TN Department of Education

Teacher Training
Grade 3

Tennessee Academic Standards for Science

Tennessee Department of Education | Summer 2018

Welcome, science teachers!

We're excited to welcome you to our Teacher Training on the new Tennessee Academic Standards for Science. We appreciate your dedication to the students in your classroom and to your growth as an educator. We hope you are able to use the Tennessee Academic Standards for Science, the eight lessons created by Tennessee educators for your grade level, and the two days of training content, to support your students and serve as a resource to other teachers in your school and district. You do outstanding work every year, and our hope is that the knowledge you gain this week will enhance the high-quality instruction you provide Tennessee's students.

We are honored that the new science standards, training content, and sample lessons were developed by and with Tennessee educators for Tennessee educators. We believe it is important for our standards and professional development to be informed by current practitioners who work each day to cultivate every student's potential.

—Dr. Candice McQueen, Commissioner, Tennessee Department of Education

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Digital Training Resources

Access Teacher Training Digital Resources here:

goo.gl/hss2EY **or**

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Teacher Training Digital Resources

Training Resources	K-12 Science Framework Links	TDOE Science Documents	STEM Teaching Tools

• Training Agenda
• Presentation, Manual, and Activities
• Three-dimensional Lesson Planning Tool
	• NRC Document Cover Page
	• Science and Engineering Practices
	• Crosscutting Concepts
	• Disciplinary Core Ideas
	  ○ Physical Science
	  ○ Life Science
	  ○ Earth and Space Sciences
	  ○ Eng., Tech., & Applications
		• Tennessee Academic Standards for Science
		• TN Science Standards Implementation Guide
		• TN Science Standards Reference
			• Integrating Science Practices Into Assessment Tasks
			• Prompts for Integrating Crosscutting Concepts Into Assessment and Instruction

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Teacher Training Agenda Day One

7:30–8 a.m.	Sign-in
8–8:30 a.m.	Introduction and Goals
8:30–9:30 a.m.	Three-dimensional Activity
9:30–10:30 a.m.	Three-dimensional Instruction
10:30–10:40 a.m.	Break
10:40–11:30 a.m.	Three-dimensional Instruction
11:30 a.m.–12:45 p.m.	Lunch
12:45–1:15 p.m.	Grade-level Standards Activity
1:15–3:45 p.m. (includes break)	Three-dimensional Learning Activities
3:45–4 p.m.	Closing

Day One Activities

- Learn about the components of the new Tennessee Academic Standards for Science
- Review the science standards for our grade
- Participate in lessons aligned to the new Tennessee Academic Standards for Science

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Teacher Training Agenda Day Two

8–8:05 a.m.	Welcome Back!
8:05–11:25 a.m. (includes break)	Three-dimensional Activities
11:25–11:30 a.m.	Morning Debrief
11:30 a.m.–12:45 p.m.	Lunch
12:45–3:45 p.m. (includes break)	Instructional Planning
3:45–4 p.m.	Closing

Day Two Activities

- Participate in lessons aligned to the new Tennessee Academic Standards for Science
- Discuss literacy and instructional strategies in the science classroom
- Utilize an instructional planning tool to plan a three-dimensional learning activity

Standards Timeline

Fall 2018

New TN Science Standards in the Classroom

Spring 2019

Operational Field Test

- Data used to test the reliability of the questions
- No data reported to teachers, schools, or districts
- No accountability measures reported for science
- Grades 3-8 take TNReady field test
- No chemistry EOC field test
- EOC field test for biology
    - Students only take EOC in spring 2019
    - Students taking biology in the fall on a block schedule do not take an EOC

Fall 2019

Second Year of Science Standards in the Classroom

Spring 2020

Fully Operational Test

- Fully operational assessment
- No chemistry EOC

Summer 2020

Standard Setting

- This is the process where Tennessee educators set the performance levels based on the results of the fully operational assessment
- Based on all scores across the state

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A Framework for K–12 Science Education

Key Terms from the Framework

Term	Notes
Discipline	
Dimension	
Three-dimensional	
Phenomena	
Grade Band Endpoints	

Three-dimensional Science Instruction

Science and Engineering Practices (SEPs)

What will my students **do** to learn science content?

- Asking Questions and Defining Problems
- Developing and Using Models
- Planning and Carrying Out Investigations
- Analyzing and Interpreting Data
- Using Mathematics and Computational Thinking
- Constructing Explanations and Designing Solutions
- Engaging in Argument from Evidence
- Obtaining, Evaluating, and Communicating Information

Notes:

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Three-dimensional Science Instruction

Science and Engineering Practices (SEPs)

What will my students **do** to learn science content?

Asking Questions and Defining Problems	***Developing and Using Models***
Planning and Carrying Out Controlled Investigations	***Constructing Explanations and Designing Solutions***

TN Department of Education

Three Science Words We Should Stop Using

By Rhett Allain, Associate Professor of Physics at Southeastern Louisiana University

Hypothesis:
In my opinion, this one is the worst. The worst science word ever! Well, not ever, but currently. Try this. Find some people and ask—what is a hypothesis? Just about everyone you ask will say:

> *"A hypothesis? That's easy. A hypothesis is an educated guess. BOOM! Give me another easy question."*

This is exactly why we should abolish this word. It has been reduced to a word association game. What is an educated guess anyway? That doesn't even make sense. But what about hypothesis testing? What about science fairs? How can we do these things without the word "hypothesis"? I would recommend not requiring science fair posters to use the word hypothesis. As for hypothesis testing—I will let that stay.

What does hypothesis really mean?
Well, from the Middle French *hypothese*, it means the basis of an argument. This isn't so bad, but it does *not* mean a guess. I think the best current use of the word hypothesis is the testable predictions from an idea.

Let's look at an example. Suppose I have this idea that a constant net force on an object will make it go at a constant speed. In that case, my hypothesis will be that if I apply a constant force to an object, it will indeed go at a constant speed. This could be tested in real life.

Theory:
How about we continue to pretend to ask people what this word means. Here is my generic human answer. Yes, I am gearing this response towards the general population in a slightly negative way. I'm sorry about that. I don't mean to say that humans are stupid but rather the use of this word has transformed into a negative use.

> *"A theory is a scientist's crazy idea about how something works. Really, when something is a theory, it may or may not be true. You know, like evolution. It's just a theory."*

Three Science Words We Should Stop Using

What is a theory?
A theory can be replaced with another word - see below. But as it is, a theory is a scientific idea. It's not just a crazy made-up idea or wild guess. No, it is an idea that is supported by evidence. Does that mean it's true? Actually, science is not about *the truth.* I will talk more about this in a bit.

Scientific Law:
My favorite example of a scientific law is the law of energy conservation. This says that in a closed system, the total energy remains the same. Ok. Now, what is the common idea about laws?

> *"A scientific law is the next phase for a theory. Once it has been proven to be true, the theory becomes a law. This is just like that School House Rock video about how a bill becomes a law. Same thing, except for SCIENCE."*

What is a scientific law?
It's not really an upgraded theory. No, a law is just more like a generalization. The law of energy conservation is general in that it can be applied in many different cases. It can be used when looking at the collision of two particles, or light produced from a lightbulb, or a pot of water boiling on a stove. Does this mean it's true? No, you didn't read my last point where I said that science wasn't about the truth, did you?

One Word to Replace Them All
Take out all three of these "science" words from introductory texts. They do more harm than good. The problem is that people have firm beliefs that they mean something other than what they are supposed to mean. I don't think we can save these words.
We do have a word to replace them. Are you ready? It's the **model** - or you can call it the scientific model if you prefer.

What is a model?
If I say "model," what do you think of? Do you think of a plastic Corvette that you can pick up with your hands? Yep, that's a model. We agree on this idea of a model. Science is all about making models. Sometimes these models are just like tiny plastic cars, but sometimes they can take other forms. Here are some examples:

Three Science Words We Should Stop Using

Physical Model
Look at a globe—you know, of the earth. This is a physical model of the Earth. It has some features that are the same as the Earth (such as the relative locations of the continents)—but it is not the Earth. It doesn't have the same size or density as the Earth. It's clearly not the Earth. The model is still useful even if it isn't the real Earth.

Mathematical Model
What happens when you have a net force on an object?
That force changes the momentum of the object.
I can also write this idea as an equation (or two equations).

$$\vec{F}_{\text{net}} = \frac{d\vec{p}}{dt}$$
$$\vec{p} = m\vec{v}$$

The equation explains the idea. The momentum principle (above) is a great example of a model that is wrong—but still useful. We say that the momentum vector is the mass of the object times its velocity vector. This is very useful, but it doesn't work when the object's speed is near the speed of light. There is a better expression for the momentum that is more valid—but it is also more complicated.

Conceptual Model
If you rub a nail with a magnet, that nail (if it is ferromagnetic) will then also behave like a magnet. The conceptual model for this phenomena is the domain model of magnets. It says that a ferromagnetic material is made of magnetic domains. If these domains are all aligned in the same direction, the material will act like a magnet.

So, how does a model replace the three words I don't like? Well, if we say science is all about making models, you don't have to use the word “hypothesis.” Instead you can talk about the predictions a model makes (testable predictions). A theory is a model, so that would be a one to one replacement. What about laws? I don't think it would be terrible to also replace laws with the word "model.” Really, I doubt I would ever succeed in having people stop calling it "the law of energy conservation.” Even I would have a difficult time at that.

Science is really about making models and about playing. Yes, playing. Playing isn't just for kids; adults just get better toys. I just wish grade-level (and some college-level) books would move away from defining things and stating pieces of science and focus on the playing part. Many science classes as they are taught now are like studying the different parts of a clarinet—but never playing any music.

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Three Science Words We Should Stop Using

Hypothesis

Say This:	Not That:

Scientific Law

Say This:	Not That:

Theory

Say This:	Not That:

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Three-dimensional Science Instruction

Science and Engineering Practices (SEPs)

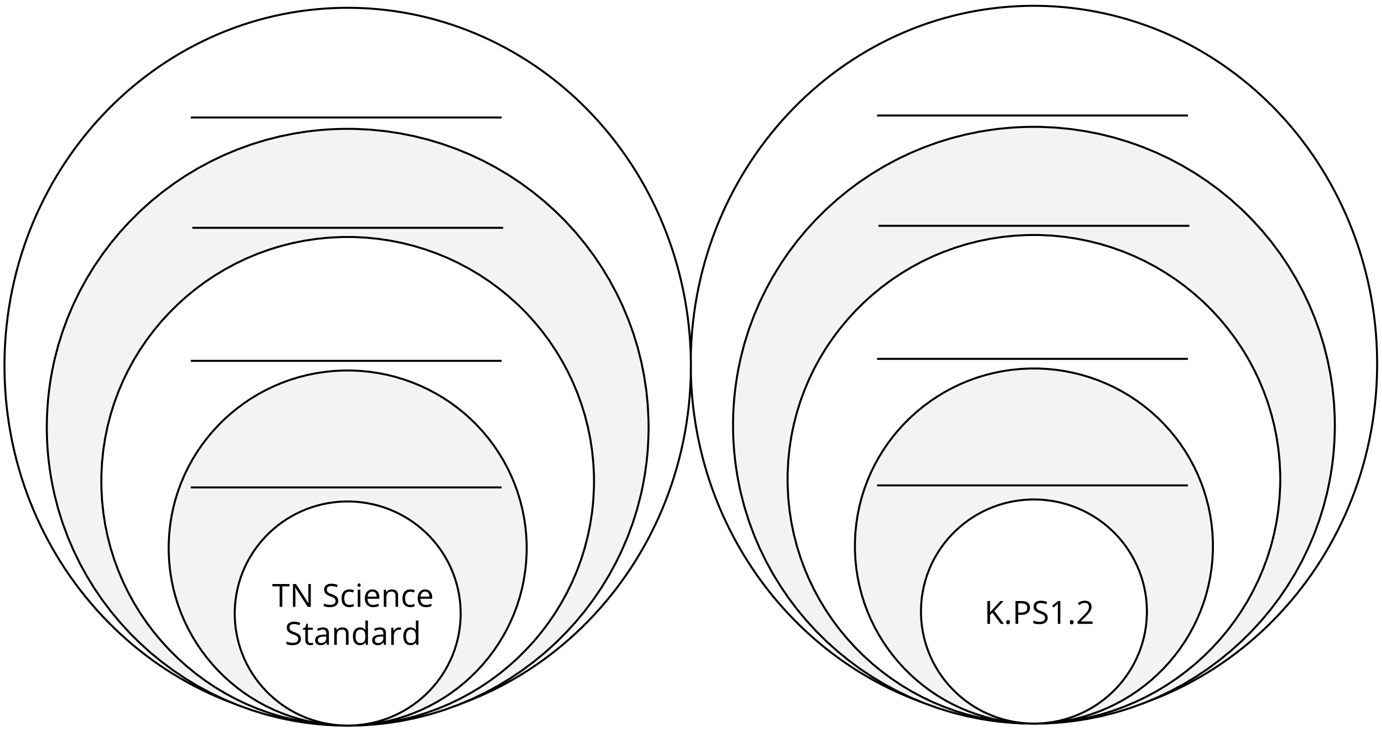
What will my students **do** to learn science content?

Using Mathematics and Computational Thinking	***Analyzing and Interpreting Data***
Engaging in Argument from Evidence	***Obtaining, Evaluating, and Communicating Information***

Three-dimensional Science Instruction

Disciplinary Core Ideas

What science content will my students **know**?



			Standard
			K.PS1.2 – Conduct investigations to understand that matter can exist in different states (solid and liquid) and has properties that can be observed and tested.

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Three-dimensional Science Instruction

Disciplinary Core Ideas

What science content will my students **know**?

Grade Band Endpoints for LS3.A: Inheritance of Traits	Tennessee Academic Standards for Science
By the end of grade 2: Organisms have characteristics that can be similar or different. Young animals are very much, but not exactly, **like their parents and also resemble other animals of the same kind**. Plants also are very much, but not exactly, **like their parents and resemble other plants of the same kind**. (NRC, p.158)	K.LS3.1: Make observations to describe that **young plants and animals resemble their parents**.
By the end of grade 5: Many characteristics of organisms are **inherited from their parents**. Other characteristics result from individuals' **interactions with the environment**, which can range from diet to learning. Many characteristics involve **both inheritance and environment.** (NRC, p.158)	5.LS3.1: Distinguish between **inherited characteristics** and those characteristics that result from a direct **interaction with the environment**. Apply this concept by giving examples of characteristics of living organisms that are influenced by **both inheritance and the environment.**
By the end of grade 8: **Genes are located in the chromosomes of cells**, with each chromosome pair containing two variants of each of many distinct genes. Each distinct gene chiefly controls the production of a specific protein, which in turn affects the traits of the individual….**Changes (mutations)** to genes can result in changes to proteins, which can affect the **structures and functions of the organism** and thereby change traits. (NRC, pp.158–159)	7.LS3.1: Hypothesize that the impact of **structural changes** to **genes** (i.e., **mutations**) **located on chromosomes** may result in harmful, beneficial, or neutral effects to the **structure and function of the organism.**

Three-dimensional Science Instruction

Crosscutting Concepts (CCCs)

What will my students **understand** about science?

- Pattern
- Cause and Effect
- Scale, Proportion, and Quantity
- Systems and System Models
- Energy and Matter
- Structure and Function
- Stability and Change

Notes:

Three-dimensional Science Instruction

Crosscutting Concepts (CCCs)

What will my students **understand** about science?

Pattern	***Cause and Effect***
Scale, Proportion, and Quantity	

Three-dimensional Science Instruction

Crosscutting Concepts (CCCs)

What will my students **understand** about science?

Systems and System Models	***Energy and Matter***
Structure and Function	***Stability and Change***

Third Grade Standards

3.PS1: Matter and Its Interactions

1) Describe the properties of solids, liquids, and gases and identify that matter is made up of particles too small to be seen.

2) Differentiate between changes caused by heating or cooling that can be reversed and that cannot.

3) Describe and compare the physical properties of matter including color, texture, shape, length, mass, temperature, volume, state, hardness, and flexibility.

3.PS2: Motion and Stability: Forces and Interactions

1) Explain the cause and effect relationship of magnets.

2) Solve a problem by applying the use of the interactions between two magnets.

3.PS3: Energy

1) Recognize that energy is present when objects move; describe the effects of energy transfer from one object to another.

2) Apply scientific ideas to design, test, and refine a device that converts electrical energy to another form of energy, using open or closed simple circuits.

3) Evaluate how magnets cause changes in the motion and position of objects, even when the objects are not touching the magnet.

3.LS1: From Molecules to Organisms: Structures and Processes

1) Analyze the internal and external structures that aquatic and land animals and plants have to support survival, growth, behavior, and reproduction.

3.LS2: Ecosystems: Interactions, Energy, and Dynamics

1) Construct an argument to explain why some animals benefit from forming groups.

Third Grade Standards

3.LS4: Biological Change: Unity and Diversity

1) Explain the cause and effect relationship between a naturally changing environment and an organism's ability to survive.

2) Infer that plant and animal adaptations help them survive in land and aquatic biomes.

3) Explain how changes to an environment's biodiversity influence human resources.

3.ESS1: Earth's Place in the Universe

1) Use data to categorize the planets in the solar system as inner or outer planets according to their physical properties.

3.ESS2: Earth's Systems

1) Explain the cycle of water on Earth.

2) Associate major cloud types (cumulus, cumulonimbus, cirrus, stratus, nimbostratus) with weather conditions.

3) Use tables, graphs, and tools to describe precipitation, temperature, and wind (direction and speed) to determine local weather and climate.

4) Incorporate weather data to describe major climates (polar, temperate, tropical) in different regions of the world.

3.ESS3: Earth and Human Activity

1) Explain how natural hazards (fires, landslides, earthquakes, volcanic eruptions, floods) impact humans and the environment.

2) Design solutions to reduce the impact of natural hazards (fires, landslides, earthquakes, volcanic eruptions, floods) on the environment.

Third Grade Standards

3.ETS1: Engineering Design

1) Design a solution to a real-world problem that includes specified criteria for constraints.

2) Apply evidence or research to support a design solution.

3.ETS2: Links Among Engineering, Technology, Science, and Society

1) Identify and demonstrate how technology can be used for different purposes.

Why new standards?

What connections can you make from the three dimensions of science instruction (disciplinary core ideas, science and engineering practices, and crosscutting concepts) to the indicators in the TEAM rubric?

- Highlight or annotate evidence of the three dimensions in the rubric.

<table>
<tr><th colspan="2">Instruction</th></tr>
<tr><td>Thinking</td><td>The teacher thoroughly teaches two or more types of thinking:
● analytical thinking, where students analyze, compare and contrast, and evaluate and explain information;
● practical thinking, where students use, apply, and implement what they learn in real-life scenarios;
● creative thinking, where students create, design, imagine, and suppose; and
● research-based thinking, where students explore and review a variety of ideas, models, and solutions to problems.

The teacher provides opportunities where students:
● generate a variety of ideas and alternatives;
● analyze problems from multiple perspectives and viewpoints; and
● monitor their thinking to insure that they understand what they are learning, are attending to critical information, and are aware of the learning strategies that they are using and why.</td></tr>
<tr><td>Problem Solving</td><td>The teacher implements activities that teach and reinforce three or more of the following problem-solving types:
● Abstraction
● Categorization
● Drawing Conclusions/Justifying Solutions
● Predicting Outcomes
● Observing and Experimenting
● Improving Solutions
● Identifying Relevant/Irrelevant Information
● Generating Ideas
● Creating and Designing</td></tr>
</table>

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<table>
<tr><th colspan="2">Instruction</th></tr>
<tr><td>Motivating Students</td><td>The teacher consistently organizes the content so that it is personally meaningful and relevant to students.
The teacher consistently develops learning experiences where inquiry, curiosity, and exploration are valued.
The teacher regularly reinforces and rewards effort.</td></tr>
<tr><td>Activities and Materials</td><td>Activities and materials include all of the following:
support the lesson objectives,
are challenging,
sustain students’ attention,
elicit a variety of thinking,
provide time for reflection,
are relevant to students’ lives,
provide opportunities for student-to-student interaction,
induce student curiosity and suspense,
provide students with choices,
incorporate multimedia and technology, and
incorporate resources beyond the school curriculum texts (e.g., teacher-made materials, manipulatives, resources from museums, cultural centers, etc.).
In addition, sometimes activities are game-like, involve simulations, require creating products, and demand self-direction and self-monitoring.
The preponderance of activities demand complex thinking and analysis.
Texts and tasks are appropriately complex.</td></tr>
</table>

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Why new standards?

What connections can you make from the three dimensions of science instruction (disciplinary core ideas, science and engineering practices, and crosscutting concepts) to the indicators in the TEAM rubric?

- Highlight or annotate evidence of the three dimensions in the rubric.

Planning	
Student Work	Assignments require students to: • organize, interpret, analyze, synthesize, and evaluate information rather than reproduce it; • draw conclusions, make generalizations, and produce arguments that are supported through extended writing; and • connect what they are learning to experiences, observations, feelings, or situations significant in their daily lives both inside and outside of school.
Assessment	Assessment plans: • are aligned with state content standards; • have clear measurement criteria; • measure student performance in more than three ways (e.g., in the form of a project, experiment, presentation, essay, short answer, or multiple choice test); • require extended written tasks; • are portfolio based with clear illustrations of student progress toward state content standards; and • include descriptions of how assessment results will be used to inform future instruction.

Tab page

Label: Day 2

TN Department of Education

Teacher Training
Day Two

Tennessee Academic Standards for Science

Literacy in the Science Classroom

Speaking	Reading
Writing	Viewing
Showing	Listening

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Instructional Strategies

Spend a Buck

Delivery	What is it worth for memory?	____________
Practice by Doing		
Audiovisual		
Lecture		
Reading		
Teaching Others		
Group Discussion		
Demonstration		

Notes:

Three-Dimensional Instruction

Using a new type of teaching in the science classroom

by Joe Krajcik

Science teaching and learning in the United States are at a pivotal point. *A Framework for K–12 Science Education* (NRC 2012b) presents a new vision for science education that shifts science educators' focus from simply teaching science ideas to helping students figure out phenomena and design solutions to problems. This emphasis on figuring out is new, provocative, and exciting, and it represents a revolution in how we teach science at all grade levels.

In their learning, students must use all three dimensions of the new standards—crosscutting concepts (CCs), disciplinary core ideas (DCIs), and science and engineering practices (SEPs)—in an integrated fashion in order to make sense of phenomena or design solutions to problems (see Duncan and Cavera 2015). Classrooms incorporating three-dimensional learning will have students build models, ask questions, design investigations, share ideas, develop explanations, and argue using evidence, all of which allow students to develop important 21st century competencies such as problem solving, critical thinking, communication, collaboration, and self-management (NRC 2012a). Three-dimensional learning also helps students learn to apply new knowledge to other situations. Every student will benefit from this new instructional approach.

What is different with three-dimensional learning?

When I started my teaching career, I frequently engaged students in labs or had them observe a demonstration so they could experience science first- or secondhand. My focus, however, was on students learning the content rather than on having them make sense of phenomena. Learning content is important and necessary; it gives students usable knowledge of the big ideas of science, which serve as tools for thinking about and figuring out phenomena. However, research clearly shows that learning content alone cannot be separated from the doing of science (NRC 2007). If we want students to learn scientific ideas and apply their knowledge, then they must use the SEPs and CCs with the DCIs together. And to learn to use scientific practices, they need to use them along with DCIs and CCs as they try to figure out phenomena or solve problems. None of the dimensions can be used in isolation; they work together so that students can build deeper understanding as they grapple with making sense of phenomena or finding solutions to problems. As a result, learners can figure out more complex phenomena or design solutions to more perplexing problems.

How often should each dimension be used?

Teachers and administrators often ask how often each of the three dimensions should be used, but this is the wrong question to ask. Rather, you should ask yourself: Are my students engaged in making sense of phenomena or designing solutions to problems? Engaging students in three-dimensional learning isn't an item on a checklist; it is an orientation one takes to science teaching, and it should be used every day. Three-dimensional learning involves establishing a culture of figuring out phenomena or designs to problems where a learner builds on his prior knowledge of DCIs, SEP, and CCs to figure out a phenomena and solve a problem and in the process builds deeper knowledge.

My friend and colleague Michael Novak expressed these ideas well while we participated in a workshop on designing curriculum materials aligned to the *NGSS*. To know whether three-dimensional learning is occurring in a classroom, Michael said that teachers should ask students to explain what they are doing. Ideally, students would say that they are trying to figure out how a phenomenon works or how to solve a problem, rather than saying that they are learning about balancing equations, adaptation, or the water cycle. Figuring out permeates classrooms that focus on three-dimensional learning.

Scientists and engineers work in three dimensions

Scientists and engineers use three- dimensional learning throughout their careers. They talk about and engage in making sense of phenomena, and to do so, they simultaneously use SEPs, DCIs, and CCs to make connections among the science ideas related to their current understanding.

For example, some scientists study the question, "Do decaying maple leaves add to the ecology of lakes?" Scientists know that aquatic plants are essential to the food web of lakes. Some scientists, however, wondered and explored the question, "What role, if any, do trees along the shoreline play in the food web of lakes?" Scientists have now gathered evidence that a major component of organic matter needed for energy, growth, and repair of lake organisms is supplied by trees along the shoreline (NSF 2015). Leaves from trees and other organic matter enter lakes and are used by aquatic animals as a source of food. This new and radical way of thinking about lake food webs required scientists to change their models. To explore this question and gather evidence to support the claim, scientists needed to use DCIs related to the organization of matter and energy flow in organisms (LS1.C), the growth and development of organisms (LS1.B), energy in chemical processes and ever yday life (PS3.D), and chemical reactions (PS1.B), along with various SEPs (e.g., Asking Questions, Analyzing and Interpreting Data, Revising and Constructing Models, Arguing from Evidence) and CCs (e.g., Structure and Function, Systems and System Models, Patterns, and Energy and Matter: Flows, Cycles, and Conservation) (NGSS Lead States 2013).

Bioengineers also try to solve problems, and some are figuring out how to make artificial limbs using "smart skin" that mimics the sense of touch (Wu, Wen, and Wang 2013). To do so, they apply concepts from DCIs related to electrical forces (PS2.B), the structure of matter (PS1.A), optimizing design solutions (ETS1.C), and the structure and function of organisms (LS1.A). They also use SEPs to develop models and design and test solutions, and they apply various CCs such as Systems and System Models, Structure and Function, and Cause and Effect.

As the examples above illustrate, scientists and engineers consistently make use of the three dimensions to make sense of phenomena and design solutions to problems. It isn't a once-in-a-while activity; it is what they do every day.

Where to start?

To start incorporating three-dimensional instruction into your classroom, look for engaging phenomena or problems that build toward performance expectations.

Take note of the questions students are asking, ones that students can explore over a sustained period of time, and ones for which students can ask and explore sub-questions. In selecting phenomena, be sure that the questions are related to the learning goals toward which you want students to build understanding. Therefore, you should be familiar with the Tennessee Academic Standards for Science before you start thinking about phenomena that students can explore. Figure 1 (p. 52) presents a summary of key characteristics associated with the best types of phenomena and questions to explore in the classroom (Krajcik and Czerniak 2013).

Some potential sources of phenomena that aligned Tennessee Academic Standards for Science include:

1. Your local environment. Students find phenomena and associated questions related to the local environment to be valuable and relevant. In trying to make sense of the phenomena related to their local environment, students can make use of DCIs related to biodiversity (LS4.D), social interaction and group behavior (LS2.D), the role of water in Earth's surface process (ESS2.C), human impacts on Earth systems (ESS3.C), the structure and properties of matter (PS1.A), and interdependent relationships in ecosystems (LS2.A).
2. Your hobbies. I love to scuba dive. Teaching students the ecology of reefs and the effects of rising temperatures of seawater present fruitful opportunities for exploration. If you like to ride bikes, you might explore why it is important to wear a bicycle helmet, which addresses force and motion (PS2.A) and types of interactions (PS2.B).
3. Current challenges facing our environment. How can we reduce our dependency on fossil fuels? How can we make use of wind and solar power to supply our energy needs? Exploring such questions allows students to delve deeply into several DCIs, including energy transfer (PS3.B), electromagnetic radiation (PS4.B), and human impacts on the environment (ESS3.C).
4. The internet, journals, and magazines. Magazines and journals, such as *Scientific American* and *Science News*, are filled with current ideas about phenomena that scientists are exploring. The National Science Foundation's Discoveries web page (see Resources) can also serve as a source of ideas.
5. Other science teachers and scientists. Your fellow science colleagues can be rich sources of ideas. Sharing your own ideas with other teachers will enrich the pool of phenomena you can use in your classroom.

Conclusion

Developing a classroom culture that focuses on students using the three dimensions to make sense of phenomena or find solutions to problems will initially be challenging. Many teachers haven't been prepared this endeavor has its advantages. First, all students will develop deeper knowledge of the three dimensions, which will allow them to apply their knowledge to new and more challenging areas. Second, as all students engage in figuring out phenomena or solutions to problems, they will also develop problem-solving, critical-thinking, communication, and self-management competencies. Third, and perhaps most importantly, three-dimensional learning will help foster all students' sense of curiosity and wonder in science. "I wonder how ... ?" and "How might ... ?" are extremely important questions that have largely disappeared from science classrooms. Three-dimensional learning brings the focus back to curiosity and wonderment, and it can support all students in developing a deeper and more useable knowledge of science. ■

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FIGURE 1 Characteristics of phenomena and questions

Feasible
- By making sense of the phenomenon, students are building understanding toward various performance expectations.

Worthwhile
- By making sense of the phenomenon, students are building understanding toward various performance expectations.

Contextualized
- The phenomenon is anchored in real-world issues or in the local environment of the learner.

Meaningful
- Learners will find making sense of the phenomena interesting and important.

Ethical
- By exploring the phenomenon, learners do not harm living organisms or the environment.

Sustainable
- Learners can pursue exploration of the phenomenon over time.

References

Duncan, G.R., and V. Cavera. 2015. DCIs, SEPs, and CCs, oh my! Understanding the three dimensions of the *NGSS*. *Science and Children* 52 (2): 16–20; *Science Scope* 39 (2): 50–54; *The Science Teacher* 82 (7): 67–71.

Krajcik, J.S., and C. Czerniak. 2013. *Teaching science in elementary and middle school classrooms: A project-based approach.* 4th ed. London: Routledge.

National Research Council (NRC). 2012a. *Education for life and work: Developing transferable knowledge and skills in the 21st century.* Washington, DC: National Academies Press.

National Research Council (NRC). 2012b. *A framework for K–12 science education: Practices, crosscutting concepts, and core ideas.* Washington, DC: National Academies Press.

National Research Council (NRC). 2007. *Taking science to school: Learning and teaching science in grades K–8.* Washington, DC: National Academies Press.

National Science Foundation (NSF). 2015. What connects fish and maple leaves? *www.nsf.gov/news/overviews/biology/bio_q05.jsp.*

Wu, W., X. Wen, and Z.L. Wang. 2013. Taxel-addressable matrix of vertical-nanowire piezotronic transistors for active and adaptive tactile imaging. *Science* 340 (6135): 952–95.

Resources

National Science Foundation: Discoveries: *www.nsf.gov/discoveries*

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Article adapted from Krajcik, Joe. 2015. Three-Dimensional Instruction; Using a new type of teaching in the science classroom. *The Science Teacher* (November 2015): 50-52."

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Sample Three-dimensional Planning Tool

Underlined text is for additional instructions (or hyperlinks).

Italicized text is the sample response.

Step 1: Select a Standard

Standard:

4.LS2.1: Support an argument with evidence that plants get the materials they need for growth and reproduction chiefly through a process in which they use carbon dioxide from the air, water, and energy from the sun to produce sugars, plant materials, and waste (oxygen); and that this process is called photosynthesis.

Step 2: Identify and Break Down Disciplinary Core Idea

A. Identify Disciplinary Core Idea and (Optional) Component Idea

Disciplinary Core Idea:

LS2: Ecosystems: Interactions, Energy, and Dynamics

Component Idea: (optional)

LS2.B: Cycles Of Matter and Energy Transfer in Ecosystems

B. Break Down Disciplinary Core Idea and (Optional) Component Idea

What content could be covered within this disciplinary core idea and (optional) component idea?

This area is for brainstorming content and clarifying ideas.

- *Needs of plants for survival*
- *Plants take in air and water and use light and minerals for growth*
- *Plants acquire materials for growth from the air (carbon dioxide) and water*
- *Photosynthesis is the process that allows plants to use the energy from the sun to grow and maintain internal conditions*
- *Sugar (glucose) as food source for plants*
- *Role of light (as energy from the sun) in photosynthesis*
- *Distinguishing between role of soil and water in plant growth/photosynthesis*
- *Oxygen is released during photosynthesis*
- *Environments needed for plants to grow.*

TN Department of Education

Sample Three-dimensional Planning Tool

C. Identify Instructional Focus

What content will be the focus of this lesson?

The content only needs to focus on a small part of the standard or disciplinary core idea you are addressing. If you have an instructional focus that that encompasses the entire standard or multiple standards, then that may serve better as a multi-day lesson or unit.

- *Plants use energy from the sun to produce sugar. The production of sugar in plants allows for the generation of plant materials. (Think about CO_2 as the source of the plant matter)*

Step 3: Brainstorm Instructional Scenarios and Select One to Use

- *Use different colors of light on several plants*
    - *Compare growth using different filters?*
- *Put plants in a jar vs. on a table*
    - *Less CO_2 available leads to less growth*
- ***Plant in a window vs. plant in a closet—Selected***
    - *Same level of CO_2 and water but no energy to start photosynthesis*
- *Use bromothymol blue to show conversion of CO_2 for water plants*

Sample Three-dimensional Planning Tool

Step 4: Identify and Break Down a Science and Engineering Practice

A. Identify a Science and Engineering Practice

Which science and engineering practices lend themselves to the lesson, activity, or the disciplinary core idea?

Consider all that apply and select one for this lesson:

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics, information and computer technology, and computational thinking
6. Constructing explanations and designing solutions
7. **Engaging in argument from evidence—*Selected***
8. Obtaining, evaluating, and communicating information

B. Break Down the Science and Engineering Practice

Brainstorm how you will have students demonstrate their understanding of the disciplinary core idea through the science and engineering practice. Use the task formats to guide your brainstorming.

Look up your selected practice in STEM Teaching Tools Brief #30: Task Formats for the Science and Engineering Practices, review the presented formats, and select which one will work best for your selected instructional scenario.

Engaging in Argument from Evidence #2:

- ***Describe a phenomenon,***
    - *Plants use energy from the sun to conduct photosynthesis and, therefore, need light to grow.*
- ***ask students to construct a claim about the phenomenon,***
    - *Plants will grow more when placed in a window vs. placed in a closet*
- ***ask students to identify evidence that supports the claim,***
    - *Plants in a window will have a higher mass than those in the closet*
    - *Plants in a window will be taller than those in the closet*
- ***and articulate the reasons for how scientific principle(s) connect each piece of evidence to the claim.***
    - *Plants acquire the materials for growth chiefly from air and water, but they require light to perform the process of photosynthesis.*
    - *Light provides the energy needed to convert carbon dioxide from the air into the sugars needed for plant growth.*

Sample Three-dimensional Planning Tool

Step 5: Identify and Break Down a Crosscutting Concept

A. Identify a Crosscutting Concept

Which crosscutting concept is related to the disciplinary core idea or science and engineering practice?

Consider all that apply and select one for this lesson:

1. Patterns
2. Cause and effect
3. Scale, proportion, and quantity
4. Systems and system models
5. **Energy and matter—*Selected***
6. Structure and function
7. Stability and change

B. Break Down the Crosscutting Concept

Think through how students can show their understanding of the crosscutting concept. Use the question prompts to guide your thinking.

<u>Look up your selected practice in STEM Teaching Tools Brief #41: Question Prompts for the Crosscutting Concepts, review the presented questions prompts, and select which one will work best for your selected instructional scenario.</u>

What kind of material is the plant made of?
Where is the matter coming from that is needed for the plant to grow?
What evidence is there that matter is conserved in these changes?

Step 6: Write a Three-dimensional Learning Performance

Possible Template:

"Students will
Science and Engineering Practice
in order to show
Disciplinary Core Idea
highlighting that
Crosscutting Concept."

Sample:

"Students will
compare and refine arguments based on an evaluation of the evidence presented
in order to show
organisms obtain gases and water from the environment and release waste matter back into the environment
highlighting that
matter is transported into, out of, and within systems."

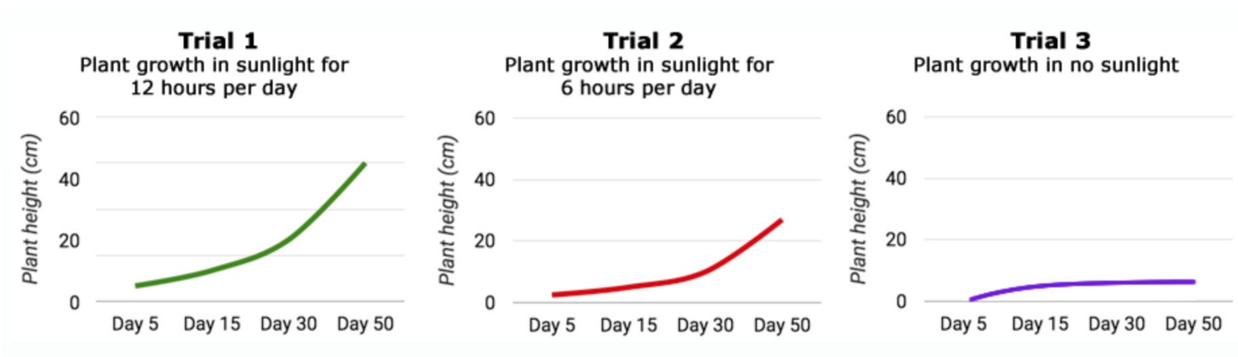
TN Department of Education

Sample Three-dimensional Planning Tool

Step 7: Write Multidimensional Questions

A. Write a Two-dimensional Question
This question should demonstrate understanding of **the content** presented in the lesson through the use of a **science and engineering practice**.

Josh, Tonya, and Marie analyzed their data after completing an investigation. Based on the data, they all gave explanations to why there is a difference.



Josh: *The reason why there was not a significant increase in plant growth from Trial 1 to Trial 3 is because the plant did not receive enough water, and water is required in order for photosynthesis to begin.*

Tonya: *Plants really do not need light to thrive.The reason why there was a decrease in plant growth from Trial 1 to Trial 3 is due to the fact that the plant was in a closet and not receiving any carbon dioxide.*

Maria: *The reason why there was a decrease in plant growth from Trial 1 to Trial 2 is because the amount of light that the plant is receiving is reduced. Photosynthesis occurs when there is light.*

Using the data above and what you know about how plants grow, which student do you most agree with, and what evidence supports their claim?

TN Department of Education

Sample Three-dimensional Planning Tool

B. Write a Two-dimensional Question
This question should demonstrate understanding of **the content** presented in the lesson and a **crosscutting concept**.

Jasmine wants to start a learning garden at her school. She has learned that plants have to undergo photosynthesis in order to thrive. However, she is not completely sure what plants need to undergo photosynthesis. She plants four flowers in the outside garden and then conducts four investigations to test how the plants would thrive.

	Plant Consumed			Plant Produces	
	water	air	sunlight	oxygen	sugar
1.	✔	✔	✔	✔	✔
2.	-	✔	✔	-	-
3.	✔	✔	-	-	-
4.	✔	-	✔	-	-

Using Jasmine's data table, explain which plant had what it needed, and describe how you know that photosynthesis occurred. Be sure to include where the plants received their energy, and where the plant matter is coming from.

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Sample Three-dimensional Planning Tool

Bullet Point Lesson

Use this space to write a bullet point lesson. Be sure to include an observation-based introduction, student activity, and opportunity for formative assessment.

Your bullet point lesson doesn't need to be this comprehensive, but use this structure to guide your thinking.

http://phenomena.nationalgeographic.com/2016/03/09/the-earth-has-lungs-watch-them-breathe/

- *Show students the image above, and have them jot down only what they see. (3-5 minutes)*
- *Using the same image, have students now jot down what they wonder about what they see. (3-5 minutes)*
- *Have students share their observations and wonderings with a partner, and have them listen to some differences and commonalities in what they see and wonder.*
- *Have students share out their observations and wonderings as a whole class.*
- *The teacher will jot down students questions and wonderings so that it is visible to the class for the duration of the lesson/unit.*
- *Pose the question to students: What does sunlight have to do with how the tree thrived throughout the seasons? (By this time students, should have mentioned something about the presence/absence of the sun.)*

Have students draw an image of the following a) flower, b) sun, c) water, d) soil. At this time, students are just drawing the image and not using arrows or academic vocabulary words to label their drawings. This will come later after they collect additional information through their investigation and research. Have students conduct the sunlight investigation. Students will place one plant in the sunlight (on a window sill) or near a lamp if there is not a window in the classroom. Students will then place another plant in an area without visible light (a closet). Students will water both plants throughout the week and monitor the plant for several days while collecting data.

Sample Three-dimensional Planning Tool

Students will be presented with several resources in which evidence will be collected from and jotted in their notebooks. The following resources can be used:

- *YouTube Video*
  - *https://www.youtube.com/watch?v=D1Ymc311XS8*
- *PBS Learning*
  - *https://tn.pbslearningmedia.org/resource/tdc02.sci.life.stru.photosynth/photosynthesis/#.WvCJOFMvzFQ*
- *Study Jams Video*
  - *http://studyjams.scholastic.com/studyjams/jams/science/plants/photosynthesis.htm*
- *Smithsonian Article*
  - *https://ssec.si.edu/stemvisions-blog/what-photosynthesis*

Using the information from the text and/or video, have students revisit their drawings and have them use arrows and words from their resources to label their drawings. At this point, look for whether students have labeled the flow of the reactants and products from the photosynthesis. The following simulation and can be used if students are having difficulty http://www.biology.ualberta.ca/facilities/multimedia/uploads/alberta/Photo.html.
The students will revisit the data they have collected from the plant they placed in the window sill and the one they placed in a dark area. The teacher will engage the students in a discussion about the data they collected.

- *What patterns do you see in the data collected?*
- *What conclusion can you draw about what would happen to the plant if we allowed it to stay in its location for another week?*
- *Would the results would be the same if they put both plants in the light and changed another variable, such as water?*

Have students complete the formative assessment in step 7.
Revisit the picture of the tree have students use what they know about photosynthesis to answer the following question: What does sunlight have to do with how the tree thrived throughout the seasons?

TN Department of Education

Three-dimensional Planning Tool

Step 1: Select a Standard

Standard:

Step 2: Identify and Break Down Disciplinary Core Idea

A. Identify Disciplinary Core Idea and (Optional) Component Idea

Disciplinary Core Idea:

(Optional) Component Idea:

B. Break Down Disciplinary Core Idea and (Optional) Component Idea

What content could be covered within this disciplinary core idea and (optional) component idea?

C. Identify Instructional Focus

What content will be the focus of this lesson?

TN Department of Education

Three-dimensional Planning Tool

Step 3: Brainstorm Instructional Scenarios and Select One to Use

Step 4: Identify and Break Down a Science and Engineering Practice

A. Identify a Science and Engineering Practice

Which science and engineering practices lend themselves to the lesson, activity, or the disciplinary core idea?

Consider all that apply and select one for this lesson:

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics, information and computer technology, and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

Three-dimensional Planning Tool

B. Break Down the Science and Engineering Practice

Brainstorm how you will have students demonstrate their understanding of the disciplinary core idea through the science and engineering practice. Use the task formats to guide your brainstorming.

Step 5: Identify and Break Down a Crosscutting Concept

A. Identify a Crosscutting Concept

Which crosscutting concept is related to the disciplinary core idea or science and engineering practice?

Consider all that apply and select one for this lesson:

1. Patterns
2. Cause and effect
3. Scale, proportion, and quantity
4. Systems and system models
5. Energy and matter
6. Structure and function
7. Stability and change

B. Break Down the Crosscutting Concept

Think through how students can show their understanding of the crosscutting concept. Use the question prompts to guide your thinking.

Three-dimensional Planning Tool

Step 6: Write a Three-dimensional Learning Performance

Possible Template:

“Students will
Science and Engineering Practice
in order to show
Disciplinary Core Idea
highlighting that
Crosscutting Concept.”

Step 7: Write Multidimensional Questions

A. Write a Two-dimensional Question

This question should demonstrate understanding of **the content** presented in the lesson through the use of a **science and engineering practice**.

Three-dimensional Planning Tool

B. Write a Two-dimensional Question
This question should demonstrate understanding of **the content** presented in the lesson and a **crosscutting concept**.

Bullet Point Lesson

Use this space to write a bullet point lesson. Be sure to include an observation-based introduction, student activity, and opportunity for formative assessment.

Next Steps

Write down 3–5 goals for your science instruction this coming school year.

List 3–5 resources you can use to help you plan for science instruction.

Identify 3–5 people you can go to when you have questions.

Identify 3–5 people you can collaborate with to implement the new science standards.

I used to ____, but now I will

____.

Tab page front

Label: Asking Questions and Defining Problems

TN Department of Education

Asking Questions and Defining Problems

Tennessee Academic Standards for Science

Teacher Guide for Grade 3

Standard
3.PS2.1 Explain the cause and effect relationship of magnets.

Tennessee Academic Standards for Science: Page 32

Three-dimensional Learning Performance for Lesson
Students will ask questions* in order to show that magnets have a causal relationship ** highlighting the cause and effect relationships that are routinely identified. ***

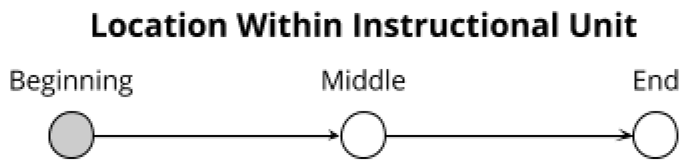
Science and Engineering Practice for Lesson
*Asking questions**
The goal of this lesson is for students to ask questions about the phenomenon of floating magnets. These questions will lead students into observing the behaviors of magnets, completing a simple investigation, and communicating their results. Students at any grade level should be able to ask questions of each other about the texts they read, the features of the phenomena they observe, and the conclusions they draw from their models or scientific investigations. Scientific questions arise in a variety of ways. They can be driven by curiosity about the world, inspired by the predictions of a model, theory, or findings from previous investigations, or they can be stimulated by the need to solve a problem. Scientific questions are distinguished from other types of questions in that the answers lie in explanations supported by empirical evidence, including evidence gathered by others or through investigation.

Disciplinary Core Idea for Lesson
*Motion and Stability: Forces and Interactions***
Electric, magnetic, and gravitational forces between a pair of objects do not require that the objects be in contact – for example, magnets push or pull at a distance. The sizes of the forces in each situation depend on the properties of the objects and their distances apart and, for the forces between two magnets, on their orientation relative to each other.

A Framework for K–12 Science Education: Page 117

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

Prior Knowledge



- Concepts that should be covered before this lesson
    - The effects of different strengths and directions of a push or a pull on the motion of an object
- This lesson covers portions of standard 3.PS2.1
    - Interactions of magnets
    - How magnets are attracted to one another
    - How magnets do not have to touch to be attracted to one another
    - Distinguishing what items are magnetic and what items are not
- This lesson does not cover magnets repelling from each other. The terminology is used, but not fully explained or explored.

Materials
- Magnets (various sizes and strengths)
- Paper clips
- Magnetic Sort (one per group: penny, nickel, dime, twig, clothes pin, tack, paperclip, aluminum foil, rubber band and paper)
- Paper plate
- Popsicle sticks
- Dowels
- Washers
- Pennies
- Unsharpened pencils
- Pipe cleaners
- Tape
- Straws
- Paper
- Yarn or fishing line

Lesson Sequence and Instructional Notes

Engage

Teacher Set-Up: There should be enough magnets for each student to have one. Each group will need a bag/plastic container with the following: a penny, nickel, dime, twig, clothes pin, tack, paperclip, aluminum foil, rubber band, and paper. Each group should have a print out of the items in the back.

- **Discussion Questions**
  Begin the lesson by passing out the student activity sheet. Have students construct an explanation of how magnets work. They are solely constructing their explanation based on previous knowledge and experiences. At this time, the teacher is not looking for a correct answer. After students have constructed their explanations, engage the class in a discussion about the questions listed below. Students will share their initial thinking and their experiences.

  - What are magnets?
  - Has anyone ever played with magnets? Explain what happened.

- **Investigation**
  Inform students that they will get an opportunity to explore with magnets. This is a group activity. Arrange students into groups of 3–4 and then pass out the handout that contains images of non-magnetic and magnetic items to students. Let students know that they will look over the pictures and discuss which of those items they would be able to pick up with a magnet. Students should put an x on all the items that they think are magnetic. Students will get a chance to interact with the objects and be able to explain which ones are magnetic after further investigation. After students have predicted on their handout, give students the bag of supplies and magnets. Allow them to interact with the objects. Ask students to put the object that are magnetic in a pile and check their original predictions. Discuss their predictions and gather the supplies.

- **Video Clip**
  After discussing what occured in the investigation, inform students that they will watch a short video clip using magnets. Remind students to think about some of the principles of magnets that they just noticed from their first investigation. Click here to show students the video clip.

  As students watch the video, have them think about what questions come to mind. You will discuss them as a class once the video stops. The teacher may want to show the video more than once. Allow the students to come up with questions about what is going on in the video. Students should use their student handout to write their questions. Once students have written their questions, have students share them out. Write the students' questions on chart paper, so that all questions are visible throughout the lesson. It is not necessary to chart questions that may be redundant. You will want to come back to these questions and see if students can answer some of their questions by the end of the unit on magnets.

- If students are not coming up with thought-provoking questions, use some of the sample questions below to get them thinking about magnets.
  - Describe what happened in the video?
  - Why do you think that happened?
  - What questions do you have about what happened?
  - What can we do to answer them?

Explore Activity

Now that students have generated a number of empirical questions about magnets, it is important to allow the students to engage in an investigation, where they can make observations and collect data to begin identifying the cause and effect relationship between magnets. Inform students that they will work to explain the phenomenon of how the paper clips, in the video, remained suspended in the air. Students will work in groups to replicate the phenomenon in the video using some of the same materials as well as added materials. The students can use supplies, such a dowels, popsicle sticks, and classroom books, to replicate the base used to hold the apparatus up in the video. The investigation below will strengthen students' thinking about magnets:

Explore Investigation Directions

- Replicate the floating paper clips using different classroom supplies
  - Materials available: magnets, dowels, washers, pipe cleaners, pennies, tape, a straw, paper clips, paper, fishing line, yarn
- When you have finished replicating the phenomenon in the video, we will test them in front of the class
- As students investigate with their materials have them draw a sketch of each design. Make sure that in their sketch they label the material that they are using.

Explore Activity Summary

Once students have completed their trials, pass out the *Magnetics Explained* article. This article can be read as a class or independently. The teacher may want to chart key information on chart paper for the students. Have students identify what key information is important for explaining what they observed in the video and in their investigation. Once evidence from the text has been recorded, have students to revisit their sketches. Based on new information, students should add the following to their sketches:

- Scientific labels such as repel, attract, magnetic field when discussing their conclusions
- Labeled magnet
- Arrows showing what is happening

After revisions are made to the group sketches, students must construct an explanation of what is going on in their sketches. Written response should explain:

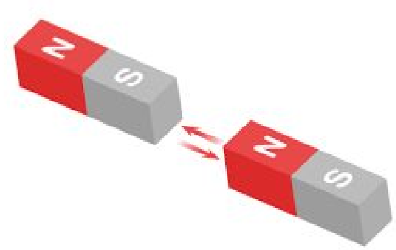
- Magnets can pull on an object without touching the object.
- The force of a magnet can work through air.
- Magnets can either attract or repel each other.
- How does this tool prove that forces can act at a distance?
- How does this device show a cause and effect relationship between certain objects and magnets?

Formative Assessment

Students will illustrate and provide a caption for the following prompt:

Draw and label a model that demonstrates two objects that attract one another. Write a brief explanation of what is going on in your model.

- *Example student response:* When opposite poles of magnets are near each other, an attractive force exists, and the magnets move toward each other if the force is great enough. These forces seem like they are pulling together or attracting to each other.



Citations and Resources

http://www.cpalms.org/Public/PreviewResourceLesson/Preview/30465
https://learning-center.homesciencetools.com/article/all-about-magnets-science/

Student Handout
Magnets

How Magnets Work: Based on what you currently know about magnets. Write 2-3 sentences to explain how you think magnets work.

____

____

____

Exploring Magnets: After exploring with the magnets and the objects in the bag, as well as watching the magnetic video, generate three questions you have about magnets? Be prepared to share your questions with your class.

Magnet Question #1	Magnet Question #2	Magnet Question #3

Explore Activity

You will complete the investigation below to strengthen your argument about magnets:

Before You Begin

1. What supplies will you use?
2. What item will you make float in the air?

3. Sketch a quick design of your initial thinking.

After you have replicated the video, make sure you can demonstrate it in front of the class and say a few sentences explaining your work.

Explore Activity Summary: Before you begin your summary, read over the article to clear up any missing information from the explore activity.

- Draw a sketch of your design:
  - Label your sketch using scientific words such as repel, attract, and magnetic field when discussing their conclusions.
  - Label the magnet.
  - Draw arrows showing what is happening.

- In a few sentences, answer the following questions:
  - Describe what you observed as you replicated the phenomena and after it was complete.
  - How does this replication prove that forces can act at a distance?
  - How does this device show a cause and effect relationship between certain objects and magnets?

Formative Assessment

- Draw and label a model that demonstrates two objects that attract one another. Write a brief explanation of what is going on in your model.

Magnets Explained

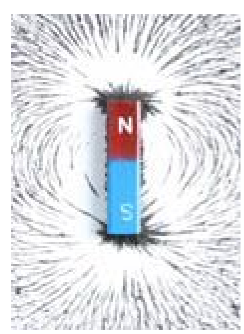
What is a magnet?

A magnet is a solid object, usually a rock or piece of metal, that has the ability to attract certain materials. What kind of objects do you think are magnetic? Look around the room and see if you can name a few. For instance, the object is made out of plastic but coated with shiny paint to make it look metallic; not all metals are attracted to magnets; or maybe just parts of an object were attracted to the magnet. What does this tell us about magnetic attraction? (That an object must be made out of metal to be attracted, but not all metals are attracted.) Metals such as iron, nickel, and cobalt are attracted to magnets. Steel has iron in it, so it is also attracted to magnets.

All magnets have the ability to attract other magnets or ***magnetic objects*** (such as iron and some other metal objects). But, a magnet doesn't necessarily have to touch a magnetic object for the object to be attracted to it.

Attraction and Repulsion

All magnets have two ends where the pull is strongest – a north pole and a south pole. The poles are named this way because if a magnet is floating in water or is suspended by a string tied around its middle, it will align itself in a north-south direction, consistent with the magnetic field of the Earth.



To best show how the poles of magnets react with each other, get two bar magnets with the north poles and south poles labeled. Holding firmly onto the magnets, try to push their hands and the ends of the magnets together so that the north poles of both magnets meet. What happens? Now, flip one of the magnets around and try pushing the ends together so that a north pole of one magnet meets with the south pole of the other magnet. What happened this time? Finally, flip the other magnet so that the south poles are facing each other and try to push them together. What happened?

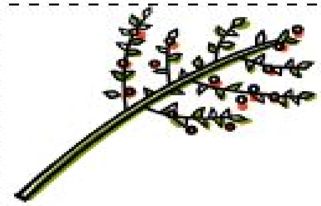
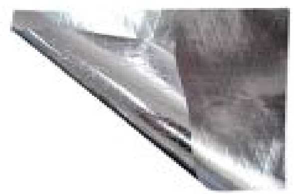
You should find that when a north pole was facing a south pole, they felt a force pulling the magnets together. Magnets attract each other when one magnet's north pole meets with another magnet's south pole. But, when the north poles were facing each other or the south poles were facing each other, they should have felt a force pushing them apart. Magnets repel each other when two of the same poles are facing each other. Try to remember: Opposite poles attract (pull together), while similar poles repel (push apart).

Magnetic Field

The invisible area around a magnet which attracts another object is called a magnetic field. Magnetic objects (such as paper clips) will get pulled toward the magnet if they are placed in this field. The magnetic field is strongest at the poles.

Citation

https://learning-center.homesciencetools.com/article/all-about-magnets-science/

 **Penny**	 **Nickel**	 **Dime**	 **Twig**	 **Pin**
 **Tack**	 **Paper Clip**	 **Aluminum Foil**	 **Rubber Band**	 **Paper**

Tab page front

Label: Using Mathematics and Computational Thinking

TN Department of Education

Using Mathematics and Computational Thinking

Tennessee Academic Standards for Science

Teacher Guide for Grade 3

Standard
3.ESS1.1 Use data to categorize the planets in the solar system as inner or outer planets according to their physical properties.

Tennessee Academic Standards for Science: Page 33

Three-dimensional Learning Performance for Lesson
Students will use mathematics and computational thinking * in order to show that planets in the solar system that are closer to the sun are smaller than planets farthest from the sun** highlighting the phenomenon that exists from the very small scales to the immensely large scales.***

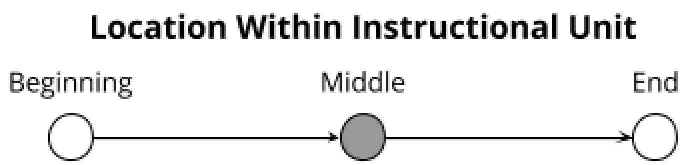
Science and Engineering Practice for Lesson
*Using mathematics and computational thinking**
The goal of this three-dimensional learning performance is for students to use data to categorize the different planets. Students will use data that they have researched to draw conclusions, data in a chart to make a scale model, and data to make and interpret a graph. In third grade, students draw scaled bar graphs and answer two-step questions about these graphs. Students generate measurement data and represent the data on graphs.

Disciplinary Core Idea for Lesson
*Earth's Place in the Universe***
"This core idea describes the universe as a whole and address its grand scale in both space and time. The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them. The sun is a star that appears larger and brighter than the other stars because it is closer. Stars range greatly in their size and distances from Earth.

A Framework for K–12 Science Education: Page 123

Crosscutting Concept for Lesson
Scale, Proportion, and Quantity [***]
Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. Using this phenomena, it is critical to recognize what is relevant at different measures of size and distance that affect the solar system's structure.

Prior Knowledge



Concepts that should be covered before this lesson
- How to use and read a ruler (second grade math standard, but may need to review since only introduced)
- The solar system is comprised of the sun, our closest star, and eight planets. The sun is at the center and is the primary energy source for Earth.
- The sun, a star, is the center of the solar system

This lesson covers a portion of standard 3.ESS1.1
- There are eight planets with their own characteristics that orbit the sun
- Size in relationship to other planets and the sun
- Distance in relationship to other planets and the sun

Materials
- Chart paper (25 in x 30 in)
- Ruler
- Meter stick
- Calculators
- Compass (Optional)
- Several rolls of toilet paper
- Markers (nine different colors)
- Planet cards
- Scissors
- Tape

Lesson Sequence and Instructional Notes

Engage

The teacher will present the students with a scenario. Inform students that they are going on a fictional trip to outer space. Let them know that before they go, they must consider some factors. Have students think about the following factors:

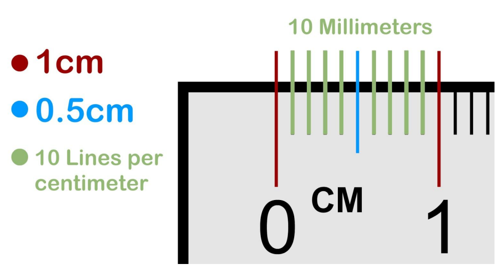
- How long do you think it would take for us to travel to outer space?
- How far do you think we would have to travel?
- What would you think we would see when we get to outer space?

Exploring Planet Size and Distance
Students will engage in two different activities that will help them to investigate the size of each of the eight planets as well as their distance from the sun. For these two activities, it is important to prep before actual implementation.

Students will need to work in group of at least 3-4 students. For the first activity students will need to use chart paper. Prior to the lesson fold the chart paper lengthwise (hotdog style), then fold that in half and then half again, ultimately having a total of 8 squares. The focus of activity one is so students are able to visualize the different sizes of the planets. Remind them throughout the lesson that the "scale" is the amount by which the size of the original has been changed proportionally, therefore, this lesson will consist of a lot of math. The teacher should engage in multiple opportunities to model for the student how to use the math as well as preserve through the parts that may be a bit more challenging. This is also a great time to collaborate with your math teacher.

Activity #1- Scale model of the planets size

Explain to students that they will conduct an investigations to find out more about the order and size of each planet. Inform students that it is impossible to draw a model of each planet by scale, because of the size of the planets; therefore, they will have to use some math to convert the diameter of planets to a scale diameter. Inform students they will be using a ruler in order to draw their models.



In order to avoid the use of decimals, which exceeds grade-appropriate math skills, millimeters can be used. Reading in millimeters can be accomplished in a grade level manner by employing a counting by groups technique. Each numbered centimeter represents a group of 10 millimeters. So, rather than reading 1cm, then 2cm, students should be instructed to county by 10mm, then 20mm. You can do this by using a document camera to project a ruler and point out how to read it, a transparency ruler and projecting it on an overhead, or simply pass out rulers to each student and have them practice.

Pass out the *Planet Size and Distance Activity Sheet.* Inform students that before they begin drawing their models of the planet, they must figure out the scale diameter so the know how large to draw their planets. Go over the directions with the students, and with students model how they are to use their calculators to convert the planet's diameter from kilometers to millimeters. The conversion chart for millimeters to centimeters is provided for students; however students can also find the scale diameter in centimeters by moving the decimal one place to the left. Remind students they are to round up to the nearest whole number.

Student Directions

Using planet data and scale conversions you will construct diagrams that show the relative sizes of planets. A scale model of distance between planets will be plotted on a strip of cash register paper.

Complete the data table below.

- Use a scale of 1 mm = 700 km (This means that for every 700 real kilometers, you will use 1 mm.
- Round all of your answers to the nearest whole number. Since students will be unfamiliar with rounding, they can be instructed to truncate (drop-off) any numbers that follow the decimal point.
- Supply students with the diameters in millimeters.
- The first one is done for you

Planet	Diameters (km)	Scale Diameter (mm)	Scale Diameter (cm)
Mercury	488	*7 mm*	*1 cm* *(Actual number - 0.7 cm)*
Venus	12,104	*17 mm*	*2 cm* *(Actual number - 1.7 cm)*
Earth	12,756	*18 mm*	*2 cm* *(Actual number - 1.8 cm)*
Mars	6,787	*10 mm*	*1 cm*
Jupiter	142,800	*204 mm*	*20 cm*
Saturn	120,00	*171 mm*	*17 cm*
Uranus	51,800	*74 mm*	*7 cm*
Neptune	495,00	*71 mm*	*7 cm*

Millimeters (mm) To Centimeters (cm) Conversion Chart

Millimeters (mm)	Centimeters (cm)
1 mm	0.1 cm
2 mm	0.2 cm
3 mm	0.3 cm
4 mm	0.4 cm
5 mm	0.5 cm
6 mm	0.6 cm
7 mm	0.7 cm

Millimeters (mm)	Centimeters (cm)
20 mm	2 cm
30 mm	3 cm
40 mm	4 cm
50 mm	5 cm
60 mm	6 cm
70 mm	7 cm
80 mm	8 cm

Teacher Answers

Once all groups have completed their chart, pass out a sheet of chart paper to each group (*the chart paper should already be folded ultimately have 8 squares)*. Have groups label each square with the name of one planet (Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune). Students will then use their scale diameter, in centimeters, to draw a circle that represents each of the planets. As noted in the material list, a compass is ideal for larger planets, however, completely optional. As students complete their drawings have them label the drawings with the actual planet diameter and the scale diameter. Once completed students should answer the following questions listed on their activity sheet.

1. What are the two largest planets? *Jupiter and Saturn*

2. Which planet is the closest to the size of Earth? *Mercury*

3. How do the sizes of the inner planets compare to the outer planets? *From the data table the inner planets are smaller than the larger planets.*

4. How many times bigger is Jupiter's diameter than the Earth's? *From the data Jupiter is 10 times bigger than earth.*

As groups finish answering their questions, engage students in a whole group discussion about their findings.

Probing Questions

- What did you notice from your models? *Students should state they notice the difference in the sizes of the planets. If students state they notice the difference in shapes,* *inform them that the difference in shape is a limitation to our model because they were all drawn by hand. However, remind them that planets are spherical.*

- Was there anything that was surprising to you in your data? *Answers may vary.*
- How do you think the size of the sun compares to other planets? *Answers may vary. You can tell students that the sun's diameter is 69.5508 billion centimeters. Ask them if that is bigger than the other planets. They should identify that the sun is significantly bigger than the other planets.*

Activity #2 - Planets Relative Distance

(This activity requires a lot of space, i.e., a gym, outside, a cafeteria. As this activity is written to be conducted within a group, it also can be done as a whole class demonstration.)

Prior to engaging students in activity two, have students retrieve, or pass out the student activity sheet. Have students read the probing question and respond independently.

> Student Probing Question: Why aren't we trying to build our model of the solar system to its actual size?

After students have constructed their response, have students share their response. Ask students what are common units to measure distance on Earth (e.g., miles, kilometers, feet/miles, centimeters). Ask them if they think these units would work well to measure distances in space and discuss. Inform students that since distances in space are so big, they are measured in astronomical units (AU); however, for this model they will use centimeters, but keeping the same relative scale. Inform them that now that they know how to identify a planet based on their size, they will now investigate how far the planets are relative to the sun, as well as each other. Again, remind students that as they engage in the investigation this is a scale and the "scale" is the amount by which the size of the original has been changed.

At this point students should still be in their groups of 2-3. Pass out the following materials to each group: roll of toilet paper, set of planet cards, scissors, marker. Inform groups that they will first need to cut out their sun and their planets *(If printing is an issue, especially since the cards are in color, the students can use their drawn planets from activity #1. As the focus is on identifying the planets distance from the sun).*

Let students know that they will use the table of distances provided to mark off the distances to each of the planets. The number in the table is the number of sheets of toilet paper needed to visualize the planets distance from the sun, so keep a running count as you go along. Students will start by taping one side of the toilet paper roll down to the floor. They will also tape down their image of the sun. Students will then need to use their chart to count how many sheets of toilet paper is needed to reach the next planet. Do not count the first sheet, which has the sun on it. Remind students to think back to how they ordered the planets in activity #1 to know which planet comes first, second, etc. Students will repeat this process until they have taped all the planets down.

Once all planets have been placed down, have students return to their activity sheet to fill out the activity questions.

Student Activity Questions

1. What did you notice about the distance between the planets? *The distances between the planets increased as their distance from the Sun increased. The inner planets were closer together than the outer planets. Etc.*

What are Inner and Outer Planets

Reading Activity

Students have conducted two investigations that allowed them to explore planets' sizes as well as their distance from the sun. However, at this time we have not identified these planets as whether they are inner or outer planets. During this portion of the lesson, students will engage in a reading activity to begin making connections to the previous activities. Pass out the *The Inner And Outer Planets In Our Solar System Reading Activity.* This part of the lesson can be done independently, whole group or in small groups. It is at the discretion of the teacher and what is best for the students. After reading the passage have students complete the inner and outer planet t-chart. On the left side students will jot down facts about inner planets and on the right side they will jot down facts about outer planets from the reading. After reading students will answer the following questions.

Student Reading Questions

1. After reading the article and collecting your facts, you should now know what scientists call the planets that are closer to the sun. The group of planets closer to the sun are called? The name of these planets are? *Inner planets. There are 4 inner planets and they are Mercury, Venus, Earth, and Mars.*
2. What physical features do these planets have in common? Refer back to the text. *The four inner planets are smaller and rockier planets. Their surfaces are solid and, as the name implies, somewhat* <u>*similar*</u> *to Earth. They're made up mostly of heavy metals such as iron and nickel, and have either no moons or few moons.*
3. After reading the article and collecting facts, you should now know what scientists call the planets that are farther away from the sun. The group of planets farther away from the sun are called? The name of these planets are? *Outer planets. There are 4 outer planets and they are Jupiter, Saturn, Uranus and Neptune.*
4. What physical features do these planets all have in common? Refer back to the text. *Outer planets are huge and are also called gas planets. They all have rings and plenty of moons each.*

After students complete their reading and answer their questions, go over the answers with the students to ensure that all students have the correct answers. This lesson is not to go over the physical characteristics of each planet, but solely the common physical characteristics of inner and outer planets.

Formative Assessment

Students will complete formative assessment on their own.

- From the models, what did you notice about the size of the planets compared to the distance between them? *The smaller inner planets were closer together than the larger outer planets.*
- Do you think it would be easy to make a model that would fit inside the classroom, if it was accurate in size and distance? Why or why not? *No, because the sizes of the planets would be extremely small, making them difficult to see and manipulate.*
- Draw a small scale diagram of the eight planets. Be sure to label each one and describe what you used to make your scale.

Formative Assessment Rubric

	Excellent 20 pts.	Good 10 pts.	Fair 5 pts.	Comments
All planets are found.	All planets are accounted for.	One planet is missing.	Two planets are missing.	
Proportion- Size	All of the planets are roughly the correct size in relationship to each other and the sun.	Most of the planets are the correct size in relationship to each other and the sun.	There are a couple of mistakes with size compared to the sun and other planets .	
Proportion- Distance	All of the planets are roughly proportional to each other.	Most of the planets are proportional to each other.	There are a couple of mistakes with the proportions of the planets.	
Labels	All planets and are correctly and clearly labeled.	All planets are correctly labeled, but are difficult to read or find.	Planets are incorrectly labeled or the labels are almost impossible to read.	
Planets are in the correct order.	All the planets were in the correct order.	One or two planets are out of order.	Three or more planets are out of order.	

Citations and Resources

- http://sbsciencematters.com/5th/earth/5.2Size-Distance.pdf
- http://www.mlbgsd.k12.pa.us/cms/lib/PA09000085/Centricity/Domain/85/lab%20solar%20system.pdf
- https://www.easthanoverschools.org/cms/lib3/NJ01001764/Centricity/Domain/124/10-22%20TP%20Solar%20System%20Lab%20Report.pdf

Name: ___________________________________

Comparing Planet Sizes Activity

Using planet data and scale conversions you will construct diagrams that show the relative sizes of planets. A scale model of distance between planets will be plotted on a strip of cash register paper.

Complete the data table below.

- Use a scale of 1 mm = 700 km (This means that for every 700 real kilometers, you will use 1 mm.
- Round all of your answers to the nearest tenths place (0.1).
- Convert the scale diameters from millimeters to centimeters.
- The first one is done for you,

Planet Size Chart

Planet	Diameters (km)	Scale Diameter (mm)	Scale Diameter (cm)
Mercury	488	***7 mm***	***1 cm*** ***(Actual number - 0.7 cm)***
Venus	12,104		
Earth	12,756		
Mars	6,787		
Jupiter	142,800		
Saturn	120,000		
Uranus	51,800		
Neptune	495,000		

Millimeters (mm) To Centimeters (cm) Conversion Chart

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4 mm	0.4 cm
5 mm	0.5 cm
6 mm	0.6 cm
7 mm	0.7 cm
8 mm	0.8 cm
9 mm	0.9 cm
10 mm	1 cm

Millimeters (mm)	Centimeters (cm)
20 mm	2 cm
30 mm	3 cm
40 mm	4 cm
50 mm	5 cm
60 mm	6 cm
70 mm	7 cm
80 mm	8 cm
90 mm	9 cm
100 mm	10 cm
200 mm	20 cm

Adapted from *http://www.mlbgsd.k12.pa.us/cms/lib/PA09000085/Centricity/Domain/85/lab%20solar%20system.pdf*

Name: ________________________________

Activity Questions

1. What are the two largest planets?

2. Which planet is the closest to the size of Earth?

3. How do the sizes of the inner planets compare to the outer planets?

4. How many times bigger is Jupiter's diameter than the Earth's?

5. Put the planets in order by their size:

    1. ______
    2. ______
    3. ______
    4. ______
    5. ______
    6. ______
    7. ______
    8. ______

Adapted from http://www.mlbgsd.k12.pa.us/cms/lib/PA09000085/Centricity/Domain/85/lab%20solar%20system.pdf

Name: ______________________________

Comparing Planet Distance Compared To The Sun

In our previous activity we had to use a scale size to visualize how big the planets are in our solar system.

Probing Question: Why is it necessary to use scale distances when dealing with large distances like those between the planets in the solar system?

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As you know, there are 8 planets in our solar system that vary in size. You also learned that the sun is larger than all 8 of the planets. In a previous lesson you also learned that the sun, a star, is the center of the solar system. So, if the sun is the center of our solar system, how far are our eight planets from the sun? In this activity you will create a model to explore the concept of a planet's distance relative to the sun.

Planet's Distance From the Sun Chart

Planet	Average Distance From Sun (miles)	Average Distance From Sun (AU)	Distance From Sun Toilet Paper Rolls
Mercury	36 million miles	0.38	2
Venus	67 million miles	0.72	3.7
Earth	93 million miles	1	5.1
Mars	142 million miles	1.52	14
Jupiter	483 million miles	5.2	26.4
Saturn	885 million miles	9.59	48.4
Uranus	1,787 million miles	19.2	97.3
Neptune	2,800 million miles	30.1	152.5

Adapted from http://www.mlbgsd.k12.pa.us/cms/lib/PA09000085/Centricity/Domain/85/lab%20solar%20system.pdf

Name: ________________________________

Activity Questions

1. What did you notice about the distance between the planets?

Name: ________________________________

Reading Activity

As you read the text, record evidence about the inner and outer planets.

Inner Planets	Outer Planets

Adapted from http://www.mlbgsd.k12.pa.us/cms/lib/PA09000085/Centricity/Domain/85/lab%20solar%20system.pdf

Name: ________________________________

1. After reading the article and collecting your facts, you should now know what scientists call the planets that are closer to the sun. The group of planets closer to the sun are called? The name of these planets are?

____

____

2. What physical features do these planets have in common? Refer back to the text.

____

____

3. After reading the article and collecting facts, you should now know what scientists call the planets that are farther away from the sun. The group of planets farther away from the sun are called? The name of these planets are?

____

____

4. What physical features do these planets all have in common? Refer back to the text.

____

____

Name: ________________________________

Formative Assessment

1. From the models, what did you notice about the size of the planets compared to the distance between them?

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____

____

2. Do you think it would be easy to make a model that would fit inside the classroom, if it was accurate in size and distance? Why or why not?

____

____

____

3. Draw a small scale diagram of the 8 planets. Be sure to label each one and describe what you used to make your scale.

Adapted from *http://www.mlbgsd.k12.pa.us/cms/lib/PA09000085/Centricity/Domain/85/lab%20solar%20system.pdf*

Name: ___________________________________

Small Scale Planet Model Diagram Rubric

	Excellent 20 pts.	Good 10 pts.	Fair 5 pts.	Comments
All planets are found.	All planets are accounted for.	One planet is missing.	Two planets are missing.	
Proportion- Size	All of the planets are roughly the correct size in relationship to each other and the sun.	Most of the planets are the correct size in relationship to each other and the sun.	There are a couple of mistakes with size compared to the sun and other planets.	
Proportion- Distance	All of the planets are roughly proportional to each other.	Most of the planets are proportional to each other.	There are a couple of mistakes with the proportions of the planets.	
Labels	All planets are correctly and clearly labeled.	All planets are correctly labeled, but are difficult to read or find.	Planets are incorrectly labeled or the labels are almost impossible to read.	
Planets are in the correct order.	All the planets were in the correct order.	One or two planets are out of order.	Three or more planets are out of order.	

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The Inner And Outer Planets In Our Solar System

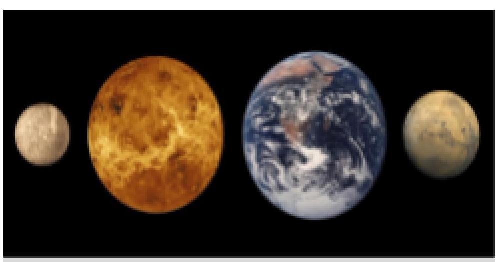
Article written: 23 Apr , 2014
Updated: 23 Dec , 2015 by Elizabeth Howell

In our Solar System, astronomers often divide the planets into two groups — the inner planets and the outer planets. The inner planets are closer to the Sun and are smaller and rockier. The outer planets are further away, larger and made up mostly of gas.

The inner planets (in order of distance from the sun, closest to furthest) are Mercury, Venus, Earth and Mars. After an asteroid belt comes the outer planets, Jupiter, Saturn, Uranus and Neptune. The interesting thing is, in some other planetary systems discovered, the gas giants are actually quite close to the sun.

This makes predicting how our Solar System formed an interesting exercise for astronomers. Conventional wisdom is that the young Sun blew the gases into the outer fringes of the Solar System and that is why there are such large gas giants there. However, some extrasolar systems have "hot Jupiters" that orbit close to their Sun.

The inner planets



The terrestrial planets of our Solar System at approximately relative sizes. From left, Mercury, Venus, Earth and Mars. Credit: Lunar and Planetary Institute

The four inner planets are called terrestrial planets because their surfaces are solid (and, as the name implies, somewhat similar to Earth — although the term can be misleading because each of the four has vastly different environments). They're made up mostly of heavy metals such as iron and nickel, and have either no moons or few moons. Below are brief descriptions of each of these planets.

Mercury: Mercury is the smallest planet in our Solar System and also the closest. It rotates slowly (59 Earth days) relative to the time it takes to rotate around the sun (88 days). The planet has no moons, but has a tenuous atmosphere (exosphere) containing oxygen, sodium, hydrogen, helium and potassium. The NASA MESSENGER (MErcury Surface, Space ENvironment, GEochemistry, and Ranging) spacecraft is currently orbiting the planet.

Venus: Venus was once considered a twin planet to Earth, until astronomers discovered its surface is at a lead-melting temperature of 900 degrees Fahrenheit (480 degrees Celsius). The planet is also a slow rotator, with a 243-day long

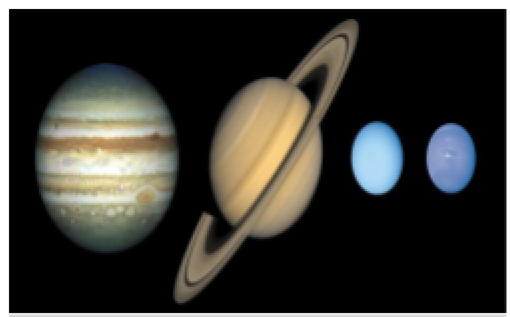
Venusian day and an orbit around the sun at 225 days. Its atmosphere is thick and contains carbon dioxide and nitrogen. The planet has no rings or moons and is currently being visited by the European Space Agency's Venus Express spacecraft.

Earth: Earth is the only planet with life as we know it, but astronomers have found some nearly Earth-sized planets outside of our solar system in what could be habitable regions of their respective stars. It contains an atmosphere of nitrogen and oxygen, and has one moon and no rings. Many spacecraft circle our planet to provide telecommunications, weather information and other services.

Mars: Mars is a planet under intense study because it shows signs of liquid water flowing on its surface in the ancient past. Today, however, its atmosphere is a wispy mix of carbon dioxide, nitrogen and argon. It has two tiny moons (Phobos and Deimos) and no rings. A Mars day is slightly longer than 24 Earth hours and it takes the planet about 687 Earth days to circle the Sun. There's a small fleet of orbiters and rovers at Mars right now, including the large NASA Curiosity rover that landed in 2012.

The outer planets

The outer planets (sometimes called Jovian planets or gas giants) are huge planets swaddled in gas. They all have rings and all of plenty of moons each. Despite their size, only two of them are visible without telescopes: Jupiter and Saturn. Uranus and Neptune were the first planets discovered since antiquity, and showed astronomers the solar system was bigger than previously thought. Below are brief descriptions of each of these planets.



The outer planets of our Solar System at approximately relative sizes. From left, Jupiter, Saturn, Uranus and Neptune. Credit: Lunar and Planetary Institute

Jupiter: Jupiter is the largest planet in our Solar System and spins very rapidly (10 Earth hours) relative to its orbit of the sun (12 Earth years). Its thick atmosphere is mostly made up of hydrogen and helium, perhaps surrounding a terrestrial core that is about Earth's size. The planet has dozens of moons, some faint rings and a Great Red Spot — a raging storm happening for the past 400 years at least (since we were able to view it through telescopes). NASA's Juno spacecraft is en route and will visit there in 2016.

Saturn: Saturn is best known for its prominent ring system — seven known rings with well-defined divisions and gaps between them. How the rings got there is one subject under investigation. It also has dozens of moons. Its atmosphere is mostly hydrogen and helium, and it also rotates quickly (10.7 Earth hours) relative to its time to circle the Sun (29 Earth years). Saturn is currently being visited by the Cassini spacecraft, which will fly closer to the planet's rings in the coming years.

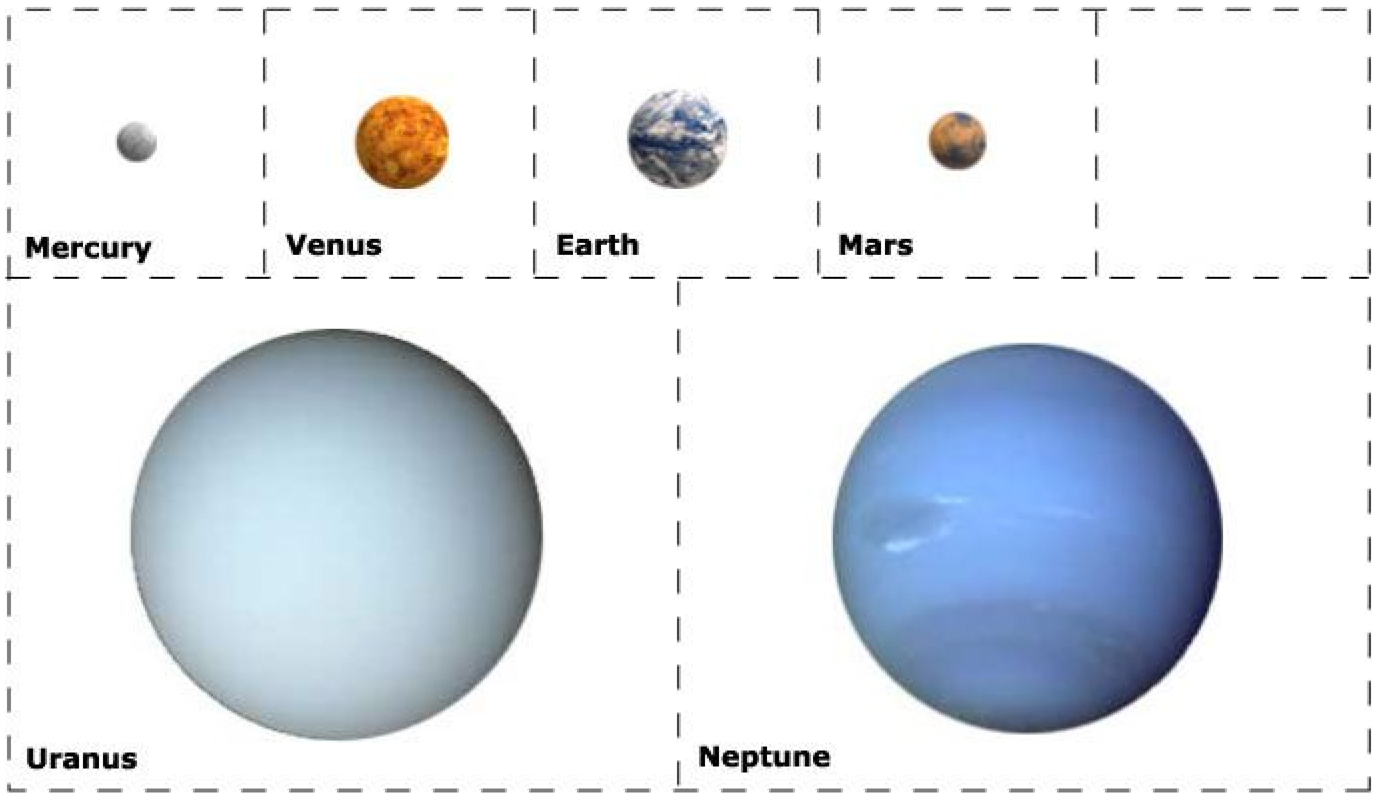
Uranus: Uranus was first discovered by William Herschel in 1781. The planet's day takes about 17 Earth hours and one orbit around the Sun takes 84 Earth years. Its mass contains water, methane, ammonia, hydrogen and helium surrounding a rocky core. It has dozens of moons and a faint ring system. There are no spacecraft slated to visit Uranus right now; the last visitor was Voyager 2 in 1986.

Neptune: Neptune is a distant planet that contains water, ammonia, methane, hydrogen and helium and a possible Earth-sized core. It has more than a dozen moons and six rings. The only spacecraft to ever visit it was NASA's Voyager 2 in 1989.

https://www.universetoday.com/34577/inner-and-outer-planets/

Planet Cards

The following cards can be printed out and used for Investigation Activity #2. Each group will need a set. If there are issues with printing and/or printing in color, students can use their Activity #1 planet drawings.



http://cse.ssl.berkeley.edu/AtHomeAstronomy/act09_imagecards.html

Planet Cards

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Jupiter

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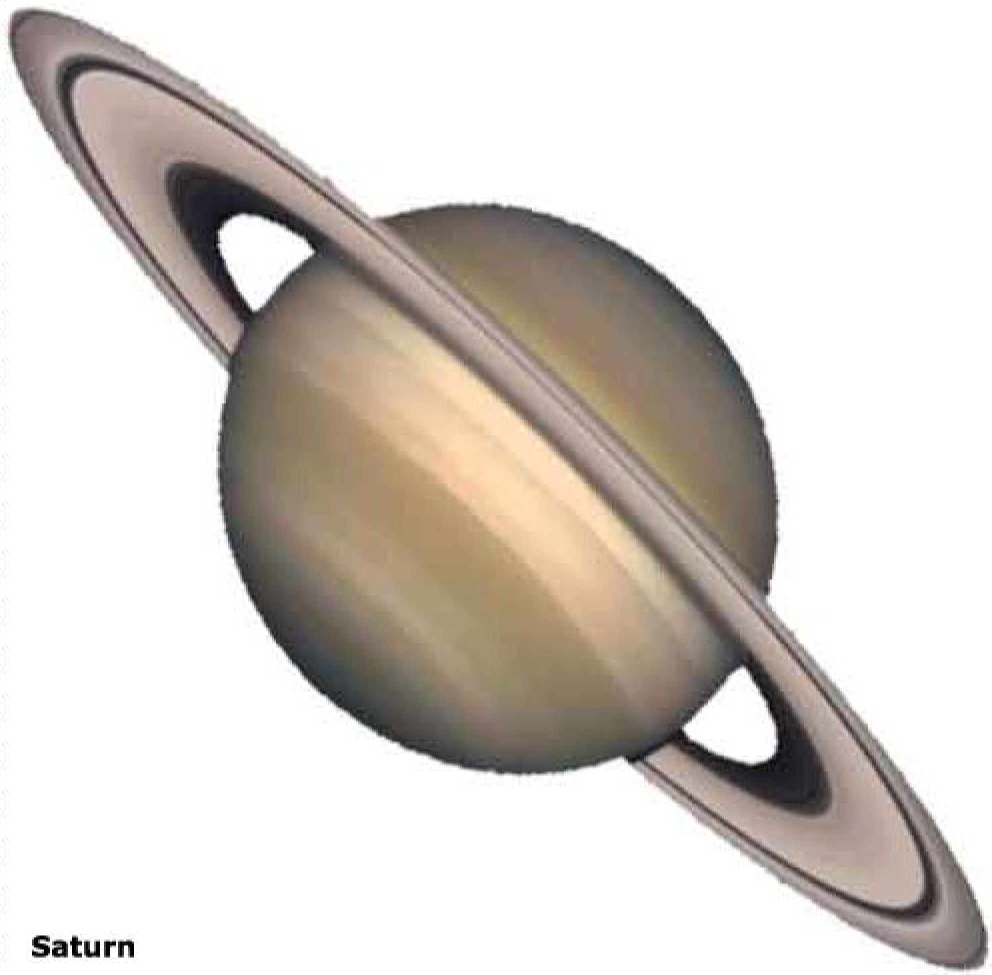

Saturn

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Planet Cards

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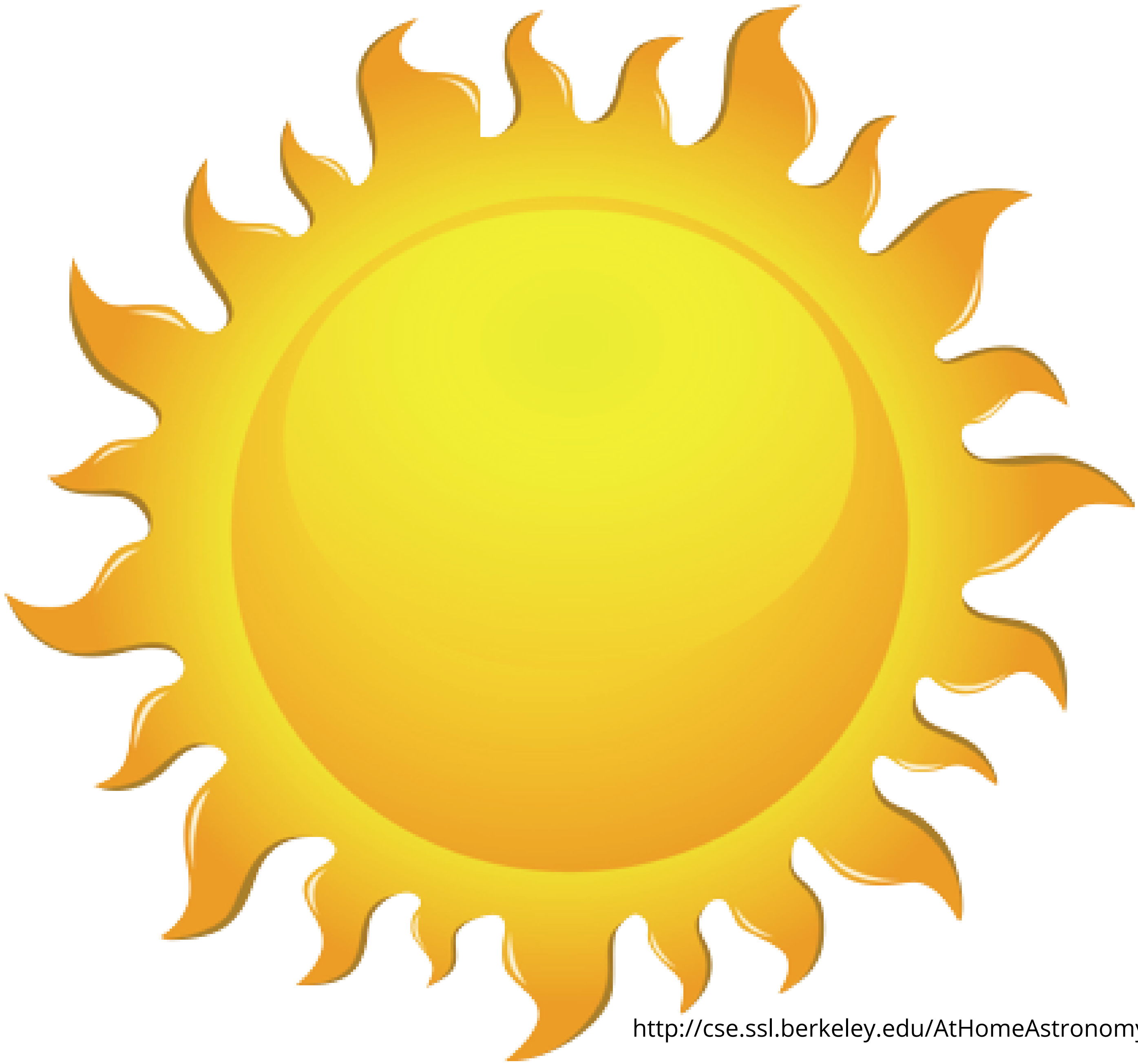


http://cse.ssl.berkeley.edu/AtHomeAstronomy/act09_imagecards.html

Tab page front

Label: Analyzing and Interpreting Data

Analyzing and Interpreting Data

Tennessee Academic Standards for Science

Teacher Guide for Grade 3

Standard
3.ESS2.3 Use tables, graphs, and tools to describe precipitation, temperature, and wind (direction and speed) to determine local weather and climate

Tennessee Academic Standards for Science: Page 33

Three-dimensional Learning Performance for Lesson
Students will analyze and interpret data from multiple maps* in order to show that precipitation helps determine local weather and climate** highlighting the patterns that can be found using tables, graphs, and maps.***

Science and Engineering Practice for Lesson
*Analyzing and Interpreting Data**
The goal of this three-dimensional learning performance is for students to use different forms of data to determine local weather and climate. Students will use the data to ask questions to help determine weather and possible weather patterns.

Disciplinary Core Idea for Lesson
*Earth Science 3: Earth's System** Weather and Climate*
"Weather, which varies from day to day and seasonally throughout the year, is the condition of the atmosphere at a given place and time. Climate is longer term and location sensitive; it is the range of a region's weather over one year or many years, and because it depends on latitude and geography, it varies from place to place. Weather and climate are shaped by complex interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions can drive changes that occur over multiple time scales—from days, weeks, and months for weather to years, decades, centuries and beyond for climate "

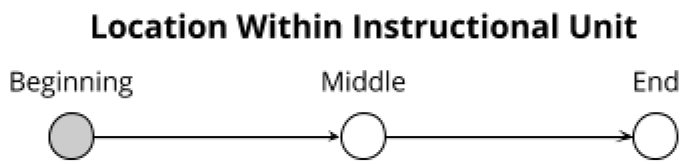
A Framework for K–12 Science Education: Page 186-188

Crosscutting Concept for Lesson

Patterns[***]

When students are able to make explicit connections between data collected about the weather and the upcoming weather, they can begin to see trends in the weather. The different ways in which data are represented can facilitate pattern recognition and lead to the development of mathematical representation, which can then be used as a tool in seeking an underlying explanation for what causes the pattern to occur.

Prior Knowledge



- Concepts that should be covered before this lesson:
    - Precipitation is rain, sleet, snow, etc…
    - How to examine data from different graphs
    - The difference between weather and climate
- This lesson covers portions of standard 3.ESS2.3:
    - Precipitation
    - Reading graphs and data tables concerning weather

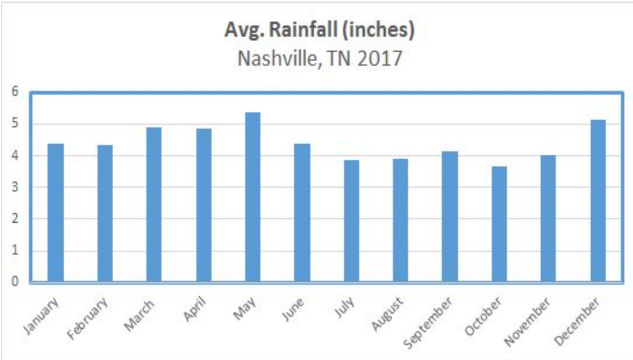
Materials

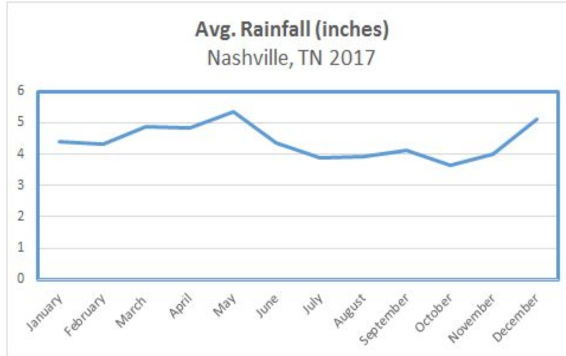
- Internet access for students
- Printed maps of the average precipitation in Tennessee and the United States
- Colored pencils

Lesson Sequence and Instructional Notes

Understanding graphs can be a guided class activity. The teacher should display the first bar graph below on the board or document camera. During this portion of the lesson, the teacher will ask students questions around reading different types of graphs and tables.

- Probing Discussion Questions:
    - What type of graph is this?
    - What are the units used on this graph?
    - How do we read this type of graph?





After the class has reviewed each of the graphs and has an understanding of how to use the graph to extract data, the teacher will have students answer the following questions on their own. The graphs and the questions can be found in the student activity sheet.

Student Activity Questions:

1. Compare the amount of precipitation in the following months using the appropriate sign: <,>,=
    a. March _________ June
    b. October _________ September
    c. January _________ February

2. About how many inches of precipitation fell in February?

3. Which month had the most rainfall?

4. On average, about how much rain falls each month in Nashville?

5. Which graph makes it easier to compare the amount of rainfall each month? Explain your reasoning.

The teacher will allow time for students to respond, independently, to the questions on their student activity sheet. After all students have responded, review answers to the questions with students. At this time, the teacher may want to discuss bars and lines that fall between numbers. For bars that are in between, inform students to round up or down to the nearest whole number. Also inform students that in their responses it is important to reference the units in which the data is represented.

Now that we have examined the rainfall in Nashville, we will look at the rainfall across Tennessee.

Students will use the I^2 approach to make meaning of different graphs and figures in this lesson. The *Identify and Interpret* (I^2) strategy helps students make sense of graphs, figures, sketches, and other ways to represent data. This strategy helps students break down the information into smaller parts. To do this, first identify what can be seen in the graph or figure. Then, interpret each of those observations by deciding what they mean. Once it has been determined what the smaller parts of the graph or figure mean, students can put all the information together. To do this, they write a caption. Captions are a summary of the information in the graph or figure. They are written in complete sentences. Captions help show understanding of the material being studied. To help understand how to use the I^2 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 U.S. city.

<table>
<tr><th>I^2 step</th><th>Example</th></tr>
<tr><td>

Step 1: Identify ("What I see" comments)

- Identify any changes, trends, or differences you see in the graph or figure.
- Draw arrows and write a "What I see" comment for each arrow.
- Be concise in your comments. These should be just what you can observe.
- Do not try to explain the meaning at this point.

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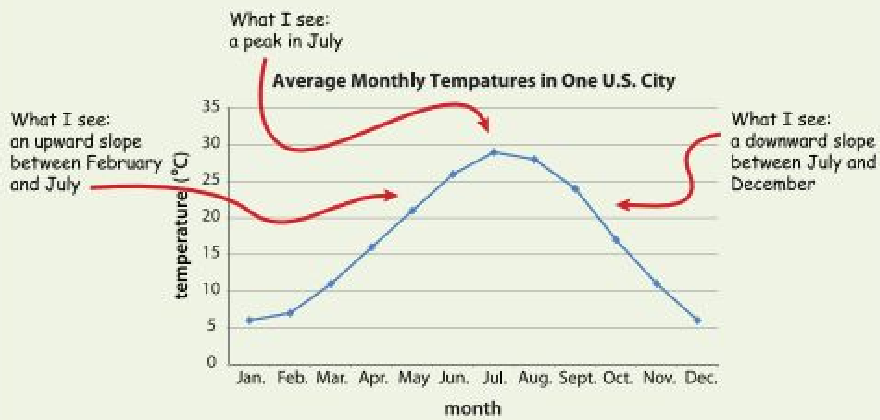


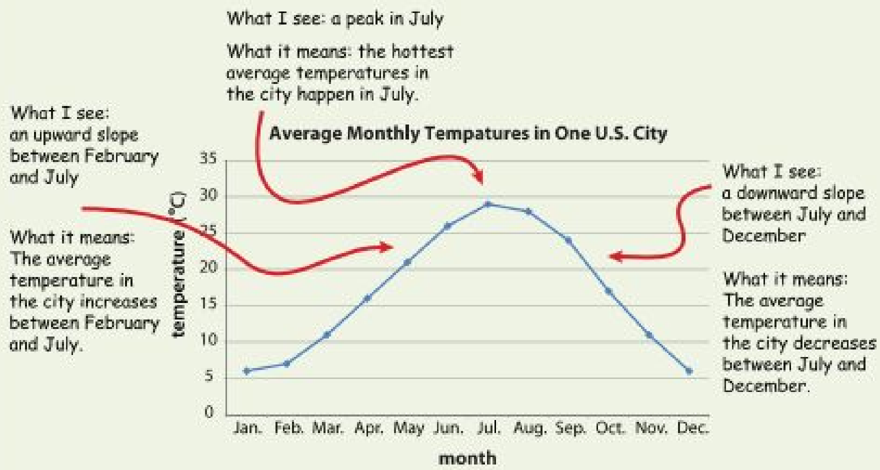
For this example, there are arrows drawn that point to the two trends and the change. Notice that the arrows point to the general upward and downward trends, not to each data point. A "What I see" comment describes what each arrow points to on the graph.

</td></tr>
</table>

I² step	Example

Step 2: Interpret ("What it means" comments)

- Interpret the meaning of each "What I see" comment by writing a "What it means" comment.
- Do not try to interpret the whole graph or figure.

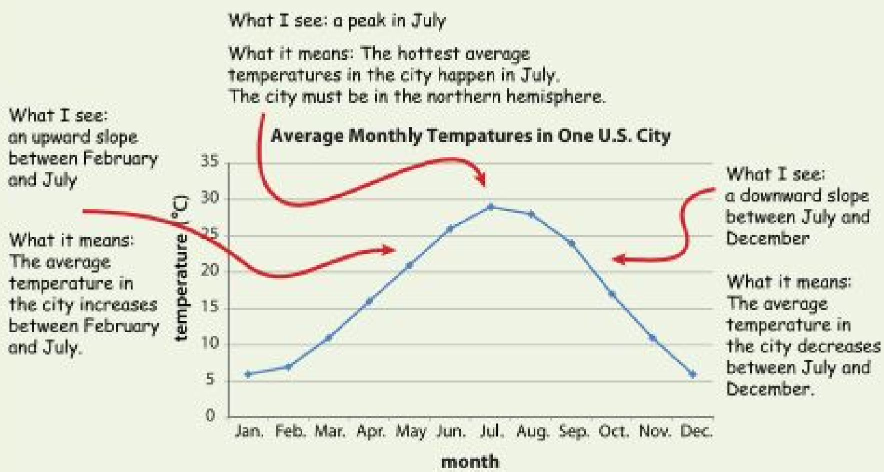


In this example, "What it means" comments were added to each "What I see" comment. The "What it means" comments explain the changes, trends, and differences that were identified in Step 1.

I² step	Example

Step 3: Caption

- Write a caption for the graph or figure.
- Start with a topic sentence that describes what the graph or figure shows.
- Then join each "What I see" comment with its "What it means" comment to make a sentence.
- Build a coherent paragraph out of your sentences.

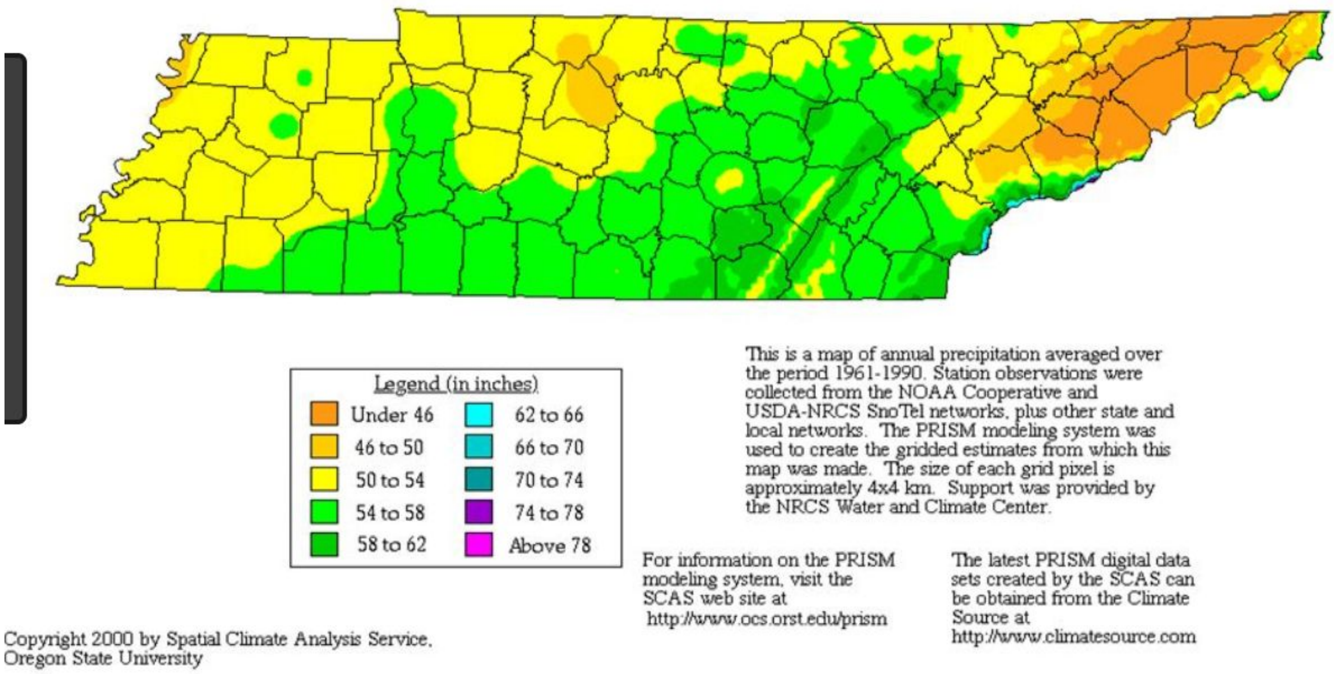


This graph shows the average temperature in a city over a year. There is an upward slope from February to July, showing that there is an increase in the average temperature during these months. There is a downward slope from July to December, which means the average temperature decreases during this time. There is a peak in July, which shows that the hottest average temperature in the city happens in July. The peak in July also means that the city must be in the Northern Hemisphere.

In this example, the first sentence of the caption describes what the graph shows. Then each "What I see" comment was combined with its "What it means" comment to form complete sentences. Those sentences make up a paragraph that describes each part of the graph.

Now, students will complete the I^2 method using the diagram on the Tennessee average rainfall.

Average Annual Precipitation
Tennessee



Students will answer the following questions on their student handout. The students should also be drawing on the map.

Step 1:

1. Identify any changes, trends, or differences you see in the graph or figure.

2. Draw arrows and write a "What I see" comment for each arrow. Be concise in your comments. These should be just what you can observe. Do not try to explain the meaning at this point.
    - I see a lot of green on the bottom
    - I see that the top left corner of Tennessee does not get a lot of rain
    - I see a line of dark green going through the middle of Tennessee

Step 2:
Students should not try to interpret the whole graph or figure. Interpret the meaning of each “What I see” comment by writing a “What it means” comment.

- I see: A lot of the green at the bottom. It means: There is more rain in the southern parts of the Tennessee.
- I see: The top left corner of Tennessee does not get a lot of rain. It means: The top left part of the state gets less than 46 inches a rain each year.
- I see: A dark green line going through the middle of Tennessee. It means: The middle streak of Tennessee gets the most rain each year.

Step 3:

- Write a caption for the graph or figure.
    - Average rainfall in Tennessee

- Start with a topic sentence that describes what the graph or figure shows.
    - This map shows average rainfall in Tennessee for the years of 1961 to 1990.

- Then, join each “What I see” comment with its “What it means” comment to make a sentence.

- Build a coherent paragraph out of your sentences.

Sample Paragraph

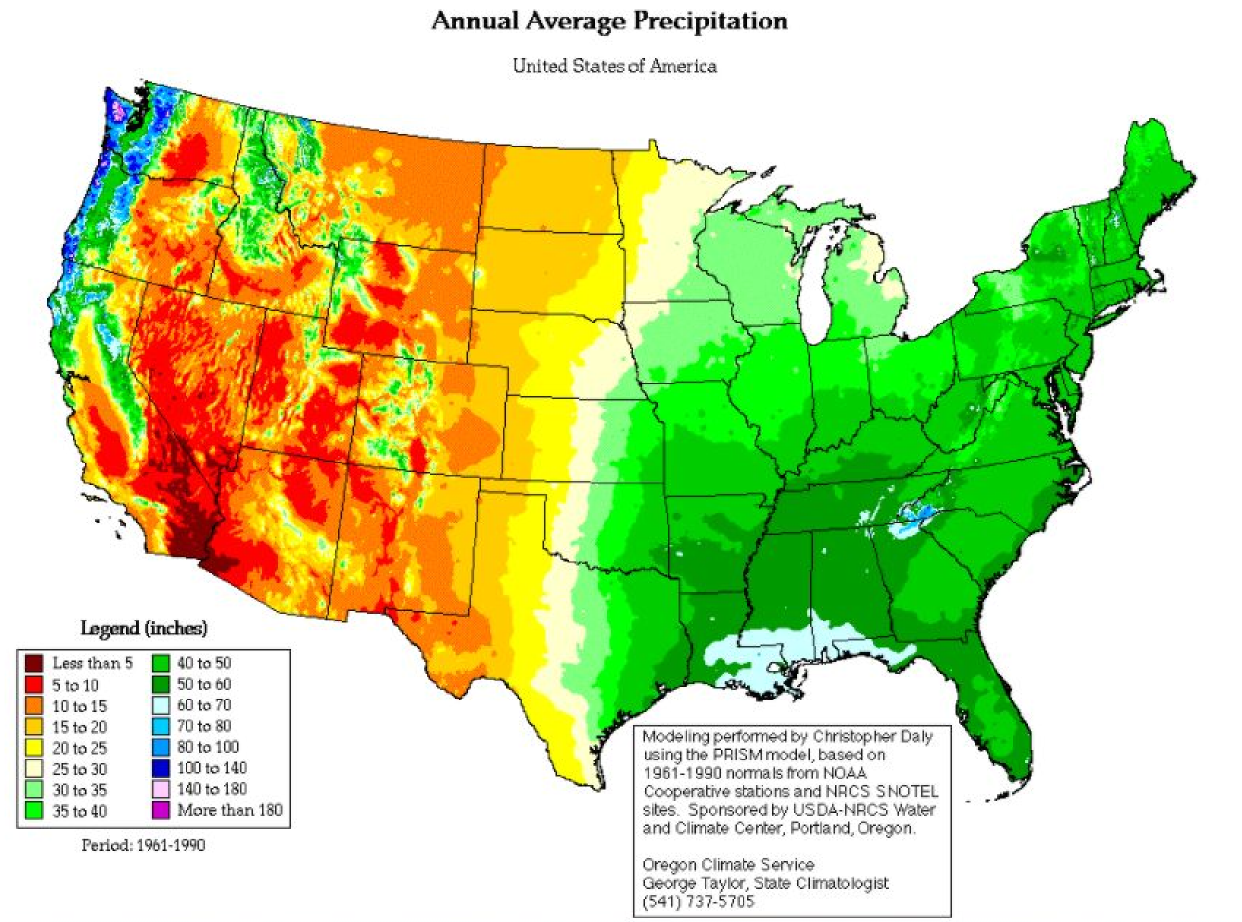
- This map shows the average rainfall in Tennessee for the years of 1961 to 1990. The map has a lot of green at the bottom, which means the southern half of the state gets about 54 to 58 inches of rainfall each year. The upper lefthand corner has an orange color, which shows it gets the least amount of rainfall each year. There is a darker green streak that goes through the middle of Tennessee, which shows that area gets the most rainfall on average.

Ater students have finished examining the Tennessee map and completing the steps within the strategy, have a short class discussion about their findings.

Inform the students that they will now examine a map of the average precipitation in the United States.

Class Discussion Questions

- Using the legend, what does the map of the United States depict?
- Are there any noticeable patterns between the two maps?
- Based on the legend, does Tennessee have more or less precipitation than other states in the country?



Students will complete the I^2 model on the map of the United States.

Step 1:

1. Identify any changes, trends, or differences you see in the graph or figure.

2. Draw arrows and write a “What I see” comment for each arrow. Be concise in your comments. These should be just what you can observe. Do not try to explain the meaning at this point.
    a. I see the west coast is blue.
    b. I see that Tennessee all the way down to the gulf gets a lot of rain each year.
    c. I see that right by the ocean the rain is pretty heavy each year.

Step 2:
Students should not try to interpret the whole graph or figure. Interpret the meaning of each “What I see” comment by writing a “What it means” comment.

1. I see: The west coast is blue. This means: The west coast gets more than 100 inches of rain each year.
2. I see: Tennessee all the way down to the gulf gets a lot of rain each year. This means: This is one of the parts of the United States that gets the most rain.
3. I see: That right by the ocean the rain is pretty heavy each year. This means: That the west coast gets about 100 inches of rain each year.

Step 3:

1. Write a caption for the graph or figure.
    - Average rainfall in the United States

2. Start with a topic sentence that describes what the graph or figure shows.
    - This map shows average rainfall in the United States for the years of 1961 to 1990.

3. Then, join each “What I see” comment with its “What it means” comment to make a sentence.

4. Build a coherent paragraph out of your sentences.

Sample Paragraph

- This map shows the average rainfall in the United States. Areas like the west coast are shaded blue, which means on average they get the most rain in the United States. The area I live in, Tennessee, is a green color on the map which means we get around 50 inches a rain a year. The area south of us closest to the ocean gets even more rain at about 60 inches a year.

Assessment

- Students should complete the following assessment question by themselves on the student handout.
- Using the information from the first two maps and the information below, students should support one of the claims below:
    - Tennessee precipitation has increased over the last few years.
    - East Tennessee on average has the lowest amount of precipitation.

Your paragraph supporting your claim should include the following:

- One-sentence main idea
- Supporting evidence
    - One statistic
    - One thing from the first two maps

    - One thing from the article or chart below
- Summary sentence

Tennessee Precipitation
Tennessee's climate is changing. Average annual rainfall is increasing. The state of Tennessee receives ample precipitation, about 51 inches (1,300 mm) a year, rather evenly distributed over the seasons and regions. Annual precipitation in Tennessee has increased approximately 5 percent since the first half of the 20th century (1901-1950). But rising temperatures increase evaporation, which dries the soil and decreases the amount of rain that runs off into rivers. Although rainfall during spring is likely to increase during the next 40 to 50 years, the total amount of water running off into rivers or recharging ground water each year is likely to decline 2.5 to 5 percent, as increased evaporation offsets the greater rainfall. Droughts are likely to be more severe, because periods without rain will be longer and very hot days will be more frequent.

The table below shows the annual precipitation totals averages based on weather data collected from 1981 to 2010 for the NOAA National Climatic Data Center for the state of Tennessee.

Region of Tennessee	**Average Rainfall (inches)**
West	54
Middle	53
East	50

Teacher Extensions
- To make a model of precipitation, the class could build a terrarium.

Citations and Resources

http://mrcc.isws.illinois.edu/resources/guides/BeAWeatherAndClimateWatcher_combined.pdf

Maps

https://www.google.com/search?q=average+rainfall+in+tn&source=lnms&tbm=isch&sa=X&ved=0ahUKEwjd0IKDgdPaAhUB0lMKHabtDpcQ_AUICigB&biw=1242&bih=535&dpr=2&safe=active&ssui=on#imgrc=b_q5aBimgr9NiM:

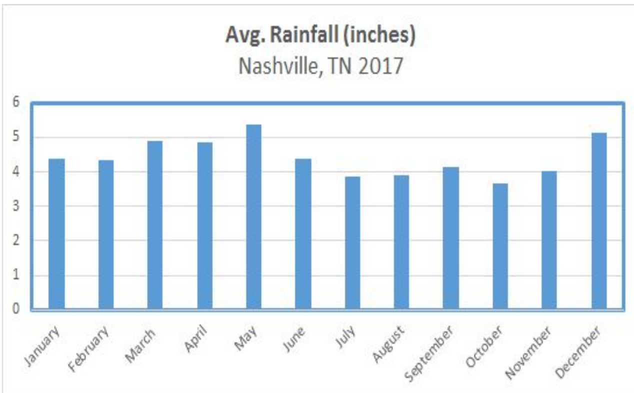
https://ag.tennessee.edu/climate/Documents/Avg_Ann_Ppt.pdf

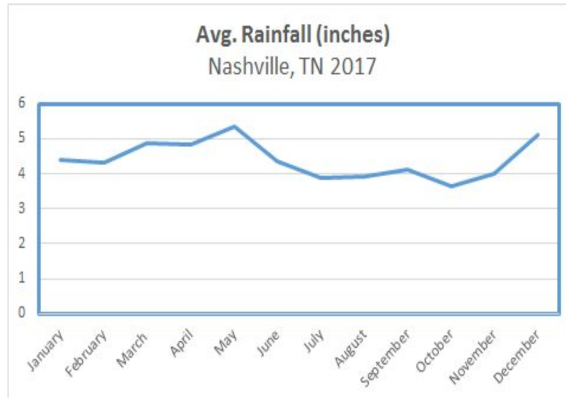
https://bscs.org/sites/default/files/_legacy/BSCS_PDI_Notebooking_Student_Version_NSTA_2012.pdf

https://media.bscs.org/icans/Icans_I2_SE.pdf
https://19january2017snapshot.epa.gov/sites/production/files/2016-09/documents/climate-change-tn.pdf

Weather Data Collection

Part 1: Understanding Graphs/Data





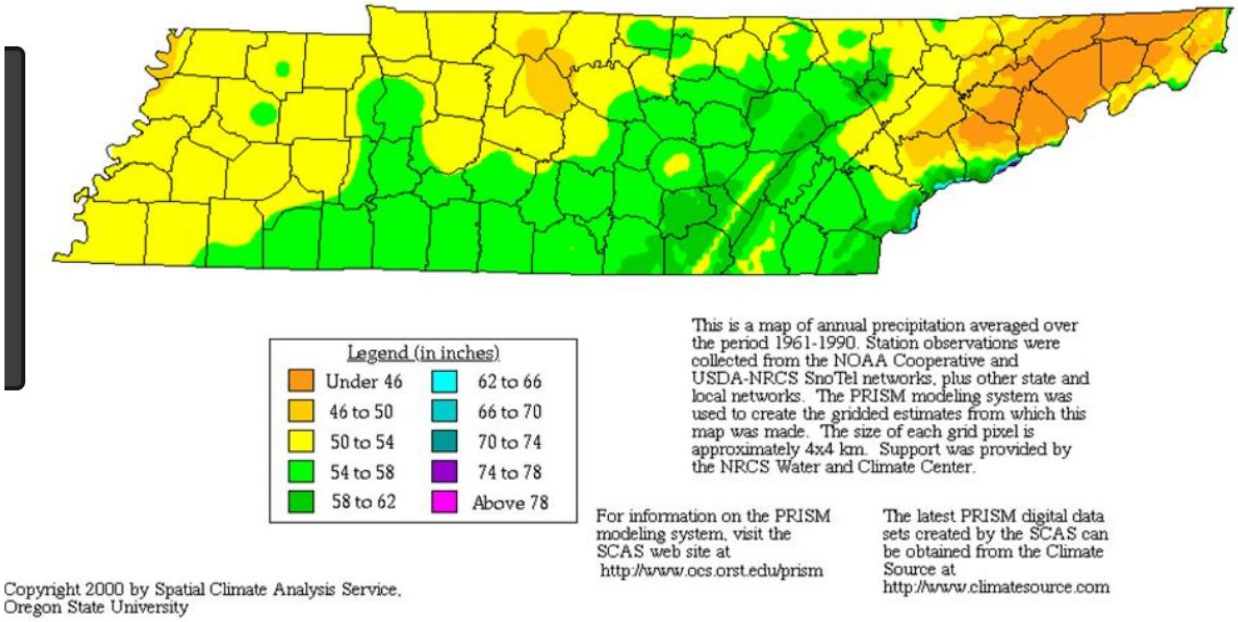
1. Compare the amount of precipitation in the following months using the appropriate sign: <,>,=
    a. March _________ June
    b. October _________ September
    c. January _________ February
2. About how many inches of precipitation fell in February?

3. Which month had the most rainfall?

4. On average, about how much rain falls each month in Nashville?

5. Which graph makes it easier to compare the amount of rainfall each month? Explain your reasoning.

Part 2: Map of Tennessee Average Precipitation



Step 1:

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2. Draw arrows and write a "What I see" comment for each arrow. Be concise in your comments. These should be just what you can observe. Do not try to explain the meaning at this point.

Step 2:
Do not try to interpret the whole graph or figure. Interpret the meaning of each "What I see" comment by writing a "What it means" comment.

Step 3:

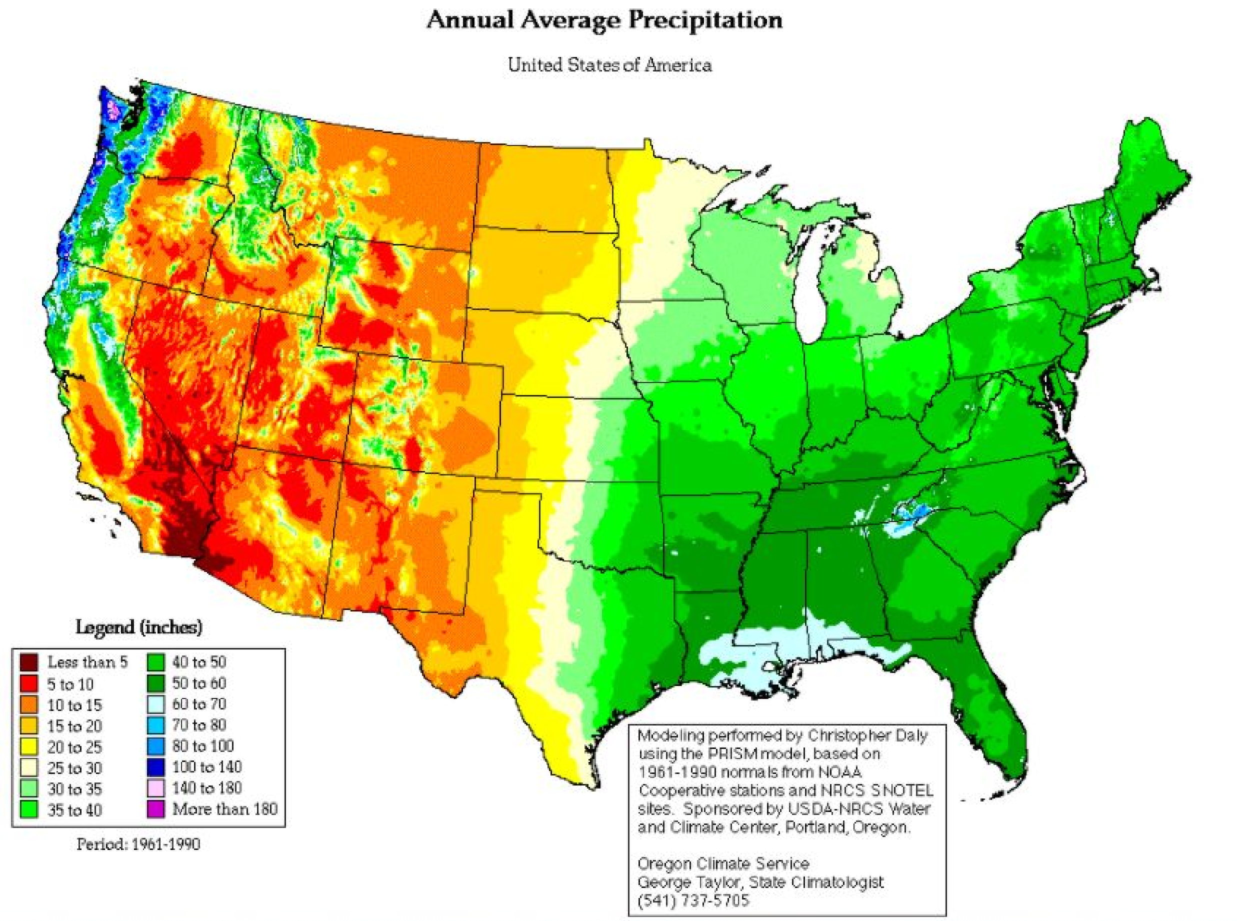
1. Write a caption for the graph or figure.

2. Start with a topic sentence that describes what the graph or figure shows.

3. Then, join each "What I see" comment with its "What it means" comment to make a sentence.

4. Build a coherent paragraph out of your sentences.

Part 3: Map of the Average Precipitation in the United States



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2. Draw arrows and write a "What I see" comment for each arrow. Be concise in your comments. These should be just what you can observe. Do not try to explain the meaning at this point.

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Step 3:

1. Write a caption for the graph or figure.

2. Start with a topic sentence that describes what the graph or figure shows.

3. Then, join each “What I see” comment with its “What it means” comment to make a sentence.

4. Build a coherent paragraph out of your sentences.

Part 4: Formative Assessment

Using the information from the first two maps and the information below. Write a small paragraph that supports one of the claims below:

- Tennessee precipitation has increased over the last few years
- East Tennessee on average has the lowest amount of precipitation

Your paragraph supporting your claim should include the following:

- One-sentence main idea
- Supporting evidence
  - One statistic
  - One thing from the first two maps
  - One thing from the article or chart below
- Summary sentence

Tennessee Precipitation

Tennessee’s climate is changing. Average annual rainfall is increasing. The state of Tennessee receives ample precipitation, about 51 inches (1,300 mm) a year, rather evenly distributed over the seasons and regions. Annual precipitation in Tennessee has increased approximately 5 percent since the first half of the 20th century (1901-1950). But rising temperatures increase evaporation, which dries the soil and decreases the amount of rain that runs off into rivers. Although rainfall during spring is likely to increase during the next 40 to 50 years, the total amount of water running off into rivers or recharging ground water each year is likely to decline 2.5 to 5 percent, as increased evaporation offsets the greater rainfall. Droughts are likely to be more severe, because periods without rain will be longer and very hot days will be more frequent.

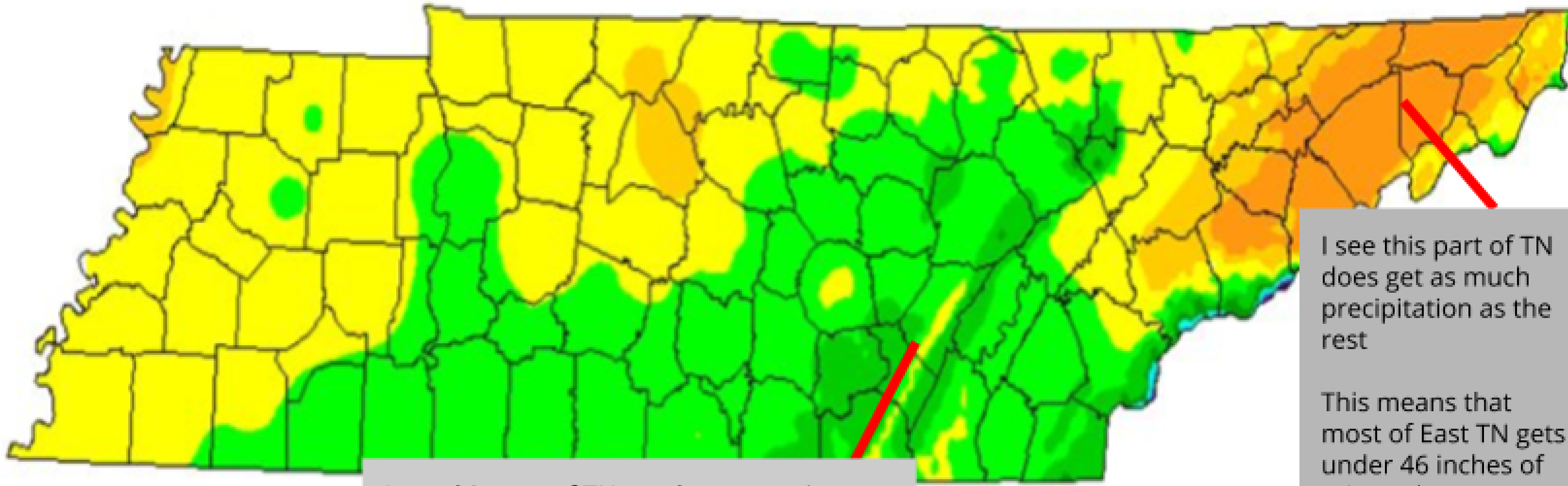
The table below shows the annual precipitation totals averages based on weather data collected from 1981 to 2010 for the NOAA National Climatic Data Center for the state of TN.

Region of Tennessee	**Average Rainfall (inches)**
West	54
Middle	53
East	50

Claim:

- I picked this claim ____ ____________________ because _______________________________________

Paragraph:



I see this part of TN does get as much precipitation as the rest

This means that most of East TN gets under 46 inches of rain each year

I see this part of TN get the most rain
This means this streak gets over 62 inches of rain

Legend (in inches)

Under 46	62 to 66
46 to 50	66 to 70
50 to 54	70 to 74
54 to 58	74 to 78
58 to 62	Above 78

...s a map of annual precipitation averaged over the period 1961-1990. Station observations were collected from the NOAA Cooperative and USDA-NRCS SnoTel networks, plus other state and local networks. The PRISM modeling system was used to create the gridded estimates from which this map was made. The size of each grid pixel is approximately 4x4 km. Support was provided by the NRCS Water and Climate Center.

This data was collected between 1961 and 1990

This means this data is almost 30 years old

For information on the PRISM modeling system, visit the SCAS web site at http://www.ocs.orst.edu/prism

The latest PRISM digital d... sets created by the SCAS can be obtained from the Climate Source at http://www.climatesource.com

I see a legend that tells me how much rainfalls inches
This means the map is colored coded for the different amounts of rainfall

Part 3:

1. Write a caption for the graph or figure.
    - Average rainfall in Tennessee

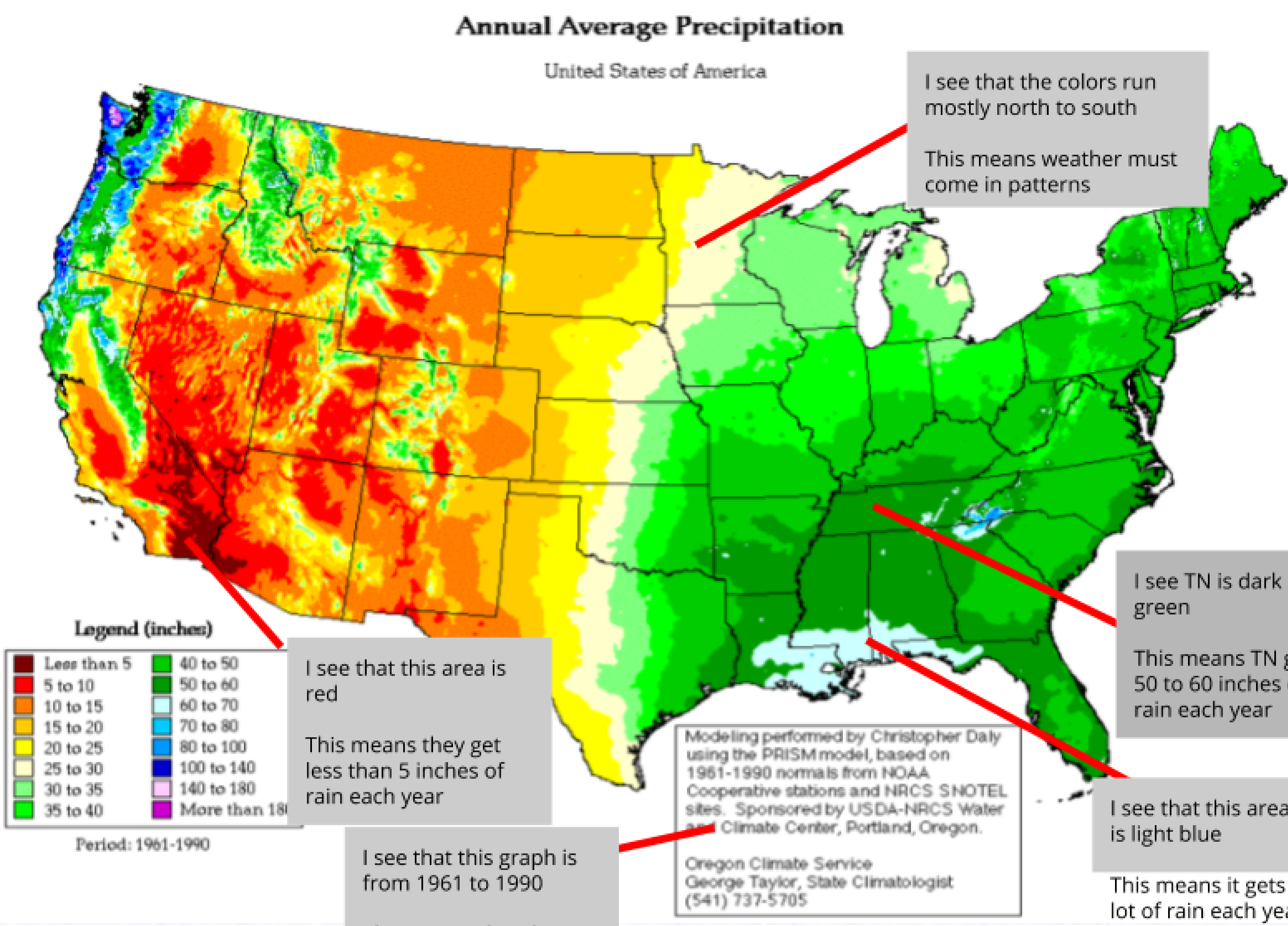
2. Start with a topic sentence that describes what the graph or figure shows.
    - This map shows average rainfall in Tennessee for the years of 1961 to 1990.

3. Then join each “What I see” comment with its “What it means” comment to make a sentence.

4. Build a coherent paragraph out of your sentences.

Sample Paragraph

- This map shows the average rainfall in Tennessee for the years of 1961 to 1990. The map has a lot of green at the bottom, which means the southern half of the state gets about 54 to 58 inches of rainfall each year. The upper lefthand corner has an orange color, which shows it gets the least amount of rainfall each year. There is a darker green streak that goes through the middle of Tennessee, which shows that area gets the most rainfall on average.



I see that the colors run mostly north to south

This means weather must come in patterns

I see TN is dark green

This means TN gest 50 to 60 inches of rain each year

I see that this area is red

This means they get less than 5 inches of rain each year

I see that this graph is from 1961 to 1990

This means that the graph is about 30 years old

I see that this area is light blue

This means it gets a lot of rain each year (60 to 70 inches)

Step 3:

1. Write a caption for the graph or figure.
    - Average rainfall in the United States

2. Start with a topic sentence that describes what the graph or figure shows.
    - This map shows average rainfall in the United States for the years of 1961 to 1990.

3. Then, join each “What I see” comment with its “What it means” comment to make a sentence.

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Sample Paragraph

This map shows the average rainfall in the United States. Areas like the west coast are shaded blue this means on average they get the most rain in the United States. The area I live in, Tennessee, is a green color on the map which means we get around 50 inches a rain a year. The area south of us closest to the ocean gets even more rain at about 60 inches a year.

Tab page front

Label: Constructing Explanations and Designing Solutions

TN Department of Education

Constructing Explanations and Designing Solutions

Tennessee Academic Standards for Science

Teacher Guide for Grade 3

Standards
3.ETS1.1 Design a solution to a real-world problem that includes specified criteria for constraints.

3.ETS1.2 Apply evidence or research to support a design solution.

3.ESS3.1 Explain how natural hazards (fires, landslides, earthquakes, volcanic eruptions, floods) impact humans and the environment.

3.ESS3.2 Design solutions to reduce the impact of natural hazards (fires, landslides, earthquakes, volcanic eruptions, floods) on the environment.

Tennessee Academic Standards for Science: Page 33

Three-dimensional Learning Performance for Lesson
Students will develop and design solutions* in order to show how man-made devices can help reduce the impact of natural hazards on the environment ** highlighting the fact that their design is a model of a flood and not the actual size of a real flood.***

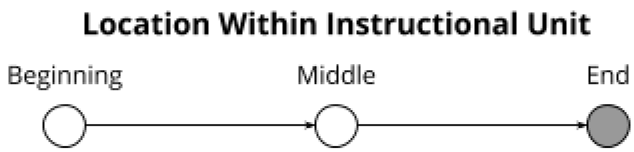
Science and Engineering Practice for Lesson
*Designing Solutions (for engineering)**
The goal of this three-dimensional learning performance is for students to design a solution to help alleviate flooding in different areas. It is important that the class has the impression that they are engineers working toward designing a device that could lessen the impact on humans during a flood. Time should be permitted for students to develop their solution, test it, and compare it to others' designs.

Disciplinary Core Idea for Lesson
*Earth and Human Impact***
"Humans depend on all of the planet's systems for a variety of different resources, some of which are renewable or replaceable and some which are not. Natural hazards and other geological events can significantly alter human populations and activities. Human activities, in turn, can contribute to the frequency and intensity of some of these natural hazards."

A Framework for K–12 Science Education: Pages 190-191

Crosscutting Concept for Lesson
Scale, Proportion, and Quantity***
When thinking scientifically about systems and processes, it is essential for students to recognize that they vary in size, time span, and the amount of energy flowing through them. Students should be able to realize that they are making a small model of what happens in a flood, compared to real floods that happen in their neighborhoods during and/or after a storm.

Prior Knowledge



- Concepts that should be covered before this lesson:
    - Background Information on natural hazards
    - Basics of the engineering design process
    - How to use a measuring device such as a measuring cup, beaker, ruler, etc.
- This lesson covers portions of standard 3.ESS3.1 & 2
    - Floods

Materials
- Small rectangle plastic containers (one per group)
- Fake class money
- Sand or gravel
- Duct tape
- Cotton balls
- Plastic sandwich bags
- Sponges
- Popsicle sticks
- Plastic drinking straws
- Cardboard
- Ruler
- Graduated cylinders
- Glue
- Small plastic cups
- Straws

Lesson Sequence and Instructional Notes

Student Discussion and Teacher Pre-Assessment Corners

Pass out the student activity sheet to each student. Have students record their responses on their sheet.

- What are natural hazards? Disasters? *Hurricanes, earthquakes, tornadoes*
  Most students will not know the difference between natural disaster and hazard. The teacher could highlight the differences (i.e., a natural hazard becomes a disaster when human lives are threatened).
- What can happen during a hurricane, earthquake, tornado, etc.? *Answers will vary. Some responses may include flooding, falling trees, land destruction, etc.*
- What are the steps that engineers take to solve a problem? *Answers will vary based on background knowledge. Hopefully students will be able to articulate that their designs, come up with a plan, and test them.*

Think-Pair-Share: Students think about the questions on their own, pair with another student to talk about it, and then share their ideas with the whole group. Allow two minutes for the first two steps (think and pair), and then conduct a whole group discussion.

Whole Class Pre-Assessment Corners Activity
Assess student prior knowledge regarding natural hazards, human impact, and the engineering design process. Label one side of the room YES and the opposite side NO. Gather students into the middle of the room.

Inform students that you will read several statements. If they agree with the statement, they will move to the YES side of the room, and if they disagree with the statement, they will move to the NO side of the room.

Statements

- Yes or No: Flooding provides nutrients to organisms in streams.
- Yes or No: Engineers can design devices to have less environmental impact.
- Yes or No: There are only a few ways engineers can solve problems.
- Yes or No: Humans can’t affect natural hazards such as floods, earthquakes, volcanoes.
- Yes or No: Engineers can predict some natural hazards.

Once students move to either side of the room, invite discussion by encouraging students to explain why the agreed or disagreed with the statements.

Student Reading and Discovery
Organize students into groups of 2-3 students. Direct students back to the student activity sheet. Inform them that they will read a short article and answer the follow-up questions. During this time, the teacher's role should be to travel through the class, observing the discussions taking place and the models being developed.

Student Questions from Article

1. Describe natural hazards.
2. What is a flood?
3. Describe one type of flood.
4. Why do engineers care about flooding?

After completing the reading task, pass out a post-it note to each student. Students will use post-it notes to jot down what they learned from reading the article and what more they want to learn about natural hazards.

- Two post-it notes per group
  - One new thing that the group has learned
  - One new thing the group wants to learn

Once all students have completed the reading task, the teacher should read and discuss the students responses.

Designing a Solution to Help with the Impact of Floods
After students have learned a little about floods, levees, and that engineers help solve real-world problems, tell them they will now become the engineers that help solve these type of problems. They will become the engineers by building a levee system to stop flooding in a community.

Show a quick video clip of a levee.

- https://www.youtube.com/watch?v=klu4JnBCKhk
- https://www.youtube.com/watch?v=X-pxokpBDvk

Teacher Pre-Setup Directions

Students will be designing a levee. The basic principle of the levee design is to split the plastic container into two parts. The first part will represent a lake or river, and the other half will represent the town, which we want to stay dry.

Students will design a model of their levees, test out two materials, build their levees, and then test the different levees as a whole class. The teacher should demonstrate an example of the container with water and explain that when their device is inserted, water should not cross the barrier.

After each group has completed their design, the teacher will guide the students to test their designs by filling one side of the plastic container with water to represent the lake or river. A successful levee design would keep the water from flooding the town.

Here is a Teacher Video of some examples of what students could build. The example is not to be shown to students, but should be used as an exemplar for the teacher.

- https://www.youtube.com/watch?v=e4DxUTyestU

Student Design Challenge
Divide the class into groups of three students each. Give each group a copy of the student handout worksheet. The teacher will go over the scenario and the criteria for the design challenge with the whole class.

Possible Teacher Dialogue

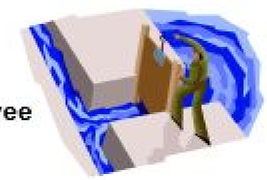
- We have just seen a short video and read an article about floods. Now it is time for you to become part of the solution. Each group will be a team of engineers. Your task is to create a levee that can stop flooding after a natural hazard. A levee is an edge constructed to prevent the overflow of a body of water.
- Here is a short video clip of students in New Orleans building a pool-size levee system after Hurricane Katrina https://www.youtube.com/watch?v=6i9Wpi1L7UU. Your group will not be making a levee this large, but one in a small plastic container.
- Your group will have a budget of $10. These are classroom dollars to build your design. Please plan and use your money wisely. You can use your money to buy sponges, zip lock baggies, tape, glue, etc.
    - The teacher should have random supplies that students could possibly ask for to use as a bonus material such as: straws, plastic cups, pantyhose, foil, etc.
- Your design requirements are on a smaller scale than a real-sized levee. Your levee will be at least 12 cm high and wide enough to prevent the water on one side of a plastic container from flooding into the other side of the container. *(Leave about three minutes or so to answer clarifying questions from students.)*

Students will design and build their levees by completing the design steps described on the student worksheet. Go through each step together as a class, giving teams time for each step.

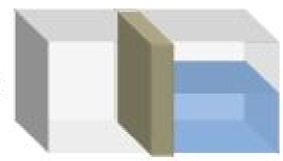
Step 1: Define the Problem
Problem: Build a new levee system that will maintain the boundary between the lake/river and the city.
Constraints:

- **Size:** The real levee must be 5 meters higher than sea level and wide enough to prevent the surrounding lake or harbor from flooding. Your prototype must be at least 12 cm high, and wide enough to prevent the water on one side of a plastic container from flooding into the other side of the container.
- **Budget & Materials:** Your group will receive a plastic container in which to build the prototype levee. Your team has a budget of $10 to purchase levee supplies. You may only buy from the following list of approved materials: (materials list provided on student handout)

actual levee



prototype levee



Give each student about three minutes to write the problem in their own words on their paper.

Step 2: Gather Information/ Research
Possible Teacher Dialogue

- Now that we understand our problem, it is time to come up with a solution. Before you begin to make your levee, you will need to complete some research on the items. Please research how these different items could best be used in your design. Feel free to test out up to two different items. I will model testing out straws as an example. I know they're are not on your list, but could be used as an additional supply.

Pull up research about straws on the computer. If you look up plastic straws and water absorption, you will find a lot of information on how they are polluting the ocean. Search a few different keywords such as straws and water, straw dimensions, etc. Read and see if you can find any valuable sources. After that, I would make physical observations about straws such as:

  - Flexible
  - Plastic
  - I don't get soaked when I drink soda

    - Easy to manipulate

Possible Teacher Dialogue

- Now, I want to test out my straw since I did not get much from my internet research. I will test my straw by taping three to the bottom of plastic dixie cup with a hole in it. I would then pour in 10 mL of water and see how much water went through the straws. I would then allow students to research and test materials. On the student handout, there is only space for two materials. Students can research and test as many materials as time, space, and materials will allow.

Have students conduct a simple experiment and research. Have a few computers for students to look up information. Pass out cups, water, graduated cylinders for the simple experiment. Using two materials of their choice from the list provided, have them determine how well each stops or slows down the flow of water. If there is enough time and supplies, students could test and research all the materials. If not, give each group a selected two supplies for them to share with the class.

Student Directions

- Gather information by testing two of the above materials that you think will be the best material to use in your design.
- Using at least two of the supplies, test how well they slow down water.
- To do this, put a small hole in a paper cup, and put your test material at the bottom of the cup. Measure 10 mL of water in a measuring cup. Then, pour the water into the cup with a hole and observe how well the material absorbs the water. Describe what you see.
- Research using the internet and make observations about how this material will be a good or a bad idea for stopping water.

Sample Student Answer

Material 1: Cotton Balls

Research: absorbs liquid, 25 times its size

Observations:

- Poured water on it, cotton ball did not drip
- Easy to move around
- Small
- Cheap: can get five for $1

After students have completed this part, have a short class discussion to share their findings.

Sample Questions

- What do you think is the best material to include in your design? Why?

- Using your research/experiment what was the best material to absorb water? Use some of your data to explain.
- What surprised you from the research/experiment? Explain.

Step 3: Brainstorming
Next, students will begin to actually generate design ideas to build their levees. While students are in their groups they should ponder on the following questions:

1. What was the best material from my research?
2. How can I make something that will be 12 cm tall?
3. How will I get my design to cover the plastic container from side to side?
4. How can I make my design work with a budget of $10.

Remind students that in brainstorming, no idea or suggestion is "silly." All ideas should be respectfully heard. Take an uncritical position, encourage wild ideas, and discourage criticism of ideas.

Expectations from Students During Brainstorming
- Trying to figure out how the height of the items
- Figuring out how to budget their money and supplies
- Sketching a picture of their levee
- Making a budget
- Using their research to pick the best design

Step 4: Select the Best Idea
Students should converge on an idea, and determine which materials they will use as their budget allows. This step completes the initial design process.

Questions to Ask the Groups

1. Has everyone got to share their opinion?
2. Did you decide to make a mix of everyone's idea or go with one person's idea?
3. How did you use your research to pick this levee design?
4. How are you doing with the budget?

Give students feedback on their design before they began to build. This can be done orally as you walk around and monitor groups or written if you collect their papers to review them at the end of each class period.

All designs should include the following:
- A list of resources they will need (reminder is to stay under the budget)
- Able to cover from side to side of the container

Step 5: Build and Test
Have students "buy" their materials with their classroom money. Give them plenty of time to build their levees. When they are ready, have them bring their plastic containers to a sink. Fill it with 200 mL of water, and help them observe how well the levee prevents the water from flooding to the other side of the container. Determine which group was able to retain water the most effectively. Some ways to determine which group was most effective include: how much water trickled to the other side, measure the amount of water on the other side, put a piece of paper on the other side and visually observe how much water was absorbed.

Step 6: Evaluate Design
Have students reflect on what they learned from the design process by answering the questions on the worksheet and self-grading themselves on the project rubric.

Project Rubric

	Expert Engineer	Skilled Engineer	Emergent Engineer
Design/Budget	• Picture drawn neatly and labeled • Budget accurately completed	• Picture drawn and most parts are labeled • Budget accurately completed	• Picture drawn and only a few to none of the parts are labeled • Budget has some figures incorrectly
Solution	• Solution was well put together • Minimum to no water passed through levee	• Solution was well put together • Some water passed through levee	• Solution needed some work • A lot of water passed through levee

Step 7: Redesign
Students will answer some questions concerning how they would redesign their project if they had time to redo their levee.

Teacher Evaluation Notes

- This lesson could get messy with the students dealing with water. Teacher could have water pre-measured.
- For the testing of the levees, teachers should try to demonstrate all in front of the class and control the water.
- Additional Options
    - Not giving students a budget requirement, if the money will become an issue
    - Giving students two opportunities to get supplies: one when they first make the design and a second trip to redesign.

Citations and Resources

https://www.education.com/lesson-plan/floods-and-droughts-and-water-oh-my/

https://www.teachengineering.org/curriculum/browse?q=floods

Earth and Human Activity Student Sheet

Part 1: Thinking Questions

1. What are natural hazards? What are natural disasters?

2. How do they affect humans?

3. Have you ever been involved in one? Explain if you feel comfortable sharing.

4. What are the steps that engineers take to solve a problem?

Part 2: Read the following article below and answer the questions that follow.

Natural Hazards

Engineers learn about our planet so that humans can exist with and survive its natural hazards. A natural hazard has the potential to cause damage to people, but doesn't necessarily. Types of natural hazards include: avalanche, earthquake, flood, forest fire, hurricane/typhoon/cyclone, landslide, thunderstorm/blizzard/ice storm, tornado, tsunami and volcano. Engineers must be aware of natural hazards in order to prevent or minimize their harmful effects on people and property. They create devices that detect natural hazards, build structures to withstand them, and invent devices to study them.

In this lesson, we will cover the natural hazard: flood. Floods can be deadly and destructive to people and property. Engineers work with geologists and meteorologists to devise ways to control flooding with a range of human-made structures: dams, dikes, levees, flood gates, seawalls, drainage canals, sewer/water/storm drainage systems, pumping stations, bridges, concrete river banks, spillways, overflow basins, embankments, retention ponds and wetlands restoration. To aid in prediction and planning, engineers and scientists also develop instruments and computer programs to monitor weather (precipitation, temperature, snow pack, etc.), and develop complex models to estimate worst-case-scenario storm surges and flood risks. Too much rainfall or melting snow can sometimes cause a flood.

There are different types of floods. The most common type is generally called a river flood. It occurs when a river or similar body of water (stream, creek, brook, etc.) overflows because of heavy rainfall and sometimes because of melting snow and ice. Other times, heavy rains are the result of hurricanes or other large storms.

Many streams and rivers that have been flooding for thousands of years (or longer) become a problem when people start building in areas where the flooding happens. Flash floods occur over a very short periods of time, and are usually caused by heavy rains. They can also be caused by ice jams on rivers, or when a dam breaks (natural and human-made). *Coastal flooding* is another type of flooding that occurs when strong onshore winds from storms push water onto the land. This is the type of flooding that you see along the seashore during a hurricane or tropical storm. It usually happens in combination with flooding from heavy rains. When flooding is really heavy or not predicted, it becomes dangerous and destructive.

The many floods throughout history have affected a lot of people. Some engineers study flooding, and use what they learn to protect people and property. These engineers design things to control flooding such as *dams*, *dikes,* and *levees* that help keep fast moving and dangerous flood waters away from people's homes and roads. Engineers also work with scientists to develop instruments and computer programs to monitor the rain and snow weather patterns to better predict when and where floods might occur.

Retrieved from: https://www.teachengineering.org/lessons/view/cub_natdis_lesson01

Reading Questions

1. Describe natural hazards.
2. What is a flood?
3. Describe one type of flood.
4. Why do engineers care about flooding?

When your group is done reading and answering the questions, you will put two post-it notes on the board: one new thing you learned and one thing your group wants to learn more about.

Part 3: Designing Solutions

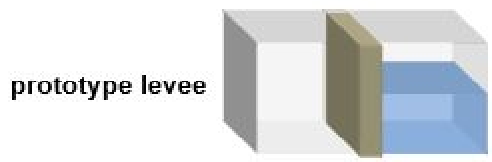
Stopping the Flood

Scenario: For this lesson, you will be an engineer who designs devices to help with flooding. You will be creating a levee that can stop flooding after a natural hazard. A levee is an edge constructed to prevent the overflow of a body of water.

Step 1: Define the Problem

Problem: Build a new levee system that will maintain the boundary between the lake/river and the city.

Constraints:



- **Size:** The real levee must be 5 meters higher than sea level and wide enough to prevent the surrounding lake or harbor from flooding. Your prototype must be at least 12 cm high, and wide enough to prevent the water on one side of a plastic container from flooding into the other side of the container.
- **Budget & Materials:** Your group will receive a plastic container in which to build the prototype levee. Your team has a budget of $10 to purchase levee supplies. You may only buy from the following list of approved materials:

Material	Cost
1 cup of sand/gravel	$1
5 cotton balls	$1
5 straws	$1
5 popsicle stick	$1
1 plastic bag	$2
1 sponge	$2
1 piece of cardboard	$2
30 cm of duct tape	$2
Glue	$2
Your choice material (approved by teacher)	$3

Rewrite the problem in your own words:

____

____

Step 2: Gather Information/Research

- Gather information by testing two of the above materials that you think will be the best material to use in your design.
- Using at least two of the supplies, test how well they slow down water.
- To do this, put a small hole in a paper cup, and put your test material at the bottom of the cup. Measure 10 mL of water in a measuring cup. Then, pour the water into the cup with a hole and observe how well the material absorbs the water. Describe what you see.
- Research using the internet and make observations about how this material will be a good or a bad idea for stopping water.

Material 1: ____________________

Research:

____

____

Observations:

____

____

Material 2: ____________________

Research:

____

____

Observations:

____

____

Step 3: Brainstorm

When engineers get ready to design a solution, they come up with as many ideas as possible. From what you know about water, flooding, and your initial test of the materials, come up with several different ideas for building your levee. In this space, come up with as many ideas and designs as possible. Please remember your budget of $10.

Step 4: Pick your Best Design

<table>
<tr><td colspan="2">Invention Illustration:

</td></tr>
<tr><td>Describe the Problem:</td><td>Describe your Solution:</td></tr>
<tr><td>

</td><td>

</td></tr>
</table>

Use the following table to determine how you will spend your budget on materials.

Material	Cost	Amount you Want	Cost
1 cup of sand/gravel	$1		
5 cotton balls	$1		
5 straws	$1		
5 popsicle stick	$1		
1 plastic bag	$2		
1 sponge	$2		
1 piece of cardboard	$2		
30 cm of duct tape	$2		
Glue	$2		
Your choice material (approved by teacher)	$3		

Step 5: Build and Test

Purchase materials and build your levee prototype. Then, with the teacher's help, test your levee by pouring water into one side of your container.

Step 6: Evaluate your Design

After engineers test their prototypes, they think about how well it worked. This helps them make changes to improve the final, real version.

Project Evaluation:

- Describe what happens when you tested your levee.

____

____

- What did you like best about your levee system design?

____

____

Grade Your Project on the Rubric:

	Expert Engineer	**Skilled Engineer**	**Emergent Engineer**
Design/Budget	• Picture drawn neatly and labeled • Budget accurately completed	• Picture drawn and most parts are labeled • Budget accurately completed	• Picture drawn and only a few to none of the parts are labeled • Budget has some figures incorrectly
Solution	• Solution was well put together • Minimum to no water passed through levee	• Solution was well put together • Some water passed through levee	• Solution needed some work • A lot of water passed through levee

Step 7: Redesign

- What changes would you make to your levee system if you were to build it again?
- What other materials do you think should have been available to the class?

Tab page front

Label: Obtaining, Evaluating, and Communicating Information

TN Department of Education

Obtaining, Evaluating, and Communicating Information

Tennessee Academic Standards for Science

Teacher Guide for Grade 3

Standard
3.LS1.1 Analyze the internal and external structures that aquatic and land animals and plants have to support survival, growth, behavior, and reproduction.

Tennessee Academic Standards for Science: Page 32

Three-dimensional Learning Performance for Lesson
Students will obtain, evaluate, and communicate information* in order to show that different external structures support survival, growth, and behavior ** highlighting how the different structures and functions of animals help them survive.***

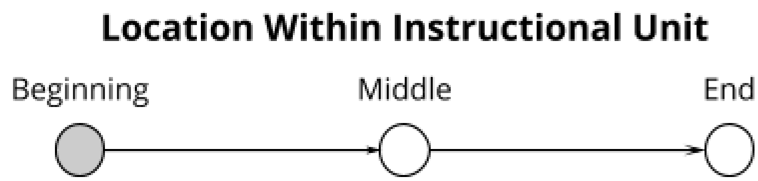
Science and Engineering Practice for Lesson
*Obtaining, Evaluating, and Communicating Information**
The goal of this three-dimensional learning performance is for students to obtain, evaluate, and communicate information about animals' internal and external structures that support survival, growth, behavior, and reproduction.

Disciplinary Core Idea for Lesson
*Life Science 1: Structure and Function***
A central feature of life is that organisms grow, reproduce, and die. They have characteristic structures (anatomy and morphology), functions (molecular-scale process to organism-level physiology), and behaviors (neurobiology and for some animal species, and psychology). Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction.

A Framework for K–12 Science Education: Page 123

Crosscutting Concept for Lesson
*Structure and Function****
Exploration of the relationship of structure and function begin in the early grades when looking at different shapes to explore stability or purpose as animals use different parts to obtain food. This lesson highlights how different external and internal structures of animals play an important part in their function.

Prior Knowledge



- Concepts that should be covered before this lesson:
    - Introduction to the external features of land/aquatic animals
- This lesson covers portions of standard 3.LS.1:
    - Focuses on external structures, not on internal structures
    - Does not cover the different structures of plants

Materials
- Internet access
- Poster boards
- Various coloring supplies

Lesson Sequence and Instructional Notes

Introduction

- Draw a T-chart on the board. On one side of the T-chart, label it structural and on the other side label it behavioral.
- Have students generate a list of human structures (external parts of the body) that help us survive. Jot down students responses on the T-chart on the structure side (left side of chart).
- After students have identified about five different human structures, ask them to think of how we use these structures for survival (behavioral). Jot down these behaviors on the right side of the T-chart.

Tell the class that our structures help us to survive, but what about the structures of animals? Inform students that today's lesson will focus on the external structures that help different animals survive.

Students Obtaining Information

Present students with the reading passage in their student activity sheet. Guide the class through reading the passage together. If students are able to read the passage independently, this can be done. After reading the passage, discuss with the class the chart that compares human structure and functions to a fish. Explain to students that even though humans are not fish, we both share commonalities when it comes to our structures and how we function (e.g., movement, breathing, eating, etc.).

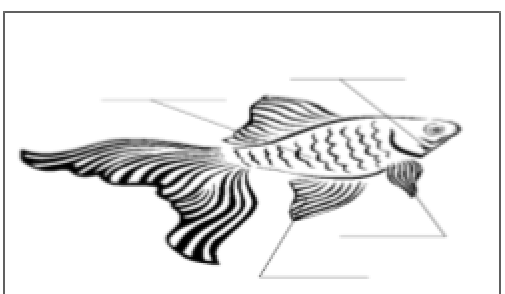
Student Article/Chart/Diagram

Living things are similar to and different from each other. When we look at a fish, a human, and a plant we will learn that certain organs and systems are similar and other organs and systems are not. The external structures (outside body parts) and the internal structures (inside body parts) of an organism can also tell us a lot about a species—where it lives, how it finds food, how it reproduces and how it protects itself from predators. Even though humans and fish do not look the same, we share similar organs and body parts. Read the chart below to see a few of the differences.

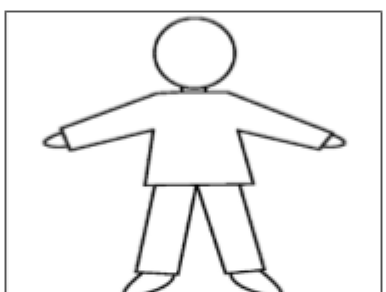
	Humans	Fish
Breathing	Lungs	Gills
Outside Layer	Skin	Scales
Movement	Arms	Pectoral Fins
Movement	Legs	Pectoral Fins

After going over the passage and the chart, inform students that they will now label a picture of a fish and human to model where the structures listed in the chart are located on the fish and human. Again at this time as students label their structures discuss how fins of fish are used to move and legs of humans function the same way for the purpose of movement. Once each part of the fish and human are labeled discuss with the class how each structure is important for survival, growth, and behavior. You may want to ask students what would happen if they or the fish were missing one of the structures that they labeled.

Label the Pictures Below: Explain how the parts you labeled help with the following: Survival, Growth or Behavior



Picture from https://www.etsu.edu/coe/ruai/documents/3ls12internalandexternal.pdf



Picture from-
https://images.template.net/wp-content/uploads/2015/08/Blank-Human-Body-Outline-Template-For-Kids.jpg

After going over the passage and chart, and having students label their fish and human body, inform students that you now would like them to think about other animals that share some of the same structure and functions. Encourage them to think about an aquatic animal and a land animal. If students are confused by the word aquatic, remind them that aquatic animals are those animals that live in water, such as fish, sharks, etc. Have students share out some of the aquatic and land animals that came to mind. Next, inform students that they will pick one of the aquatic animals and one of the land animals and complete a comparison chart. They would need to identify two external structures that each animal has that function similar to one another. If students are unsure, refer them back to the activity with the fish and human.

Fill in your own chart below.

	Aquatic Animals	Land Animals
Name of Organism		
External Structure #1:		
External Structure #2:		
How do those structures support the following: a. Survival b. Growth c. Behavior		

After all students have completed their comparison chart. Have them share out. Ask students if they can identify similarities amongst the animals that their peers shared.

Students Evaluating Information

Tell students that they just engaged in identifying similarities and differences in animals' and humans' structure and function. By this time, students should notice that although the structure between a fish and a human, or an aquatic animal and a land animal are not the same, they still serve some of the same functions. Let students know now you will have them explore this concept even further by investigating some different animals.

The teacher should pull up the external features of animals presentation. The presentation is a slide deck of several different types of animals. As the teacher goes through each slide, have students think about the following questions:

- **Slide 1 (introduction):** Class, we are about to look at several different slides containing different animals. Examine all of the animals' different external features that help them survive.

- **Slide 2 (two polar bears):** Here are two polar bears.
  - What do you observe about them? *(They are two polar bears playing in the snow. Students may also notice their heavy fur, big paws, etc.)*
  - What do you think the weather is like in this place? *(Snow and ice show that it's cold.)*
  - What features do these polar bears have that help them to live in this cold place? *(Focus on features such as the bears' heavy fur, large paws for walking, and their white color that helps protect them from their enemies because they blend into their white environment.)*

- **Slide 3 (penguin and chick):**
  - How are these penguins like the polar bears you just saw? *(The penguins have young, too, and live in a cold environment.)*
  - How are they different? *(Encourage students to point out features that show the penguins are birds rather than mammals.)*
  - What external features do they have to help them survive?

- **Slide 4 (great egret):**
  - What do you notice about these birds? *(Encourage students to point out the adult bird and chicks as well as the birds' feathers, beaks, wings, and other physical features.)*
  - How are they like the penguins you just saw? *(Encourage students to notice that both are birds and recognize their similar physical features.)*
  - How are they different from the penguins? *(Answers will vary. Encourage students to notice physical features, such as size, feathers, etc.)*
  - What can you determine about the type of place these birds live in? (*It appears to be near water.)*
  - What do you notice about the birds that helps them live in this place? *(These birds have long legs that help them walk in water and light feathers that help keep them cool.)*

- **Slide 5 (lions):**
    - What kind of place do you think these lions live in? *(It looks warm and it's a land environment.)*
    - What features do the lions have that help them live in this place? *(They're light colored like the grass around them, which helps protect them from their enemies, and their fur is short, which helps keep them cool.)*
    - What external features help them survive? *(sharp teeth, large mouths, large size)*
- **Slide 6 (elephants):**
    - What kind of place do these elephants live in? *(It looks hot and dry. It's a land environment.)*
    - How are the elephants like the lions? *(They live in a hot, dry land environment.)*
    - What distinguishable features do elephants poses? *(Large tusk, heavy, large legs, long trunk)*
    - Can you describe how any of these features help them to survive? (*Large tusk - used for defense, helps them dig; long trunk - helps them eat food from distance)*
- **Slide 7 (dolphins swimming):**
    - Where do these dolphins live? *(They live in a water environment.)*
    - What do you notice about the dolphins that helps them to live there? *(Their shapes, fins, and tails help them move easily through the water.)*
    - How do these features help them to survive? *(fins - help them get through the water, navigation; tails - defense)*
- **Slide 8 (otter):**
    - How is this otter like the dolphins? *(It also lives in or near a water environment. It also has a smooth shape that helps it swim easily.)*
    - How is it different from them? *(It has fur and it lives on land.)*

Students Communicating Information

Once the teacher has gone through the presentation and students have engaged in discussion around each of the animals' structure and its function, inform students that they will now work in groups to use some of that information to construct a poster, in which they will then communicate more detailed information about a specific animal.

Pass out a different animal article to each group. Students will complete a chart about the animal's structures, design a poster presentation, and then present information to the class. On the communicating results part, some articles are more detailed than others. When selecting groups, you can arrange them by mixed ability and allow them to pick their own article or you can do homogenous groups and assign the articles.

- Hummingbird Article
- Porcupine Article
- Octopus Article
- Fennec Fox Article
- Penguins Article

Before allowing students to engage in reading the text, part out the *Internal and External Structure of Animals Chart*. Inform students that as they read, they are to record their evidence on the chart. Emphasize to students that completing the chart is a graphic organizer tool to jot down evidence that they will use for their poster presentation. It is also important for the teacher to review the rubric with students so that they are aware of the criteria and expectations for the task.

Internal and External Structures of Animals
Animal: ____

External Structures: Explain how they work	
How does the animal support survival?	
How does the animal support growth?	
How does the animal support behavior?	
How does the animal support reproduction?	
Any additional information	

Poster Presentation Rubric

Poster Requirements	
Content	• Description of the animal's habitat (1-2 sentences) • Explanation of three different ways your animal is physically adapted to its environment • Explanation of two different ways your animal is behaviorally adapted to its environment • Interesting fact about your animal
Creative and clear graphic (drawing and/or pictures)	• At least one picture or diagram showing your animal
Organization	• Titles/Labels • Flow of Information

Presentation Component	**Possible Score**	**Your Score**
Volume/eye contact/clear speech	25	
Quality Content: Complete sentences and effective word choice	25	
Enthusiasm/preparedness	25	
Explanations of the content and graphic(s) of the poster	25	

Citations and Resources

https://www.etsu.edu/coe/cuai/documents/3ls12internalandexternal.pdf

http://sciencenetlinks.com/esheets/animal-diversity/#

https://learning-in-action.williams.edu/files/Lesson-13-full.docx

https://www.superteacherworksheets.com/reading-comp/4th-hummingbirds_WDFTF.pdf?up=1466611200

https://www.superteacherworksheets.com/reading-comp/4th-fennec-fox_WDFMZ.pdf?up=1466611200

https://www.superteacherworksheets.com/reading-comp/5th-penguins_PENGU.pdf?up=1466611200

https://www.superteacherworksheets.com/reading-comp/4th-porcupine_WDFNZ.pdf?up=1466611200

https://www.superteacherworksheets.com/reading-comp/3rd-octopus_WDFZN.pdf?up=1466611200

Student Handout

Obtaining Information

Read the following paragraph and fill in the chart below:

Living things are similar to and different from each other. When we look at a fish, a human, and a plant, we will learn that certain organs and systems are similar, and other organs and systems are not. The external structures (outside body parts) and the internal structures (inside body parts) of organisms can also tell us a lot about a species--where it lives, how it finds food, how it reproduces, and how it protects itself from predators. Even though humans and fish do not look the same, we share similar organs and body parts. Read the chart below to see a few of the differences.

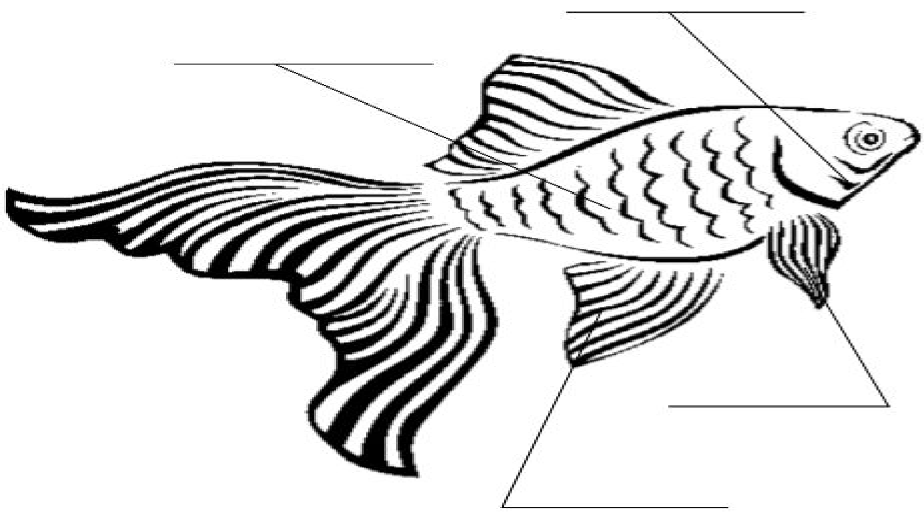
	Humans	Fish
Breathing	Lungs	Gills
Outside Layer	Scales	Slime Layer
Movement	Arms	Pectoral Fins
Movement	Legs	Pectoral Fins

Fill in your own chart below.

	Aquatic Animals	Land Animals
Name of Organism:		
External Structure #1:		
External Structure #2:		
How do those structures support the following: a. Survival b. Growth c. Behavior		

Label the Pictures Below

Explain how the parts you labeled help with the following: Survival, Growth or Behavior.



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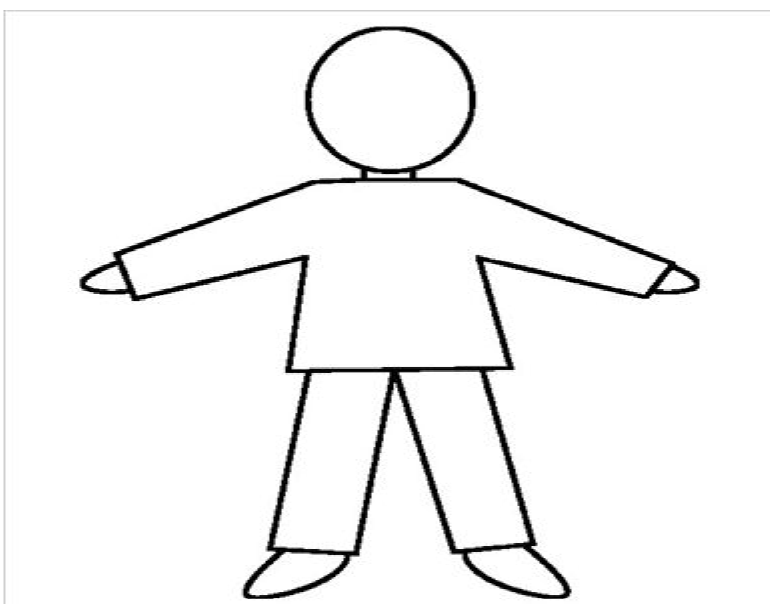


[2]

[1] Picture from https://www.etsu.edu/coe/cuai/documents/3ls12internalandexternal.pdf
[2] Picture from https://images.template.net/wp-content/uploads/2015/08/Blank-Human-Body-Outline-Template-For-Kids.jpg

Evaluate Information

- For each animal, we are about to see, I would like you to consider the following questions:
  - Where does this animal live?
  - Do you think it could live in somewhere different? Why or why not?
  - Do you think something else also could live in this animal's environment?
  - Why or why not? If an animal could, which animal would it be?

Communicate Information

- Your group will be given a short article about an animal. Your job is to gather as much information about that animal as possible to share with the class. Your job is to focus on the special internal and external features of your animal. You will complete a small poster to present your information to the class.

- Things to consider while you are reading:
  1. What makes my animal unique?
  2. What are some special adaptations that allow my animal to survive?
  3. What are some interesting facts that I could share with the class?
  4. How could I compare my animal to another animal that we have discussed earlier in class?

- After you have read the article and taken some notes, fill in the chart below.
- A completed chart is a tool for you to collect evidence so that you can complete your poster presentation.

Internal and External Structures of Animals
Animal: ___________________________________

External Structures: Explain how they work	
How does the animal support survival?	
How does the animal support growth?	
How does the animal support behavior?	
How does the animal support reproduction?	
Any additional information	

- Allow your teacher to check over your chart before you begin your poster. Please make sure that you are adding accurate information.
- When you have finished your poster, practice who will say what during the whole-class presentation. Your poster presentation should be three minutes or less.

Poster Presentation Rubric

Poster Requirements	
Content	● Description of the animal's habitat (1-2 sentences) ● Explanation of three different ways your animal is physically adapted to its environment ● Explanation of two different ways your animal is behaviorally adapted to its environment ● Interesting fact about your animal
Creative and clear graphic (drawing and/or pictures)	● At least one picture or diagram showing your animal
Organization	● Titles/Labels ● Flow of Information

Presentation Rubric

Presentation Component	Possible Score	Your Score
Volume/eye contact/clear speech	25	
Quality Content: Complete sentences and effective word choice	25	
Enthusiasm/preparedness	25	
Explanations of the content and graphic(s) of the poster	25	

A Mighty Flier
by Kelly Hashway

What is two inches tall, can hover in mid-air, and flies in every direction including backwards? It's not an insect. The answer is the bee hummingbird.

Most hummingbirds are about three to five inches long. But the bee hummingbird is only five centimeters, or approximately two inches, making it the smallest species of bird alive today. Really it isn't bigger than a large insect. But don't let its tiny body fool you. This bird is a fierce flier. It can beat its wings up to 80 times per second. If you ever see one in flight, you'll notice its wings are just a blur to the human eye. Hummingbirds are also the only vertebrates that can hover in one place. Add to that being able to fly backwards and upside down, and these creatures are amazing flying machines.

And being a master flier isn't the only one of the bee hummingbird's talents. The bee hummingbird does a great job performing its part in plant reproduction. During the course of a single day, the bee hummingbird can visit up to 1,500 flowers. And just like a bee, when the bee hummingbird drinks nectar from the flowers, pollen is transferred from the flower to the bird's body. This pollen is carried to the next flower. Transferring pollen from one flower to another helps plants make seeds.

Besides drinking nectar, bee hummingbirds eat insects. In fact, they eat about half their body mass each day. But what's more impressive is that they drink eight times their body mass every day. This is why they live in areas where there are gardens and shrubbery. These tiny birds are found primarily in Cuba, but some have been spotted in Jamaica and Haiti as well.

Despite its size, there's no arguing that the bee hummingbird is a mighty flier.

[1] https://www.superteacherworksheets.com/reading-comp/4th-hummingbirds_WDFTF.pdf?up=1466611200

The Big-Eared, Bushy-Tailed Fennec Fox

by Guy Belleranti

In the deserts of North Africa and Saudi Arabia lives the smallest of all foxes with the largest of ears. This animal is the fennec fox.

Fennec foxes have ears that are 5 to 6 inches long. That's big for an animal that weighs less than four pounds. Their ears help shed body heat. And, as you may have guessed, they also provide great hearing.

It's interesting to compare the big ears of fennec foxes to the small ears of arctic foxes. Arctic foxes live in cold climates, so they don't need to shed heat. Instead, they need to save heat. Big ears would not save heat and would probably even cause an arctic fox to get frostbitten!

It's also interesting to think about the hair of fennec foxes. Why would a fox that lives in the desert need a thick, fur coat? Actually, the desert isn't always warm. During the nighttime, a desert can be downright cold! A fennec fox's fur keeps them warm during those chilly desert nights. They also have long bushy tails that they use as a blanket. And the hair on their feet protects them from the hot sand in the daytime.

Fennec foxes live in small communities of burrows or dens. They spend most of the day sleeping in their dens, out of the hot sun. Then, when night comes, out they come in search of food. In addition to their great hearing, fennecs also use their great sense of smell and big eyes to track down dinner. Animals that are active at night are called nocturnal.
Like other foxes, fennecs are omnivores. This means they eat both meat and plants. Some of their favorite foods include rodents, birds, eggs, insects, lizards, snails, fruit and leaves.
Fennec fox mothers give birth to a litter of one to five babies (called kits). The average lifespan of a Fennec fox is 10 to 12 years.

The cream coloration of fennec foxes help them blend into their desert habitat. Still, they have to watch out for predators. These include caracals (a type of wild cat), jackals, eagle owls, hyenas and humans. Humans catch them for their fur and to sell as exotic pets.

[2] https://www.superteacherworksheets.com/reading-comp/4th-fennec-fox_WDFMZ.pdf?up=1466611200

Talking About Penguins

By Guy Belleranti

Penguins are one of the world's most interesting birds. They waddle when they walk, and have flippers instead of wings. The bones in a penguin's flippers are heavier and more solid than those in the wings of a flying bird. This helps the penguin "fly" through the water. The penguin's black back and white front has an important function, too -- camouflage in the water. Penguins blend in with the sea from above and with the sky from below. This makes it harder for predatory birds, leopard seals, sea lions, orcas and sharks to see them. Many people think all penguins live in the cold and ice of Antarctica. However, only 6 of the 17 species or types of penguins live in Antarctica. The others live in parts of New Zealand, Australia, South Africa and South America and on the Falkland and Galapagos Islands.

Let's talk about two of the penguin species – the Emperor penguin of Antarctica and the Galapagos penguin of the Galapagos Islands. The Emperor penguin is the world's largest penguin. Its oily outer feathers help keep it dry. Its dense inner down feathers and thick fat layer helps keep it warm. Emperor penguins also often huddle in groups to conserve heat. A mother Emperor penguin lays only one egg at a time. After the mother Emperor penguin lays the egg she travels to open sea to feed on fish, squid and krill (shrimp-like ocean crustaceans). The father stays behind with the egg. He keeps it warm and protected by balancing it on his feet and covering it with feathered skin called a brood pouch. The mother returns two months later, regurgitates food for the newly hatched chick, then stays with it while the father goes out to sea to feed.

[3] https://www.superteacherworksheets.com/reading-comp/5th-penguins_PENGU.pdf?up=1466611200

Quills and Thrills

By Kelly Hashway

Forests are homes to many animals. But there's one forest creature that gives off an odor and makes a rattling sound when it feels threatened. No, it's not a cross between a skunk and a rattlesnake.

It's a porcupine. Porcupines are covered with quills—about 30,000 on average. The quills cover most of the porcupine's body with the exception of the face, stomach, and the inside of the animal's legs. You probably know that rattlesnakes shake their tails to scare off predators. It's like a warning signal. Well, porcupines do something similar. When a porcupine is approached by a predator or is feeling threatened, it rustles its quills. This creates a rattling sound as a warning sign, telling other animals or even humans to back off. But the sound isn't the only warning. When a porcupine raises its quills like this, it produces an odor. So the animal uses both sound and smell to ward off enemies.
If a porcupine is attacked, its quills act as protection. You may have heard rumors that porcupines can shoot their quills at attackers. This isn't true. What actually happens is when a porcupine tenses the muscles around their quills and makes them stand up, the quills become loose. If an animal gets too close to the porcupine and brushes up against it, the quills will detach and stick into the attacker.

The quills aren't poisonous, but they have multiple layers of barbs like barbed wire, which makes them painful and sometimes difficult to remove because they embed themselves into the attacker's skin. But the interesting thing about quills is that they are coated with antibiotic fatty acids that help speed up the healing process. Why? To protect the porcupine in case it accidentally pierces its own skin. A porcupine's quills will grow back after losing them, but it does take several months.
So if you ever find yourself in a forest, and you hear a rattling sound followed by a strange odor, beware. Finding yourself on the other end of a porcupine's quills may be more thrills than you're looking for.

Questions

Think of another animal that has a special way of protecting itself from predators. Describe the animal and explain how it protects itself.

[4] https://www.superteacherworksheets.com/reading-comp/4th-porcupine_WDFNZ.pdf?up=1466611200

Magician of the Sea
By Kelly Hashway

What do three hearts, eight arms, and one huge brain add up to? An octopus, a creature that can do amazing things. Octopuses are extremely intelligent. They can learn new things just like humans. They've even learned a few tricks to get them out of sticky situations. If an octopus is threatened by a predator, such as a shark or bird, it can use some pretty incredible skills to get away. Octopuses don't have teeth or sharp claws to defend themselves. Instead, they use more clever ways to fool their attackers.

Octopuses like to hide themselves in the sand on the bottom of the ocean floor. How you ask? Well, the octopus is like a chameleon because it can change the color of its skin to match the sand. And this color change, or camouflage, happens in less than a minute. Some octopuses like to stay in more shallow water where there are rocks and coral. Because octopuses are invertebrates, meaning they don't have backbones, they can squeeze themselves into small spaces between the rocks to get out of reach of their predators. Another way an octopus can hide is by shooting ink. An octopus uses a part of its body called a siphon to shoot ink into the water. The ink forms a cloud that hides the octopus. By the time the ink clears and the predator can see again, the octopus has swum away or hidden. It's very much like a magician doing a vanishing act.

If you think that's a neat trick, then you'll love what else these creatures have up their sleeves. If an octopus is being attacked, it can actually make itself look like a venomous sea snake. It will bury itself in the sand, keeping two arms visible. It will change the color of those arms to match a sea snake. But what if there's no time to hide? If an octopus is in trouble, it can break off one of its arms. The arm will then change colors and squirm around in the water to distract the predator while the octopus swims away to safety. Don't worry though. The octopus's arm will grow back. There is one kind of octopus that has venom to use in defense. The blue-ringed octopus is tiny; it could fit in the palm of your hand.

Predators might think this size makes the octopus a great snack, but they know to stay away. The blue-ringed octopus is very poisonous and can kill predators much larger than itself, including humans. So the next time you see an octopus in the aquarium or while you're snorkeling, remember that inside that oversized head is a very large brain, making them a clever addition to the sea.

[5]

[5] https://www.superteacherworksheets.com/reading-comp/3rd-octopus_WDFZN.pdf?up=1466611200

External Features of Animals

Polar Bears

Penguins

Great Egret

Lions

Elephants

Dolphins Swimming

Otters

Tab page front

Label: Planning and Carrying Out Investigations

TN Department of Education

Planning and Carrying Out Investigations

Tennessee Academic Standards for Science

Teacher Guide for Grade 3

Standard
3.PS1.3 Describe and compare the physical properties of matter including color, texture, shape, length, mass, temperature, volume, state, hardness, and flexibility.

Tennessee Academic Standards for Science: Page 32

Three-dimensional Learning Performance for Lesson
Students will plan and carry out controlled investigations* in order to show that different physical properties of matter such as color, shape, texture, and length can describe and compare matter** highlighting the scale, proportion, and different quantities of matter.***

Science and Engineering Practice for Lesson
*Planning and carrying out controlled investigations**
The goal of this three-dimensional learning performance is for students to develop and explore an investigation to describe and explain different phenomena.

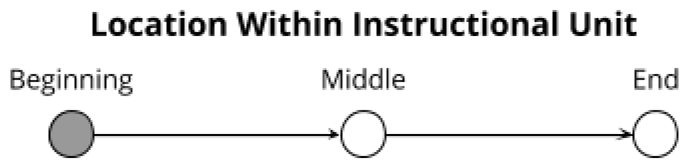
Disciplinary Core Idea for Lesson
*Physical Science: Matter and its interactions***
"Different kinds of matter exist (e.g., wood, metal, water), and many of them can be either solid or liquid, depending on temperature. Matter can be described and classified by its observable properties (e.g., visual, aural, textural), by its uses, and by whether it occurs naturally or is manufactured. Different properties are suited to different purposes. A great variety of objects can be built up from a small set of pieces (e.g., blocks, construction sets). Objects or samples of a substance can be weighed, and their size can be described and measured. Matter of any type can be subdivided into particles that are too small to see, but even then the matter still exists and can be detected by other means (e.g., by weighing or by its effects on other objects). Measurements of a variety of properties (e.g., hardness, reflectivity) can be used to identify particular materials.

A Framework for K–12 Science Education: Pages 106-108

Crosscutting Concept for Lesson
*Scale, Proportion, and Quantity****
When considering different phenomena, it is critical to recognize what is relevant at different measures of size, time, and energy to recognize how changes in scale, proportion, or quantity affect system's structure or performance. From a human perspective one can separate three major scales at which to study science: (1) macroscopic scales that are directly observable- that is, what one can see, touch, feel, or manipulate; (2) scales that are

too small or fast to observe directly: and (3) those that are too large or too slow. This lesson will focus on how standard units are used to measure and describe physical quantities such as weight, time, temperature, and volume or objects on the macroscopic scale.

Prior Knowledge



- Concepts that should be covered before this lesson:
    - How to complete a simple investigation
    - Classifying different material by color, texture, hardness, and flexibility
    - Identifying matter as either a solid, liquid, or gas
    - Matter can be in the form of particles too small to be seen
- This lesson covers portions of standard 3.PS1.3
    - Describing and compare the physical properties of matter
    - The lesson did not examine hardness or flexibility

Materials
- Balloons
- Small containers
- Powdered sugar
- Baking powder
- Baking soda
- Salt
- Clear rubbing alcohol
- Vinegar
- Chart paper

Teacher Set-Up
For this lesson, there is some preparation that needs to occur prior to implementing the lesson. It is recommended that you prepare a few of the items the day before the actual activity. Step-up consists of:

- You will need to blow up and fill several small balloons with water. You will then freeze the water balloons overnight. The ballons can vary in shape, color, and size. They will be used for the refrigerated compartment portion of the lesson.
- You will need six small containers, with lids, for each group. Three of the containers will need to be filled with three different powdered substances, and the other three containers will need to be filled with three different types of liquids. Develop a system for labeling the containers so that as students begin to discuss what is in

each one, you are aware of the actual substance or liquid. Do not put the name of the substance on the container. An example labeling system is as follows, with the powdered substance you can label the containers as:
    - A1 = Powdered Sugar
    - A2 = Baking Powder
    - A3 = Baking Soda
- For the liquid substances, you can label the containers as:
    - B1 = Alcohol
    - B2 = Vinegar
    - B3 = Water

Lesson Sequence and Instructional Notes

Engage

Begin by explaining to students that an object thought to be a space capsule has been found in the schoolyard. It contained a refrigerated compartment with large, round objects in it and several smaller unrefrigerated compartments with different containers of fluids and substances. The Department of Homeland Security (DHS) wants to know what the contents are so they can figure out where the capsule came from and what it means. DHS has asked your class to help analyze the materials. They are looking for younger students that can think creatively and help to resolve the issue.

As a class, you need to answer the following questions (these questions will be answered as they complete the investigations and after they have completed the investigations):

Objects in the refrigerated compartment
a) What are the physical properties of the object in the refrigerated compartment?
b) What are the objects? What are they made of?
c) Are the objects in the refrigerated compartment changing?

Substances in the containers
a) What are the physical properties of the substances in the vials?
b) What happens when the substances in the vials are mixed with other substances?

Challenge the class to come up with ways to answer the questions. Explain that DHS will require explanations for all of the answers. They will need to know what observations were made and what analyses were conducted, so it is important to take careful notes in the science journals.

DHS has sent over a short reading passage to make sure that you understand some of the important concepts. Please read the passage and answer the questions with it, so you can began examining the first material.

Reading Passage

Physical Properties of Matter

Mass

Every object on Earth is made up of matter; therefore, every object has mass. Mass is the measure of how much matter an object contains. Objects can have a lot of mass or very little mass. For example, a table would have a lot of mass because it is solid and heavy. On the other hand, a feather would have less mass because it is small and light. Mass is measured in kilograms or grams. Objects measured in kilograms would have more mass than objects measured in grams. You can compare the mass of different objects by using a pan balance.

Stop: Give an example of something that has a lot of mass and of something that has little mass. Explain.

Shape

The shape of matter depends on whether it is a solid, liquid, or gas. Solid matter keeps it own shape. For instance, a table would maintain its shape because it is made out of wood. Wood is a solid. Liquid matter takes the shape of the container it is in. Water, soda, and milk are all liquids and can be seen forming shapes of different shaped bottles. Gases like oxygen do not have a shape at all because this type of matter will spread through air. Matter can also be described as having a round or square shape.

Stop: Fill in the table below to explain the different shapes of matter

Phases of Matter	Shapes
Solid	
Liquid	
Gas	

Volume

Volume is the amount of space that matter takes up. Volume is measured in cubic centimeters. A cubic centimeter is a cube that is 1 centimeter high, 1 centimeter long and 1 centimeter wide. You can find volume of solids by multiplying the height, length, and width of an object. For example, let’s say that a box is 2 inches high, 5 inches long and 8 inches wide. To find the volume, you would need to multiply 2 x 5 x 8, which would equal 80. So, the box has a volume of 80 cubic centimeters. To find the volume of liquids, you would use measuring tools that measure pints, quarts and gallons. Most scientists use liters and milliliters to measure the volume of liquids.

Stop: Describe some of the different ways of measuring volume.

Students will answer the questions on their student handout.

Explore

Now that we have some of the basic knowledge, let's explore the object in the refrigerated compartment.

1. Arrange students into groups of 3-4. Provide each group a sheet of chart paper. Have students create a T-chart on their chart paper. Label the left side of the chart paper *observations* and the right side of the chart paper *inferences.* At this time, also pass out the student activity sheets so that students can also record their observations and inferences on their individual student activity handout.
2. Put the frozen balloon in a bowl in the middle of each group of students and instruct them to examine it, describe it, and infer what it is.
3. Explain to students that they MUST NOT destroy the object in any way. Explain to students that they will be making observations about the different objects and a few inferences.
4. They should record their observations (something directly observable) and inferences (understanding that is not directly observed but is based on direct observations) so that they can compare with the other groups.

Sample Chart

Observations	**Inferences**
Object is round. *Object is red.* *Object is cold.* *Outside is rubbery.* *Inside feels hard* *Over time, outside is getting wet.* *Over time, the object is getting warmer.* *The inside of the object seems to be melting.* *Over time, the outside of the object became more flexible and not as hard.*	*Object is a balloon.* *Inside the balloon is ice.* *The ice is melting.* *The water on the outside is leaking out of the balloon.* *The water on the outside is condensing from the air.*

5. As students are working, challenge students to think critically about their observations and inferences:
    - *What is this made of? What is on the outside? What is on the inside?*
    - *What can you actually observe with your eyes, hands, ears, and nose?*
    - *What are you inferring: what do you think you know based on your observations?*
    - *Can you be 100% sure?*
    - *What could you do to be 100% sure?*

6. Allow the class to discuss their charts. Have each group make a prediction of what they think the object is. Encourage students as they make predictions about what they think the object is to use evidence from their chart. Students will also need to record their prediction on their student activity handout.
    - If time permits, have students continue to observe the object and make observations over time.
    - You're going to see if the object changes over time or stays the same. *Guide students to observe using their eyes, ears, nose, and hands. Students should think about changes in temperature, flexibility, color, size, solidity, etc. Students may first observe condensation on the balloon. After a while, they may infer that the inside is melting.*
    - How is the object changing? *The inside is melting; the outside is warming up; the skin of the object is becoming more flexible.*
    - Where is the liquid on the surface coming from? *Condensation from water vapor in the air*

Explain
Come back together as a class to begin the second portion.

Experiment
1. Explain to students that they will now investigate the substances found in the containers in the unrefrigerated compartment.
2. Explore the containers by completing short Investigations to determine what an item is depending on its physical properties.
3. As a group, decide how to conduct the investigation and how to record observations.

Each group should receive a small amount of each of the substances in group A and B and have to determine the identity of each.
- Substance A
    1. Powdered Sugar
    2. Baking Powder
    3. Baking Soda
- Substance B
    1. Alcohol

2. Vinegar
3. Water

Students will need to record their observations and construct their explanations on their student activity handout sheet.

	Observations	Explanations
Substance A		
1.		
2.		
3.		
Substance B		
1.		
2.		
3.		

	Magnetic	Color	Odor	Shape	Hardness/ Flexibility	Other Test
Substance A						
1.						
2.						
3.						
Substance B						
1.						
2.						
3.						

Once all students have gathered enough evidence about each of the substances in the containers, students will now pick two of the substances that they think they can identify. They will use the summation portion on their student activity sheet to justify their predictions.

Teacher Notes

Another option could be to give different groups one of the substances in each category and allow the students to compare their information to determine if they have the same or different substances.

Citations and Resources

https://www.acs.org/content/dam/AACT/elementary-school/states-of-matter/physical-change/secure/Lesson_Alien.pdf

http://www.mccracken.kyschools.us/Downloads/5th%20Grade%20Structures%20and%20Properties%20of%20Matter.pdf

http://www.cpalms.org/Public/PreviewResourceLesson/Preview/29483

Student Handout
Physical Properties of Matter

Mystery Substance Investigation

There has been a mystery package dropped by the school front door. We have to help the Department of Homeland Security (DHS) analyze and identify materials found in this mysterious package. It contained a refrigerated compartment with large, round objects in it and several smaller unrefrigerated compartments with different containers of fluids and substances. The DHS wants to know what the contents are so they can figure out where the package came from and what it means. DHS has asked your class to help analyze the materials. They are looking for younger students that can think creatively and help to resolve the issue.

As a class, you need to be able to answer the following questions by the end of the lesson:

Objects in the refrigerated compartment
a) What are the physical properties of the object in the refrigerated compartment?
b) What are the objects? What are they made of?
c) Are the objects in the refrigerated compartment changing?

Substances in the containers
a) What are the physical properties of the substances in the vials?
b) What happens when the substances in the vials are mixed with other substances?

Step 1: Gathering Information

Physical Properties of Matter[1]

Mass
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kilograms would have more mass than objects measured in grams. You can compare the mass of different objects by using a pan balance.

Stop: Give an example of something that has a lot of mass and of something that has little mass. Explain.

Shape

The shape of matter depends on whether it is a solid, liquid, or gas. Solid matter keeps it own shape. For instance, a table would maintain its shape because it is made out of wood. Wood is a solid. Liquid matter takes the shape of the container it is in. Water, soda, and milk are all liquids and can be seen forming shapes of different shaped bottles. Gases like oxygen do not have a shape at all because this type of matter will spread through air. Matter can also be described as having a round or square shape.

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Stop: Describe some of the different ways of measuring volume?

Step 2: Refrigerated Item
Examine it and fill in the chart below. Please include as much information as possible. We need to correctly identify it.

Don't forget...Observations are things you can directly observe and inferences are things that you can make an educated guess about.

Observations	**Inferences**

Group Prediction:

The item is ______________________________ because ____ (use your observations).

Step 3: Items in Containers
Now you will attempt to identify the unrefrigerated items. Please try to test as many physical properties as you can. Remember **NOT** to taste anything!

Explore the containers by completing short Investigations to determine what an item is depending on its physical properties

- As a group, decide how to conduct the investigation and how to record observations.
- Make a data table to record your results.

After you have collected your data, you will pick two substances that you know you can identify. Use the summation script below to fill in your answers. You must use evidence about the physical properties for DHS to take your report seriously.

	Observations	Explanations
Substance A		
1.		
2.		
3.		
Substance B		
1.		
2.		
3.		

	Magnetic	Color	Odor	Shape	Hardness /Flexibility	Other Test
Substance A						
1.						
2.						
3.						
Substance B						
1.						
2.						
3.						

Summation

My decision is that substance ______________ is

____.

I based my decision on the following evidence (look back at observations and data):
First,

____

____.

Second,

____

____.

People who disagree with my decision might say that (find an observation or data that does NOT support your idea)

____.

However, I still think

____.

My decision is that substance _______________ is

____.

I based my decision on the following evidence (look back at observations and data):
First,

____

____.

Second,

____

____.

People who disagree with my decision might say that (find an observation or data that does NOT support your idea)

____.

However, I still think

____.

Tab page front

Label: Engaging in Argument from Evidence

Engaging in Argument from Evidence

Tennessee Academic Standards for Science

Teacher Guide for Grade 3

Standard
3.PS1.2 Differentiate between changes caused by heating or cooling that can be reversed and that cannot.

Tennessee Academic Standards for Science: Page 32

Three-dimensional Learning Performance for Lesson
Students will engage in argument from evidence* in order to show the difference between changes caused by heating or cooling that can be reversed and those that cannot** highlighting the cause and effect relationship in each system investigated.***

Science and Engineering Practice for Lesson
*Engaging in Argument from Evidence**
Students will examine examples of changes in materials due to heating or cooling. Using the observations gathered as evidence, students will construct responses to explain how the examples represent reversible and irreversible changes.

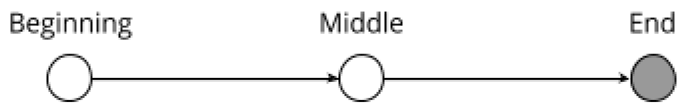
Disciplinary Core Idea for Lesson
*Matter and Its Interaction***
Heating or cooling a substance may cause changes that can be observed. Sometimes these changes are reversible (e.g., melting and freezing), and sometimes they are not (e.g., baking a cake, burning fuel).

A Framework for K–12 Science Education: Page 110

Crosscutting Concept for Lesson
*Cause and Effect****
By examining evidence of changes in the properties of different materials caused by heating and cooling, students will begin to determine cause and effect relationships. These relationships will allow students to determine whether the changes noted are the result of reversible or irreversible changes in the matter.

Prior Knowledge

Location Within Instructional Unit



- Concepts that should be covered before this lesson:
    - Matter is made up of particles too small to be seen
    - Properties of solids, liquids, and gases
    - Ability to describe and compare the physical properties of matter including color, texture, shape, length, mass, temperature, volume, state, hardness, and flexibility
    - Matter can change its phase when heat is added or removed.
- This lesson covers portions of standard 3.PS1.2
    - Students will be able to differentiate between reversible and irreversible changes in matter due to heating and cooling. The standard is limited to those changes that are easily observable for students.

Materials

- Microwave or other accessible heating device
- Freezer (will be used for preparation the night before the lesson)
- Crayons
- Plastic molds
- Lemonade
- Bathroom cups
- Ice cube trays
- Eggs
- Microwavable brownie or cake mix
- Plastic spoons
- Microwave safe bowl or pan

Lesson Sequence and Instructional Notes

Begin with a brief review of the basic properties of solids, liquids, and gases. This could be done as a whole class activity in which students sort pictures/descriptions into the three basic categories. Guided teacher questioning should remind students of the basic properties of each as the list is sorted. The teacher should record the list in a manner that allows all students to participate and observe the classifications.

Pass out the student activity sheet.

Direct student attention to the picture of the crayons. Ask them to decide which state of matter the crayons should be classified as and to complete the first two sections on page one of the student activity page. Provide explicit directions so the students know that the first question is asking for properties that provide evidence of the state of matter of the crayon. The second question is asking for properties that identify the matter as being a crayon. Both of these are important as students will be asked later to determine if the material is *STILL* a crayon after undergoing heating and cooling.

Possible answers to state of matter of the crayon:

- Have a definite or fixed shape
- Do not spread out
- Take up a certain amount of space

Possible answers to identification properties of the crayon:

- Hard
- Smooth
- Solid
- Writes or transfers color to paper

Tell students that you are now going to microwave the crayons. This activity works best if the crayons are broken into small pieces. An alternate method would be to melt the crayons in a pot on a stove, if that is available. Students will complete the data table as the teacher guides the demonstration.

- Ask: What is the phase of the crayons as we begin? *The crayons are solid.*
- Ask: Are we adding heat or removing heat? *Adding heat.*
- Ask: What is the phase of the crayon after heating? How do we know? *The crayons are now a liquid. They flow and can take the shape of a container. They are no longer in a fixed shape.*
- Ask: What observations can you make? *Students might note the phase change, smell, how easily the melted crayon flows, etc.*
- Ask: What cause and effect relationship do you see?
  - *Cause: Adding Heat* *Effect: Changes solid to a liquid*
  - *Cause: Removing Heat (Or Cooling)* *Effect: Changes liquid to a solid*

Pour the melted crayon material into plastic molds. Have students write “liquid” on the second row of the data table. Smaller molds will solidify much quicker and are easier for students to use in making observations in the next part of the lesson.

After heating and cooling the crayons, remove the material from the molds. Students should complete row two of the data table.

	Crayon Phase Before	Heat (+) or Heat (-)	Crayon Phase After	Observations
1.	Solid	Added	Liquid	The color stayed the same. There was some odor. It melted and turned into a liquid.
2.	Liquid	Took Heat Away	Solid	It cooled down. The color stayed the same. It turned back into a solid.

Allow students to investigate the cooled material. It is suggested that teachers not refer to them as "crayons" at this point. Allow the students to determine if heating and then cooling the material has caused a change in identity. Have students work with a partner or table group to answer the next question on the activity sheet:

- After heating and cooling the crayon, is it still a crayon? How do you know? Use the properties of a crayon that you listed above in your answer.

After students have had an opportunity to complete the question, have students share out their responses. Listen for and point out appropriate use of evidence in answers. Teachers could do a simple "thumbs up, thumbs down" vote to see how many students are satisfied that the material is still a crayon.

- Sample student answer: *The material is a solid and a crayon is a solid. The material is still capable of writing or drawing even though the shape has changed. The material also has its original color.*

Point out the question on the activity sheet:
Does all matter behave the same way when heated and cooled?

Ask students how scientists would get evidence to answer that question. Students should respond that testing different materials through adding or removing heat would provide evidence to answer the question.

Tell students that the next activity will involve starting with a liquid and then changing it into a solid.

Pass out small bathroom cups of lemonade for the students to observe and taste.

Have them complete the “Properties of Lemonade” section by writing in the properties of lemonade that they can observe. Possible responses include:

- Liquid
- Takes shape of the cup
- Pours easily
- Yellow color
- Sour or “lemon” taste
- Bits of solid material (pulp)

Tell the students that you took some of the lemonade the day before and poured it into ice cube trays. Teachers should “pop out” the frozen lemonade cubes and place one cube into a plastic cup for each student. Students will complete the next data table as they examine the frozen lemonade. Do not use the term “lemonade” at this point. Allow students to determine if the substance is still lemonade or has it been changed.

- Ask: What was the phase of the lemonade before it was frozen? *Liquid*
- Ask: Did we add heat or remove heat? How did we do that? *Heat was removed by placing the lemonade in the freezer.*
- Ask: What is the phase of the material now? *Students might note that it is mainly a solid but can see that small amounts are melting and turning back into a liquid.*
- Ask: What observations can you make? *Students should note the yellow color, sour taste, and even the presence of pulp.*
- Ask: What cause and effect relationship do you see?
    - *Cause: Removing Heat (Cooling); Effect: The lemonade went from being a liquid to a solid.*
    - *Cause: Adding Heat; Effect: The frozen lemonade is changing from a solid to a liquid.*

Have students work with a partner or table group to complete the next question:
After freezing the lemonade, is it still lemonade? How do you know? Use the properties of lemonade that you listed above in your answer.

Allow students time to complete their written responses and then share out answers. Encourage the use of evidence to support their decisions about whether the material is still lemonade.

It is now appropriate to introduce the concept of “reversible changes.” A short informational text selection is included in the lesson. Teachers should read the text titled “*Reversible Changes*” in a manner appropriate to their class.

After reading the text, have students fill this phrase in on the activity sheet. As a class, list other examples of reversible changes. Possible answers include:

- Ice melting
- Water freezing
- Ice cream melting
- Chocolate candy melting

Let's look at our question again: Does all matter behave the same way when heated and cooled? This is a good opportunity to point out that scientists do multiple trials when they complete investigations. We have some good evidence to support the idea of reversible changes, but are there changes that would *NOT* be reversible? Let's test some more materials to see if we can find out.

Show students a raw egg. Teachers should break the egg open into a bowl and allow students to take turns stirring the yolk/egg white with a spoon. Allow opportunity for students to make observations and to complete the data table on the student activity sheet.

When ready, microwave the egg. It is easiest to just cook the egg as a scrambled egg, although it is possible to also hard boil the egg in the microwave as well.

- Ask: What is the phase of the raw egg? *Students will probably note that the outside shell is a solid but the inside appears to be a liquid.*
- Ask: Are we adding or removing heat? *We are adding heat with the microwave.*
- Ask: What is the phase of the egg after heating? *It is considered a solid. It holds its shape and doesn't spread out to take the shape of a container.*
- Ask: What properties of the egg did you note? *The inside of the raw egg is runny and contains both clear and yellow/orange parts. The shell is white, hard, smooth, and solid. In contrast, the cooked egg has changed phase, is light yellow, and appears to be completely solid. Students might also note a new smell.*
- *Ask: What cause and effect relationship do you see?*
    - *Cause: Adding Heat; Effect: The raw egg becomes cooked. It turns into something different. It changes from being a liquid into a solid.*

Students will now work with partners or in small groups to answer the next question: After heating and cooling the egg, does it have the same properties as when we started? Can we reverse the change?

Allow time for students to complete written responses and then share out answers. Some students may state that they would not be willing to eat a raw egg, but they would be willing to eat the cooked egg. Although this is technically not a scientific observation, this still allows for discussion of the fact that the egg has undergone a significant change due to heating that cannot be reversed. There is no way to turn the cooked egg back into a raw egg.

Students might also wonder if it is still an egg. This is a complicated question for this age group. Although we would refer to this as a cooked egg, there are in fact chemical changes which occur including the denaturing of proteins.

Teacher background information: Chemical changes result in the formation of new substances, and the changes that occur cannot be reversed (at least without other chemical changes). The heat from cooking an egg causes the egg's protein to change permanently in texture and in appearance through a process called denaturing. The "white" of the egg goes from being basically clear to being yellow or white in color. The cooked egg's properties are different from those of the raw egg. These changes cannot be undone.[1]

Tell the students that you have one last material that you would like to test. This demonstration can be done by purchasing microwavable brownie or cake mix. Teachers might also want to use one of several simple recipes that allows students to see how a mixture of eggs, milk, flour, cocoa, and vanilla will most definitely be changed into something new by heating.

Students will complete the last data table as the teacher completes the demonstration.

- Ask: What is the phase of the batter? *Liquid (but students may note that the batter is a mixture of solid and liquid).*
- Ask: Are we adding or removing heat? *We are adding heat.*
- Ask: *What is the phase of the batter after adding the heat? It is now a yummy solid.*
- Ask: What observations were made? *Students may note that the color has changed, a new smell is produced, the texture has changed, etc*.
- Ask: What cause and effect relationship do you see?
    - *Cause: Adding heat Effect: The batter is cooked and turns into something different. It goes from being mainly a liquid to a solid.*

Students are now ready to work with a partner or small group to complete the final question:

- After heating and cooling the batter, does it have the same properties as when we started? Can we reverse the change? In the space below, explain your answer. Use the properties of the batter and your observations to support your answer.

Allow time for students to complete written responses and then share out. Students should note that the properties are completely different. There is no way to reverse the change and get the raw materials back.

Introduce the term “irreversible” to students at this point. A short text on “irreversible changes” is included. Teachers should have students read the text in a manner appropriate for their class.

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[1] Adapted from: https://www.reference.com/science/frying-egg-chemical-change-9649c58c01699016#

Have students fill this word in on the activity sheet and ask for additional examples. Possible answers include anything that deals with cooking or combustion. For example, burning paper, leaves, or wood is an irreversible change. Cooking, baking, frying, and toasting are all considered to be irreversible as well.

- Be sure to point out that melting and burning are NOT the same thing. Melting is a reversible physical change. Burning is a chemical reaction and is irreversible.

A formative assessment is included in this activity which asks students to sort examples into either reversible or irreversible changes due to adding or removing heat. Students will then be asked to develop an argument for their choices and use evidence to support their decisions.

- Copy and cut out a set of cards for each pair of students. Each pair will also need one “reversible” grid and one “irreversible” grid.
- Be sure to “shuffle” the cards.
- The template labeled “reversible” and “irreversible” is included so that students can lay out the cards on top of each grid.
- Have students work in pairs to sort the pictures. Correct answers are:
    - *Reversible Changes: Ice cream melting, melting butter, candy bar melting, freezing popsicles, snowman melting, candle melting.*
    - *Irreversible Changes: Burning leaves, boiling noodles, baking pancakes, baking cookie dough, burning gasoline, making toast.*

Students should now complete written Claim-Evidence-Reasoning responses:

Claim #1: Sometimes adding heat to a substance causes a <u>reversible</u> change.

Evidence:
Melted ice cream can be refrozen into solid ice cream.
Melted butter can be put back in the refrigerator and it will become solid again.
A melted candy bar can be put in a refrigerator and it will become solid again.
The melted snow from the snowman could be frozen again.
The melted wax from the candle could be cooled and made into a candle again.

Reasoning:
All of the examples above show that when heat was added, the substance melted and turned into a liquid. But if you cool the substance again, it will turn back into a solid and will be the same material that it was at the beginning.

Claim #2: Sometimes adding heat to a substance causes an irreversible change.

Evidence:
Burning leaves turns the leaves into ash.
Boiling noodles changes them from a hard material into something soft and edible.
Baking pancakes changes the batter into pancakes.
Cars burn gasoline and turn it into energy to move.
When you put bread into the toaster, the heat makes it brown and crunchy.

Reasoning:
These examples show that sometimes adding heat changes the material into something different. You can't change the ash back into leaves. The cooked pancakes can't change back into batter. The toasted bread can't become "un-toasted."

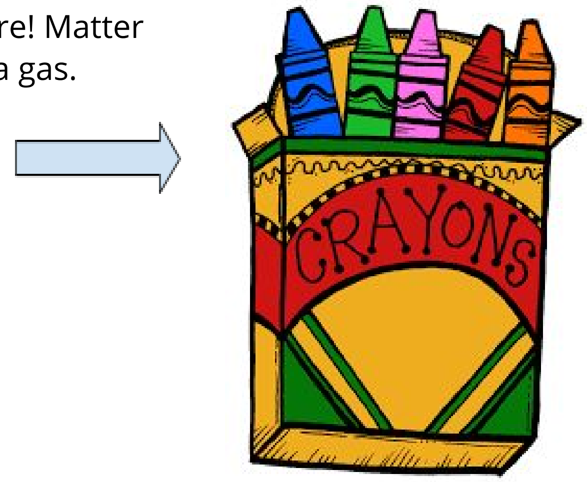
Citations and Resources

Lesson adapted from:
https://betterlesson.com/lesson/639235/matter-and-heat-reversible-changes and https://betterlesson.com/lesson/639234/matter-and-heat-irreversible-changes

Informational Text from:
http://www.bbc.co.uk/bitesize/ks2/science/materials/reversible_irreversible_changes/read/2/

When we look around us, matter is everywhere! Matter can be classified as either a solid, a liquid, or a gas.

Here's an example of some matter that we use a lot!
How would you classify this matter?



A crayon is a solid. _________
A crayon is a liquid. ________

What properties helped you decide the <u>state of matter</u> of the crayon?

What properties help to identify this matter as a crayon?

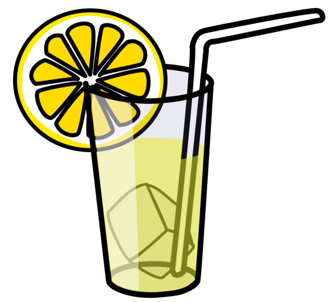
What happens to the crayon when heat is added or removed?

	Beginning Crayon Phase	Heat (+) or Heat (-)	Crayon Phase After	Observations
1.				
2.				

After heating and cooling the crayon, is it still a crayon? How do you know? Use the properties of a crayon that you listed above as evidence in your answer.

Does <u>all</u> matter behave the same way when heated and cooled?

Let's check out another material.
List the properties of the lemonade. How do you know that it is lemonade?

Properties of Lemonade


What happens if we add or remove heat from lemonade?

	Beginning Lemonade Phase	Heat (+) or Heat (-)	Lemonade Phase After	Observations
1.				
2.				

After freezing the lemonade, is it still lemonade? How do you know? Use the properties of lemonade that you listed above as evidence in your answer.

____

____

____

____

____

When a material can change back and forth between phases, this is called a

____. What other materials can you think of that would also be able to change back and forth between phases when heat is added or removed? List them in the space below.

Let’s look at our question again: Does all matter behave the same way when heated and cooled? Even though we have looked at some types of materials, a good scientist would examine even more! Let’s look at what happens to some other kinds of matter.

	Beginning Egg Phase	Heat (+) or Heat (-)	Egg Phase After	Observations
1.				
2.				

After heating and cooling the egg, does it have the same properties as when we started? Can we reverse the change?

In the space below, explain your answer. Use the properties of the egg and your observations as evidence to support your answer.

	Beginning Batter Phase	Heat (+) or Heat (-)	Batter Phase After	Observations
1.				
2.				

After heating and cooling the batter, does it have the same properties as when we started? Can we reverse the change? In the space below, explain your answer. Use the properties of the batter and your observations as evidence to support your answer.

____

____

____

____

____

A ______________________ change is one in which the material cannot go back to its original state after heating and cooling. Can you list other changes that CANNOT be reversed? List them in the space below.

Let's see what you have learned! Your teacher will give you a set of cards. Each card has an example of either a reversible or an irreversible change. Sort the cards into two piles based on the type of change.

Use the examples on the cards as evidence to answer the following:

Claim #1: Sometimes adding heat to a substance causes a reversible change.

Evidence:

Reasoning:

Claim #2: Sometimes adding heat to a substance causes an irreversible change.

Evidence:

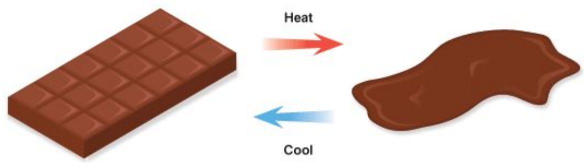
Reasoning:

Reversible Changes

A reversible change is a change that can be undone or reversed. A reversible change might change how a material looks or feels, but it doesn't create new materials.

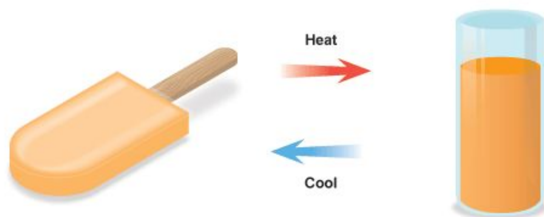
Melting

Melting is an example of a reversible change. For example melted chocolate can be changed back into solid chocolate by cooling.



Freezing

Freezing is an example of a reversible change. For example we can freeze orange juice to make ice lollies. The ice lollies can be changed back into orange juice by heating.



Boiling, Evaporating, and Condensing

Boiling, evaporating, and condensing are all examples of reversible changes. For example, if you could capture all the steam that is made when a kettle boils, you could turn it back to water by cooling it.

Dissolving

Dissolving is an example of a reversible change. For example, when salt is mixed with water, it disappears because it **dissolves** in the water to make salty water. But, we can get the salt can back again by boiling off the water. That leaves the salt behind.

Irreversible Changes

A change is called **irreversible** if it cannot be changed back again. For example, you cannot change a cake back into its ingredients again.

Irreversible changes are permanent. They cannot be undone.

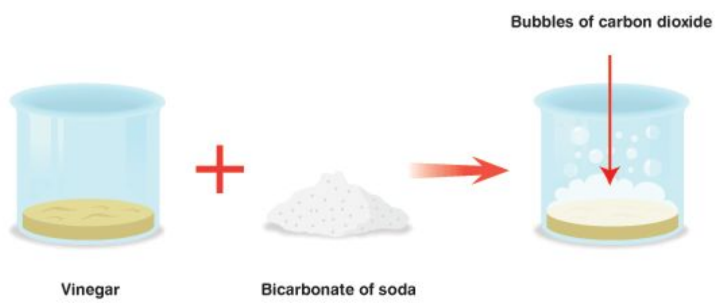
In an irreversible change, new materials are always formed. Sometimes these new materials are useful to us.

Heating

Heating can cause an irreversible change. For example, you heat a raw egg to cook it. The cooked egg cannot be changed back to a raw egg again.

Mixing

Mixing substances can cause an irreversible change. For example, when vinegar and bicarbonate of soda are mixed, the mixture changes and lots of bubbles of carbon dioxide are made. These bubbles, and the liquid mixture left behind, cannot be turned back into vinegar and bicarbonate of soda again.



Burning

Burning is an example of an irreversible change. When you burn wood, you get ash and smoke. You cannot change the ash and smoke back to wood again.

Informational Text from:
http://www.bbc.co.uk/bitesize/ks2/science/materials/reversible_irreversible_changes/read/2/

REVERSIBLE CHANGES

IRREVERSIBLE CHANGES

ICE CREAM MELTING 	BURNING LEAVES 	BOILING NOODLES 
MELTING BUTTER 	BAKING PANCAKES 	A CANDY BAR MELTING 

BAKING RAW COOKIE DOUGH 	BURNING GASOLINE IN A CAR FOR FUEL 	FREEZING POPSICLES 
MAKING TOAST 	A SNOWMAN MELTING 	A CANDLE MELTING 

Tab page front

Label: Developing and Using Models

TN Department of Education

Developing and Using Models

Tennessee Academic Standards for Science

Teacher Guide for Grade 3

Standard
3.ESS2.1 Explain the cycle of water on Earth.

Three-Dimensional Learning Performance for Lesson
Students will develop and make revisions to a model* in order to demonstrate that water cycles on earth ** highlighting that a system is a group of related parts that make up a whole and can carry out functions its individual parts cannot.***

Science and Engineering Practice for Lesson
*Developing and Using Models**
The goal of this three-dimensional learning performance is for students to develop a working model of the water cycle. This model of the water cycle will be used to track the flow of water around the Earth. It is important for students to know that all the examples are just models of the real water cycle. Time should be permitted to discuss what is happening during the initial water cycle diagram, the demonstration, differences in their stories, and the answers to their chart. Time should also be permitted for students to go back and revise/improve the water cycle model as they develop a conceptual understanding of the water cycle.

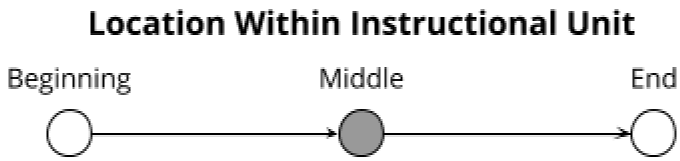
Disciplinary Core Idea for Lesson
*Earth Science 3: Earth's System***
"Explain the cycle of water on Earth. Earth is called the water planet because of the abundance of liquid water on its surface and because water's unique combination of physical and chemical properties is central to Earth's dynamics."

"Water is found almost everywhere on Earth: as vapor; as fog or clouds in the atmosphere; as rain or snow falling from clouds; as ice, snow, and running water on land and in the ocean; and as ground water beneath the surface. "

A Framework for K-12 science education: Pages 184-185

Crosscutting Concept for Lesson
*Systems and System Models****
When students are able to understand the flow of water around the Earth and make connections between what phases of matter the water is in and how it is moved through the Earth they are demonstrating an understanding of the water cycle.

Prior Knowledge



- Concepts that should be covered before this lesson:
    - State of matter, introduction to gas
    - Phase changes
    - Transformation of energy
- This lesson covers portions of standard 3.ESS2.1:
    - Water being transformed around the Earth

Materials
- Clear plastic cups
- Food coloring
- Shaving cream
- Ice
- Large construction paper

Lesson Sequence and Instructional Notes

Initial Modeling

Prior to the lesson, pass out a large sheet of paper to students. Ask students to take a moment to think about all the water they have ever seen outside. After a 1–2-minute wait time, ask them to now think about where all that water come from. Tell students that instead of verbally communicating their response, you would like them to use their sheet of paper and draw where they think all that water on earth comes from. Inform students that in their models they should use the following to ensure that others can make sense of their drawings:

- words labeling different parts of their model
- arrows if they are trying to indicate movement or flow

Teacher Information: At this point of the lesson, the idea is to elicit students' current understanding of where they think water comes from. This is not the time to correct students misconceptions, but a time to identify students' preconceptions about the water cycle. Students may not have the academic vocabulary to label their models, but as they engage in the activities in this lesson, they will collect new information and revise (add to, delete, change) parts of their model.

After drawing the initial model, inform students that they will partake in a few demonstrations. Pass out the student activity sheet to each student. Inform students that during the demonstrations, they will make observations and record it on the *Demonstration*

Observation column of their chart. They will leave the other columns blank for another part of the lesson.

Teacher Demonstration

As the students' models are initial mental models and are not completed, the teacher will provide opportunities for students to engage in a number of investigations that focus on making sense of the water cycle. As students engage in the demonstrations, they will use the student data chart to record their observations and then revise their models using the evidence in the data chart.

Demonstration #1: Evaporation
(This demonstration will need to be prepped and the teacher will need to engage students in the investigation; however, the data collection portion of the lesson may need to happen after the reading activity to allow time for the water to evaporate.)

Prior to engaging students in this demonstration, prepare three cups of water into a clear cup. Fill cups with the same amount of water. Using a pen or marker, draw a line indicating the initial water level in the cup. Place each cup of water in different areas of the room (window near the sun, heat lamp, on a desk away from any student disturbance), label the time you placed the cup there, and the label the location in which you placed it.

The teacher will lead students in a discussion by stating to the students that there are several cups filled with water throughout the room. As a class, we will monitor and record what happens to the water throughout the day. However, first record students' thoughts around what they think would happen. Some guiding questions are:

- What do you think the sunny window/heat lamp will do to the cup of water? What is this process called?
- Make a prediction about what will happen to the water throughout the day.

After predictions are made, as a class, revisit each cup of water every 10-20 minutes. (This is a suggested time interval, as the teacher will need to identify a time interval that best fits the allotted time of instruction or classroom schedule.) After each observation, as a class, have students discuss what they observe happening to the water. This can be a great way to incorporate charting data. Students could even graph the data as an extension when the lesson is completed. On the student activity sheet on the water cycle chart, in the demonstration observation column, have students record these observations.

Demonstration #2: Condensation

After the students have recorded their initial information from the evaporation demonstration, the teacher will move on to the next demonstration. The teacher will then model condensation with hot water, ice, and two plastic cups. Fill a cup approximately two-thirds full of hot water. Take another cup, flip it upside down, and place it on top of the cup with hot water. Then, place an ice cube on top of the upside down cup. Condensation will begin to form at the top of the upside down cup, just like a cloud. Connection to the real water cycle: When the water vapor reaches the sky, it cools to form clouds. Give several examples, such as dew on leaves, foggy mirrors in a hot bathroom, and water droplets on the side of a cold can. Stress the importance of condensation being important in the water cycle because of cloud formation.

Sample Teacher Questions (More questions will need to be generated based on student responses):

- What wonderings do you have about what you are observing?
- What did you observe? *Students may say fog or it looks cloudy.*
- Why do you think the cup began to get cloudy?
- What does this remind you of or where have you seen something similar to this?

Have students revisit their water cycle chart and record their observations. As a reminder, they will use this information to revise their initial models.

Demonstration #3: Precipitation

After condensation, the teacher will demonstrate precipitation. Again, fill a cup almost full with water. On top, spray shaving cream as clouds. Then, squirt several drops of food coloring on top of the shaving cream. As the “cloud” becomes heavy, the food coloring will “rain” into the cup. Discuss with the class the various forms of precipitation.

Sample Teacher Questions (More questions will need to be generated based on student responses):

- What wonderings do you have about what you are observing?
- What did you observe?
- What does this remind you of, or where have you seen something similar to this?

Have students revisit their water cycle chart and record their observations. As a reminder, they will use this information to revise their initial models. As the teacher, after you hear their comments, you could help them make the connections by saying: “When clouds become full, precipitation comes out of the cloud. precipitation comes in many forms such as rain, snow, sleet, or hail.”

Obtaining Information: Reading Activity

Prior to beginning this activity, the teacher will need to find several resources (articles, websites, textbook, etc.) about the water cycle. These resources will be used for students to collect additional information for revising their model.

While students are waiting on the evaporation part of the demonstration *(or the next day, if class time is a factor)*, students will work in their group to read a fiction book or a short article that discusses the water cycle. Each group may have different text resources about the water cycle, or you may have students read the same piece of text. The option is at the discretion of the teacher and what best fits the students. As students read, in their groups, they use the information collected from the text to complete the *In The Article* portion of their water cycle chart. An article can also be found with this lesson; however, it is recommended that students are provided with several pieces of text resources. Some suggestions are below; however, this is not an exhaustive list.

Additional Resources For Student Explanation:

- http://studyjams.scholastic.com/studyjams/jams/science/ecosystems/water-cycle.htm - Water Cycle Study James Video
- https://www.natgeokids.com/uk/discover/science/nature/water-cycle/#!/register - Water Cycle: National Geographic Kids
- http://www.cotf.edu/ete/modules/msese/earthsysflr/water.html - Water Cycle: Enviornment Project

Connecting Science To Self

Once students have completed the first two columns in the water cycle chart, inform students that you would like them to use their observation data and their text evidence to identify where or how they may have experienced something similar to *evaporation, precipitation, and condensation.* Students will use their experience/exposure to complete the last column of the chart, *In my Life.*

Discussion and Completion of the Chart

At this time, all columns of the chart should be completed. Engage the class in a whole-group discussion about the observation, text evidence, and examples that were written on the chart.

Possible Discussion Questions:

- Explain how the demonstration, the book, and your picture model are all related.
- What is one new fact that you learned about water on Earth from these different sources?
- Why is the water cycle important to life on Earth?
- Where does water go as it cycles through Earth?
- What is the relationship between the physical states of matter and the water cycle?

Exemplar of Completed Student Chart

	Demonstration Observation	In the Article	In my Life
Evaporation	• water by the window moves down slightly in a few hours	• when the sun heats the Earth, a little water from oceans, lakes, and rivers evaporates • turns into invisible gas or vapor	• puddles dry up outside
Precipitation	• blue food coloring drips through the shaving cream • shaving cream reminds me a cloud, food coloring reminds me of rain	• rain	• rain • snow • sleet • hail
Condensation	• water droplets form on the outside of the cup	• when the warm air that contains invisible water droplets rise from earth and meets cold air, droplets become visible • clouds are then formed	• water on the bathroom mirror • dew on the grass • water droplets on the car window in the morning

Student Guided Modeling

Students will be presented with an illustration of the water cycle. Students will label the components, interactions, and mechanisms in the model. Students will also write a description of the process happening in the model.

Revising The Initial Model

After the class demonstration, the article reading, and the guided modeling have students revise their initial model on the chart papers. At this time, students should focus on labeling parts of their model with the correct academic vocabulary, adding or revising arrows on the diagram, adding or revising their images, and explaining their model by constructing a brief paragraph. Having students revise their initial model supports students in visually seeing how their learning has progressed by engaging in the previous activities.

Rubric for Grading Diagram

Guidelines	**Points Possible**	**Points Received**	**Feedback**
Correctly contains all parts ● Evaporation ● Condensation ● Precipitation	30		
Explanation of the terms ● Evaporation ● Condensation ● Precipitation	30		
Arrows explaining the movement of water	15		
Story of the water droplet	20		
Organization ● Colorful ● Easy to follow	5		

Formative Assessment

For the final assessment, the teacher will have students imagine they are a water molecule telling the story of their journey. Students will use what they learned from the previous lessons to demonstrate their understanding of water cycles. Students will need to include the places they go, and the changes they would make, as they travel through the cycle. It is essential students correctly use the vocabulary words written below in their story. This assessment allows students to show what they know and be as creative as possible. It is at the discretion of the teacher if students are to illustrate their journey after they finish their writing.

Writing Assessment Rubric

(Adapted From Science Matters)

4	3	2	1
All words are included and described in the correct place. Writing indicates that water molecules travel individually and may stay longer in some places than others.	All words are included and most are described in the correct place. Writing indicates EITHER that water molecules travel individually OR may stay longer in some places than others.	Most words are included in the correct place but some are not described correctly or are incorrect. May or may not mention individual water molecules or different time in different locations.	Some words are not used. Minimal or no words are described. Does not include individual water molecules or different time in different locations.
The following words must be used and explained within the story:			
Evaporation	how water changes from a liquid to a gas through heating		
Precipitation	how water falls from the sky in forms such as rain, snow, sleet, or hail		
Condensation	how water changes from a gas to a liquid through cooling		
Sun	Students must explain the role of the sun in the water cycle.		
Clouds	Students must explain the role of clouds in the water cycle.		

Citations and Resources

Teacher Demonstration-
https://home.playfullearning.net/resource/water-is-water-3-experiments-for-kids/

Water Cycle Diagram-

https://www.teacherspayteachers.com/FreeDownload/Water-Cycle-Worksheet-1228195

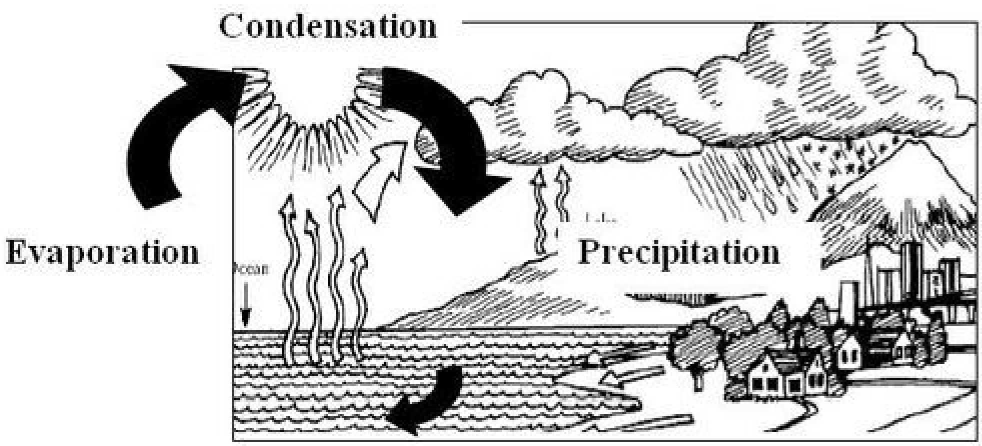
Science Matters http://sbsciencematters.com/5th/earth/5.C-FormativeAssessment-2.pdf

Water Cycle Article

Weather - the Water Cycle

Where does the water that causes rain come from? Actually, the water was there all along. All of the water in the whole world has always been here. Think of all of the oceans and lakes on the globe. This is where the tiny water particles in the air come from. But how does this happen?

The Earth's water cycle begins with a change in temperature. When the sun heats the Earth, a little water from oceans, lakes, and rivers evaporates. It turns into an invisible gas or vapor. Water molecules rise into the air. Eventually, clouds form and the water drops back to Earth as rain. The rain flows into rivers or streams back to the ocean or lakes again. Do you see the arrows in the picture? These arrows show the path of water from the ocean, to the sky, and then back to the earth. This is the water cycle.



Condensation also plays a big role in the creation of rain. The air far up in the sky can be very cold. When the warm air that contains invisible water droplets rises from earth and meets cold air, the droplets become visible. This process is called condensation. Clouds are formed as the air high up becomes colder and heavier. When the water drops grow too heavy to be held by the air, they fall out of the clouds as precipitation, or rain. The rain runs into the Earth's oceans, rivers, and lakes. Then, the cycle starts all over again!

Citation

https://www.readworks.org/article/Weather---The-Water-Cycle/49c4f252-2cdb-492d-8247-84edf9757d2b#!articleTab:content/

Water Cycle

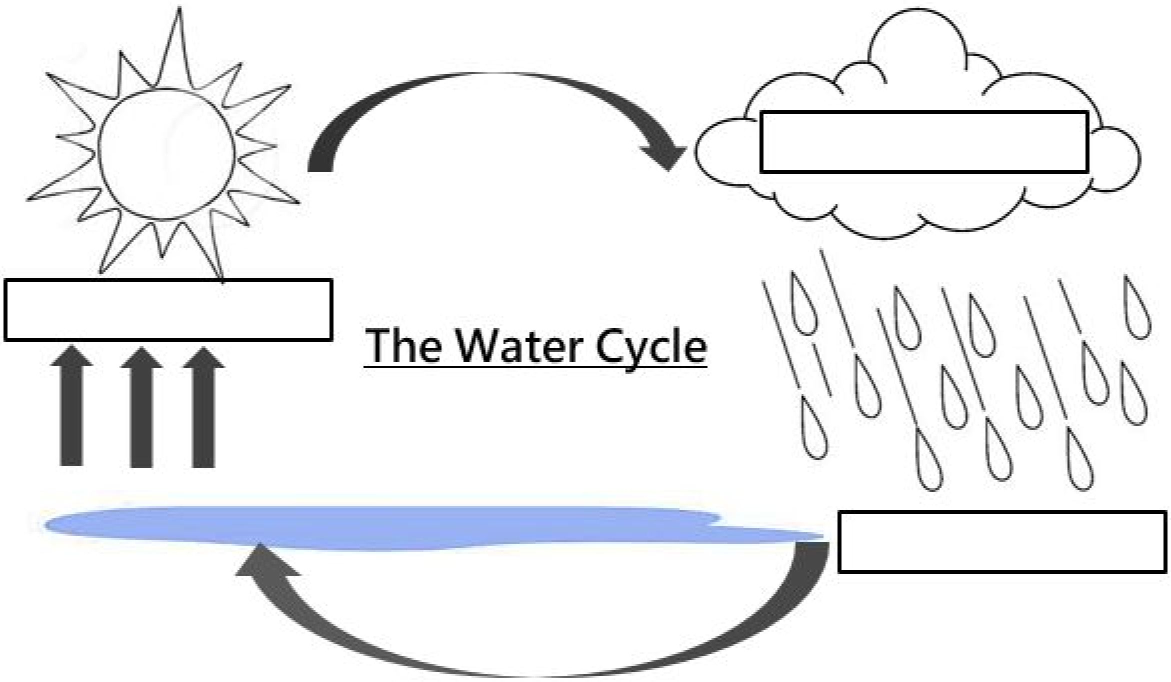
Part 1: Teacher Demonstration and Small Group Reading

Fill in the chart below.

	Observations from Teacher Demonstration	In the Article	In my Life
Evaporation			
Precipitation			
Condensation			

Part 2: Label the Water Cycle Diagram Below

- Complete the cycle with the following words:
    - Precipitation, Evaporation, Condensation
- Explain why each word is a great fit for the picture selected
- Feel free to add any extra arrows, words, explanation, or diagrams.



[1]

Part 3: Water Droplet Journey

- You are a water droplet. You must explain your journey around the Earth using scientific terms. Your water droplet can start at any place in the water cycle.
- Please include the following words in your story: sun, precipitation, condensation, evaporation, clouds, and a body of water.
- Please include a diagram of your journey.
- Make sure your model and story are neat, easy to read, and colorful.

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[1] Retrieved from https://www.teacherspayteachers.com/FreeDownload/Water-Cycle-Worksheet-1228195