the total decline in wild bees to the use of these chemicals.

Industry sources say the study shows an association, not a cause and effect.

Weighing the evidence

In recent years, several studies, conducted in the lab and in the field, have identified a negative effect on honey bees and bumble bees from the use of neonics.

But few researchers have looked at the long term impacts of these substances.

This new paper examined the impacts on populations of 62 species of wild bees across England over the period from 1994-2011.

The team, from the Centre for Ecology and Hydrology (CEH), used distribution data on wild bees, excluding honey and bumblebees collected by the bees, ants and wasps recording scheme.

They were able to compare the locations of these bees and their changing populations with growing patterns of oilseed across England over 18 years.

The amount of this crop being sown has increased significantly over the period of the study, from around 500,000 hectares in 1994 to over 700,000 in 2011.
A key innovation was the commercial licensing of neonicotinoid insecticides for the crop in the UK in 2002. Seeds are coated with the chemical and every part of the plant becomes toxic to pests.

Manufacturers hailed the development as a major advance, reducing the need for leaf spraying with other insecticides. Around 85% of the oilseed crop in England now uses this method for pest protection.

'Long term, large scale'

But this new work suggests, for the first time, that the detrimental impacts seen in the lab can be linked to large scale population extinctions of wild bees, especially for those species of bees that spend longer foraging on oilseed.

"The negative effects that have been reported previously do scale up to long-term, large-scale multi-species impacts that are harmful," said Dr Nick Isaac, a co-author of the new paper.

"Neonicotinoids are harmful, we can be very confident about that and our mean correlation is three times more negative for foragers than for non-foragers."

There was a decline in the number of populations of 10%, attributable to neonicotinoids, across the 34 species that forage on oilseed. Five of the species showed declines of 20% or more, with the worst affected declining by 30%. Overall, half the total decline in wild bees could be linked to the chemicals.

"Historically, if you just have oilseed, many bees tend to benefit from that because it is this enormous foraging resource all over the countryside," said lead author Dr Ben Woodcock from the CEH.

"But this co-relation study suggests that once it is treated with neonicotinoids up to 85%, then they are starting to be exposed and it's starting to have these detrimental impacts on them."
As if pesticides, disease and habitat loss were not enough, there's more bad news for bees. Changing temperature and weather conditions due to climate change has restricted the area where bees can survive, and the pollinators have struggled to adapt, according to new research published in the journal *Science*.

"They just aren't colonizing new areas and establishing new populations fast enough to track rapid human-caused climate change," said study author Jeremy Kerr, a professor at the University of Ottawa, on a call for journalists. "Impacts are large and they are underway. They are not just something to worry about at some vague, future time."

For the study, researchers looked at 110 years of data on 67 bumblebee species to track their movements over time. Activity between 1901 and 1974 was compared to movement in recent decades when climate change accelerated. In the northern end of their range, bees have failed to migrate closer to the North pole. In the southern end, many populations have died. Altogether, bees have lost a range of up to nearly 200 miles in both North America and Europe. The study, which evaluated land use changes and pesticide application in addition to weather conditions, attributed the drop to climate change.

The landmark study adds to scientists' understanding of how different species respond to climate change. Many animals—like the butterfly—have adjusted to a changing climate by migrating towards the Earth's poles. But the research on bees suggests that not all species have the
same ability to adjust. Though bees can easily move from location to location, researchers suggested the migration may not have occurred because they have trouble setting up a home in a new place.

"This paper is important because it reinforces our understanding that species will not all be able to shift their ranges in order to adapt to a changing climate," said Sacha Vignieri, an associate editor for the journal Science. "It provides important insight into further potential stressors to bee populations, which are already generally declining and under significant threat."

While climate change threatens many species, bees and other pollinators have received special attention at least in part because of the important role they play in agriculture. The White House, along with environmental groups, has been a particularly strong advocate, calling for an increase in the size of pollinator habitats. Bees add $15 billion in value to the U.S. agricultural sector by pollinating fruits, nuts and vegetables, according to the White House.

"Reduced crop pollination will reduce crop yield for some species, making food more expensive and some crops harder to grow successfully," said University of Ottawa researcher Alana Pindar on a conference call for journalists.

The researchers suggested a number of steps that could temporarily help mitigate the threat to the bees like assisted migration—a practice where authorities pick up bees and move them—and the creation of "safe havens." But researchers said that humans need to handle climate change comprehensively to save the bees once and for all.

"Climate change is clearly bad enough, but hitting bumblebee species with extra threats can only harm them further," said Kerr. "Above all, we must reduce greenhouse gas pollution and come to grips convincingly with the climate change threat."
## Standard 6.4.5 Learning Episode 7

<table>
<thead>
<tr>
<th><strong>Student Science Performance</strong></th>
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<tbody>
<tr>
<td><strong>Topic:</strong> Biodiversity</td>
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</table>

Overarching Performance Expectations (Standard) from State Standards or NGSS:
Standard 6.4.5 *Evaluate competing design solutions* for preserving ecosystem services that protect resources and biodiversity based on how well the solutions maintain stability within the ecosystem. Emphasize obtaining, evaluating, and communicating information of differing design solutions. Examples could include policies affecting ecosystems, responding to invasive species, or solutions for the preservation of ecosystem resources specific to Utah, such as air and water quality and prevention of soil erosion.

Lesson Performance Expectations: Students will identify possible solutions to CCD, and start to develop an action plan to save the bees.

<table>
<thead>
<tr>
<th>Students Will. . . To Construct Meaning</th>
<th>Teacher Will. . . To Support Students</th>
</tr>
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<tbody>
<tr>
<td><strong>Engage with a Phenomenon:</strong></td>
<td></td>
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<tr>
<td><em>Bees are disappearing at an alarming rate but we can help!</em></td>
<td>Start by introducing what is already being done to protect bees. Share this short video and link to ideas on ways everyone can help save the bees!:</td>
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<tr>
<td></td>
<td><strong>Introduce the Saving America’s Pollinators Act</strong></td>
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<tr>
<td></td>
<td>Video: <a href="https://www.youtube.com/watch?v=eicgb8-G7Q0">https://www.youtube.com/watch?v=eicgb8-G7Q0</a></td>
</tr>
<tr>
<td><strong>Gather</strong></td>
<td>Information about the Act: <a href="https://secure2.convio.net/abcb/site/Advocacy?cmd=display&amp;page=UserAction&amp;id=301">https://secure2.convio.net/abcb/site/Advocacy?cmd=display&amp;page=UserAction&amp;id=301</a></td>
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<tr>
<td><strong>Reason</strong></td>
<td>Have a discussion with students on how they feel about the act. Management Strategy: Think-pair-share. Students will think about the act and decide whether or not they support it. They will pair up with their elbow partner to discuss, then the class will discuss their thinking. Management Strategy: Teacher will write their</td>
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</table>
Communicate
Students will write an argumentative essay to a legislator on the importance of bees and what we can do to protect them.

I want you to think about how you feel about this act? Will it do enough to save the bees?

Discussion questions for students:
- What evidence do you have about the importance of bees in an ecosystem?
- What are the potential consequences of a continuous decline in bee populations?
- What can we do to help maintain or improve the livelihood of bee colonies?

Share the following prompt with students:
Your local representative from the Utah legislature is hosting a town hall meeting. One of the issues that will be discussed at the meeting is the Saving America’s Pollinators Act. Your job is to write an argument sharing your support or opinion of the act, as well as any other ways we can save the bees. Be sure your argument has a claim, and that you provide evidence and reasoning based on what you have learned about the role of bees in an ecosystem.

Assessment of Student Learning

Teacher will formally grade argumentative essays.

<table>
<thead>
<tr>
<th>Introduction</th>
<th>1-10</th>
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<tbody>
<tr>
<td>The writer wrote an introduction to interest readers and help them understand and care about the topic or text. The writer made sure the introduction would fit with the whole. Not only did the writer clearly state their claim, they also told the readers how the text will unfold.</td>
<td></td>
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<tr>
<td>Transitions 1-5</td>
<td>The writer used transitions to help readers understand how the different parts of his piece fit together to explain and support their argument. The writer used transitions to help connect claim(s), reasons, and evidence.</td>
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<tr>
<td>Conclusion 1-10</td>
<td>In the conclusion, the writer restated the important points and offered a final insight or implication for readers to consider. The ending strengthened the overall argument.</td>
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<tr>
<td>Organization 1-10</td>
<td>The writer organized the argument into sections: arranged reasons and evidence purposefully, leading readers from one claim or reason to another. The order of the sections and the internal structure of each section made sense.</td>
</tr>
<tr>
<td>Elaboration 1-10</td>
<td>The writer included and arranged a variety of evidence such as facts, quotations, examples, and definitions. The writer used trusted sources and information from experts and gave the sources credit. The writer worked to explain how the reasons and evidence they gave supported their claim(s) and strengthened their argument.</td>
</tr>
<tr>
<td>Craft 1-10</td>
<td>The writer chose their words carefully to support their argument and to have an effect on the reader. The writer worked to include concrete details, comparisons, and/or images to convey ideas, build the argument, and keep the reader engaged. When necessary, the writer explained terms to readers, providing definitions, context clues or parenthetical explanations.</td>
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<tr>
<td>Spelling 1-5</td>
<td>The writer used resources to be sure the words in their writing were spelled correctly, including returning to sources to check spelling</td>
</tr>
<tr>
<td>Punctuation and Sentence Structure 1-5</td>
<td>The writer used punctuation such as dashes, colons, parentheses, and semicolons to help include or connect information in some of the sentences. The writer punctuated quotes and citations accurately</td>
</tr>
<tr>
<td>Overall 1-10</td>
<td>The writer explained the topic/text and staked out a position (claim) that can be supported by a variety of trustworthy sources. Each part of the text built their argument, and led to a conclusion.</td>
</tr>
</tbody>
</table>

Total /75

Adapted from: https://www.staffordschools.org/cms/lib/NJ01001734/Centricity/Domain/24/Grade%206%20Argument%20Rubric.pdf