The Evolution of the T2L Science Curriculum

Over the last four years, the Teach to Learn program created 20 NGSS-aligned science units in grades K-5 during our summer sessions. True to our plan, we piloted the units in North Adams Public Schools, and asked and received feedback from our science fellows and our participating teachers. This feedback served as a starting point for our revisions of the units. During year 2 (Summer of 2015), we revised units from year 1 (Summer/Fall 2014) and created new units to pilot. In year 3, we revised units from years 1 and 2 and created new units of curricula, using the same model for year 4. Our understanding of how to create rich and robust science curriculum grew, so by the summer of 2018, our final summer of curriculum development, we had created five exemplar units and established an exemplar unit template which is available in the T2L Toolkit.

We made a concerted effort to upgrade all the existing units with exemplar components. We were able to do much, but not all. So, as you explore different units, you will notice that some contain all elements of our exemplar units, while others contain only some. The fully realized exemplar units are noted on the cover page. We did revise all 20 units and brought them to a baseline of "exemplar" by including the Lessons-At-A-Glance and Science Talk elements.

Grade 5

The Karma of Water

A T2L Exemplar Unit

MCLA NAPS Williams

Teach To Learn

A collaboration between MCLA, Williams College, and North Adams Public Schools

Funded by NSF DUE-IUSE Award #1432591

T2L Curriculum Unit

The Karma of Water

Earth and Space Science / Grade 5

In this unit students will learn that there is no source of new water on Earth, that there is an uneven distribution of saltwater versus freshwater, explain that all matter has density, explain the effect of gravity on matter of different densities, explain that energy plays an important role in the movement of molecules and their phase changes, explain and understand different processes of water, explain how precipitation affects and shapes the land, and explain how living things interact with surface runoff.

Creation and Revision History

Authors

Julia Choi, Psychology major, Music major, Neuroscience minor, Williams College
Joy DeMayo, Second Grade Teacher, Colegrove Park Elementary School
Jessica Lesure, Elementary Education major, Psychology major, Massachusetts College of Liberal Arts
Lisa Marceau, Fifth Grade Teacher, Colegrove Park Elementary School
Sofia Phay, Psychology major, Williams College
Sophia Robert, Philosophy major, Biology major, Cognitive Science minor, Neuroscience minor, Williams College
Jade Schnauber, Early Childhood Education major, Sociology major, Massachusetts College of Liberal Arts
Natalie Torrey, Education major, Interdisciplinary Studies major, Massachusetts College of Liberal Arts

Revisions, Summer 2018:

Stephanie Nguyen, Elementary Education, Interdisciplinary Studies, Massachusetts College of Liberal Arts

This unit was developed with funding from the National Science Foundation DOE-IUSE Award No. 1432591
This unit is downloadable at http://mcla.edu/teach-to-learn

Table of Contents

Unit Overview and Background

Lesson Plans

Unit Resources

UNIT PLAN

Stage 1 Desired Results

Grade Level Standards

5-ESS2-2. Describe and graph the relative amounts of salt water in the ocean; freshwater in lakes, rivers, and groundwater; and freshwater frozen in glaciers and polar ice caps to provide evidence about the availability of fresh water in Earth's biosphere.

5-PS1-1. Use a particle model of matter to explain common phenomena involving gases, and phase changes between gas and liquid and between liquid and solid.

5-ESS2-1. Use a model to describe the cycling of water through a watershed through evaporation, precipitation, absorption, surface runoff, and condensation.

5-ESS3-1. Obtain and combine information about ways communities reduce human impact on the Earth's resources and environment by changing an agricultural, industrial, or community practice or process.

Meaning

UNDERSTANDINGS U

Students will understand that…

- **Water is a limited resource and there is no new water on the Earth.**
- **There is a cycle which water moves from one part to another in different states of matter.**
- **Human activities in agriculture, industry, and everyday life have had major effects on the land, vegetation, streams, ocean, air, and even outer space.**
- **Individuals and communities are doing things to help protect Earth's resources and environments. For example, they are treating sewage, reducing the amounts of materials they use, and regulating sources of pollution such as emissions from factories and power plants or the runoff from agricultural activities.**

ESSENTIAL QUESTIONS Q

1. What is water's relationship to Earth systems and living things?
2. What are the physical processes and forces that facilitate or drive movement of water from one part of the water cycle to another?

Student Learning Targets

"I can" statements "

1. I can explain that there is **no source of new water** on Earth and that water is a limited natural resource.
2. I can explain that there is an **uneven distribution of saltwater versus freshwater** on Earth.

This unit was developed with National Science Foundation funding (Grant #1432591). It is a DRAFT document that will be revised as the unit is piloted and feedback received.

	3. I can recall that **water on Earth is found in different places**, such as underground, in glaciers, in lakes and rivers, and in the air and soil. 4. I can explain that **all matter has density,** whether it's a solid, liquid, or gas. 5. I can explain that **materials with different densities will become sorted when they interact**, with dense matter sinking and less dense matter floating. 6. I can explain that **energy** plays an important role in the **movement of molecules** and their **phase changes**. 7. I can explain how **water changes phases from liquid to gas**, and why this process of evaporation is important. 8. I can find examples of **how water evaporates** in my everyday life. 9. I can explain **how clouds form**. 10. I can explain **how gas transforms into liquid** through the process of condensation. 11. I can explain that when water condenses within a cloud, it becomes **heavy and falls down as precipitation**. 12. I can recall that **water in the atmosphere is a form a freshwater**. 13. I can explain how **precipitation affects and shapes the land**. 14. I can explain how **surface runoff happens** and its interaction with surrounding land. 15. I can explain how **living things interact with surface runoff**. 16. I can identify what **materials/objects absorb water**. 17. I can explain the **process of water absorption**. 18. I can identify what **materials/objects absorb water**. 19. I can explain the **process of water absorption**. 20. I explain and **reflect upon the knowledge** I learned throughout the previous lessons. 21. I can **create a model** that represents the **physical processes and components of the water cycle.**

This unit was developed with National Science Foundation funding (Grant #1432591). It is a DRAFT document that will be revised as the unit is piloted and feedback received.

Stage 2 – Evidence	
Evaluative Criteria	**Assessment Evidence**
Science journal Class discussions Group presentations Individual projects/ activities	Unit Assessment
	OTHER EVIDENCE: **OE** ● Independent science journal entries ● Class discussions ● Presentations (both group and individual) ● Individual/ group activities such as, guided learning worksheets, watershed worksheet, comic strip, and summary paragraph.

Stage 3 – Learning Plan

Lesson 1: Students will be exploring the importance of water on Earth, as its purpose as the sustenance of all life. Students will learn that the water that is on Earth is the same water that has *always* been on Earth, and that this water is divided by into unequal distributions of salt or freshwater. Students will also be able to visually see how freshwater is distributed over Earth's surface and atmosphere.

Lesson 2: Students will begin with an activator that implores the students to think about why certain things float and others sink. A powerpoint presentation will introduce the concept of density and its equation. The first physical experiment will be an extensive activity in which groups of students calculate the densities of various liquids and then see how the densities predict their order when the liquids are mixed together. **Putting the liquids into solo cups and dyeing the clear ones should be prepared by the classroom teacher or science fellow beforehand**. The students will then create their own demonstration of the molecular movement of water in the three states to understand the relationship between phase changes and energy.

Lesson 3: Students will explore the process of evaporation by conducting experiments to observe and interpret how increasing temperature (introducing energy) causes a reduction of liquid (and a subsequent increase in gas). Kinesthetic models and activities allow students to understand what is occurring at the molecular level as a water molecule goes through this phase change (liquid → gas), as well as learn about examples of evaporation that occur in their daily lives.

Lesson 4: Students will explore the processes of condensation. Students will be engaged with questions of everyday life phenomena caused by condensation, such as morning dew and water droplets, or "sweat" on a water bottle. After continuing the Ralph the Raindrop story, students will make their own clouds with the Cloud-in-a-Jar activity and be encouraged to connect the story to their real life observations to discover the mechanisms of condensation. Students will learn about the types of clouds and how to distinguish them.

Lesson 5: Students will be learning about another physical process in the water cycle - precipitation. Two of the driving forces, which will be explored in experiments by the students, are the sun's energy, in the form of heat, and gravity. Students will be reminded that rainwater in the atmosphere is freshwater. They will also explore how precipitation can affect the land.

Lesson 6: Students will be exploring how the watershed works by creating a model using crumpled paper and dyed water. Students will also be able to explore real life solutions to problems that surface runoff causes by building models and the use of discussion.

Lesson 7: Students will be exploring the process of absorption and quickly touch upon transpiration through several hands-on activities. This way they will learn through kinesthetics and experiments how these processes work. Experiments include the celery rainbow, transpiration explanation, and the path of water experiments.

Lesson 8: Students will be exploring how to clean water of certain pollutants like oil, soil, and trash. They will be discussing certain cleaning solutions for pollution, ways to prevent and protect against it and reduce the amount of pollution we make.

Lesson 9: The class will be creating a board game to show the many paths that a water molecule like Ralph can take. Students will be designing a game board as well as question and consequence cards that either themselves or another 5th grade class will be playing with. Students will later get to play the game to quiz themselves and think critically about the big ideas and concepts that were taught in the previous lessons. There is also an alternative game of Jeopardy! described below that can be used to achieve the same goals.

MCLA NAPS Williams
Teach To Learn
A collaboration between MCLA, Williams College, and North Adams Public Schools
Funded by NSF DUE-IUSE Award #1432591

Lessons-at-a-Glance

KEY:

Accessing internet — YouTube Video

Outdoor education — Independent online student research

Lesson	Core Activities	Extensions	Tech Integration	Field Work
1. Dip Your Toe In – Properties of Water	1. Ralph the Raindrop Comic 2. Comparing Saltwater and Freshwater	SP4: Analyzing and Interpreting Data	YouTube	
2. Crash Course on the Water Molecule	1. Calculating density 2. Combining liquids 3. Dropping objects 4. Changing Phases		YouTube	
3. Evaporation Dries the Nation	1. Evaporation in a cup 2. Evaporation in real life			
4. Drip, Drip, Drop - Condensation	1. Cloud in a jar 2. Condensation Game--Let's Become Clouds	Explore specific types of clouds within categories	YouTube	
5. What Goes Up Must Come Down – Precipitation	1. Hands on Rainstorm a. Gravity's role b. The Sun's role 2. Rain and the Land		YouTube	
6. Slip and Slide - Surface Run-off	1. Watershed 2. In Your Life			

7. Soak It All Up – Absorption	1. Transpiration 2. Rainbow Celery Project 3. The Path of Water			
8. Dirty Dirty – Pollution, Pt 1	1. Our Water Supply 2. Oil Spill			
8. Dirty Dirty – Pollution, Pt 2	1. What can we do? 2. Water Conservation 3. Research Project	Visit website that lists all the contaminants found in the water in a specific location		
9. Cycle Board Game	1. Play Board Game			

This unit was developed with National Science Foundation funding (Grant #1432591). It is a DRAFT document that will be revised as the unit is piloted and feedback received.

Teach To Learn
A collaboration between MCLA, Williams College, and North Adams Public Schools
Funded by NSF DUE-IUSE Award #1432591

Lesson Feature Key

Lessons in this unit include a number of features to help instructors. This key is a quick guide to help identify and understand the most important features.

Icons

Talk science icon: Look for this icon to let you know when to use some of the talk science strategies (found in the unit resources of this unit)

Anchor phenomenon icon: Indicates a time when an anchoring scientific phenomenon is introduced or when an activity connects back to this important idea.

Text Formatting:
[SP#: ….] Any time you see a set of brackets like this, it indicates that students should be engaged in a specific science or engineering practice.

<u>Underlined text in the lesson</u>:
This formatting indicates important connections back to the central scientific concepts, and is useful to note these connections as an instructor, as well as for students.

Callouts

Teaching Tip
In these call out boxes, you'll find tips for teaching strategies or background information on the topic.

Student Thinking Alert
Look out for common student answers, ways in which students may think about a phenomenon, or typical misconceptions.

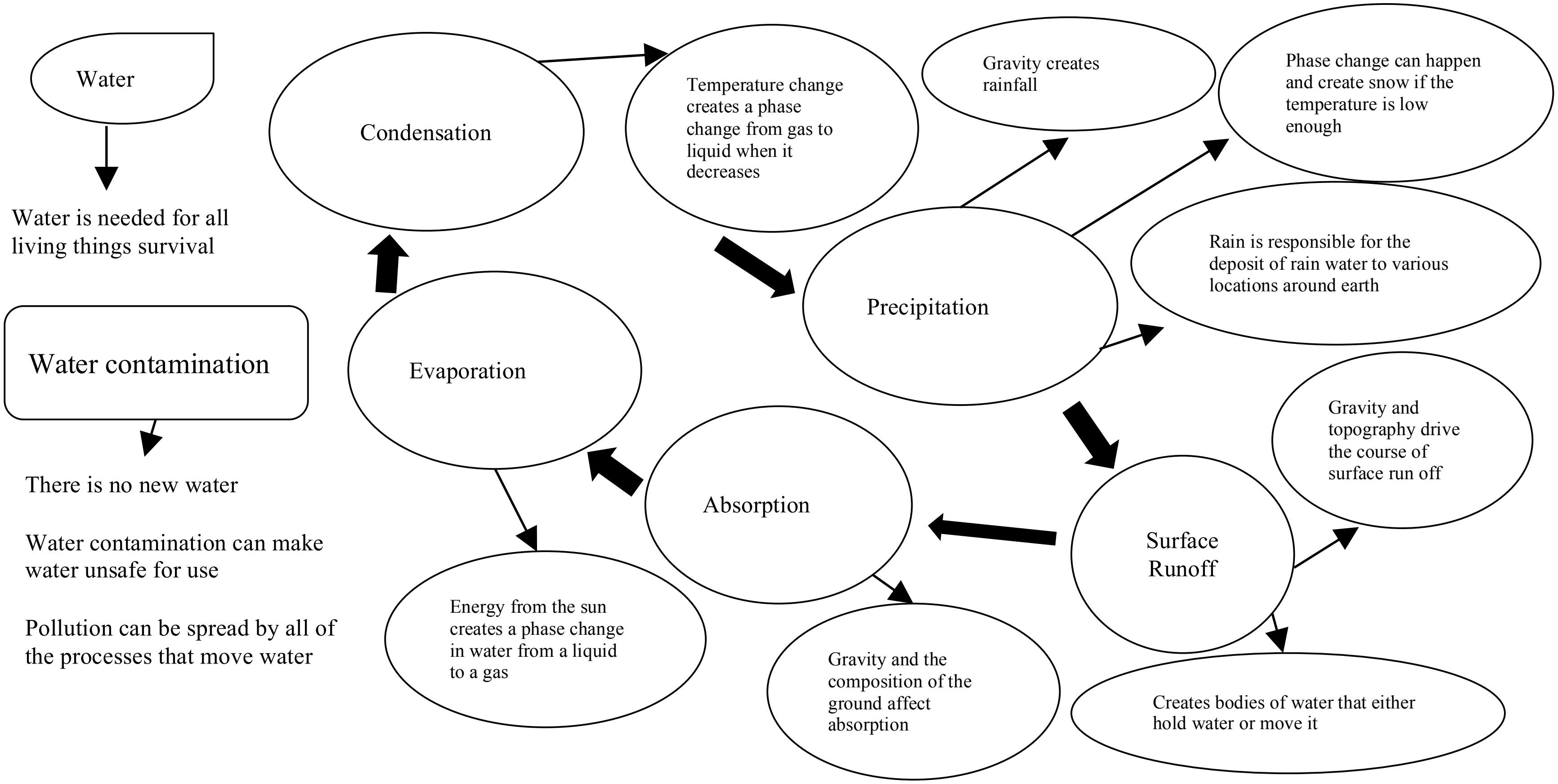
This unit was developed with National Science Foundation funding (Grant #1432591). It is a DRAFT document that will be revised as the unit is piloted and feedback received.

MCLA
NAPS
Williams
Teach To Learn
A collaboration between MCLA, Williams College, and North Adams Public Schools
NSF
Funded by NSF DUE-IUSE Award #1432591

Essential Question Concept Maps

EQ1: What is water's relationship to Earth systems and living things?

EQ2: What are the physical processes and forces that facilitate or drive movement of water from one part of the water cycle to another?



Tiered Vocabulary List

Tier 1	Tier 2	Tier 3
Water	Cycle	Phase change
Particle	Freshwater	Particulates
State	Saltwater	Aerosol
Matter	Density	Cumulus
Liquid	Evaporation	Cirrus
Gas	Molecule	Stratus
Solid	Condensation	Topography
Energy	Precipitation	
Droplets	Gravity	
Water vapor	Surface run off	
Clouds	Watershed	
Pollution	Absorption	
Sewage	Transpiration	
Fertilizer	Pesticide	
	Herbicides	

Science Content Background

Read through the explanation provided in the next few pages. Jot down questions or uncertainties. Consult internet resources to answer your questions, ask colleagues, and work together as a team to grow your own understanding of the science content and the central phenomena in this unit. This knowledge primes you to better listen and respond to student ideas in productive ways. Please feel free to revisit this explanation throughout the unit to revise and improve your own understanding of the science content.

Essential Questions:

What is water's relationship to Earth systems and living things?
Water's relationship to Earth systems and living things is both deep and broad. Water is heavily involved in many of Earth's systems as both a driver and an element of change. Living things depend on water for survival but also play a major role in the amount of available water.

What are the physical processes and forces that facilitate or drive movement of water from one part of the water cycle to another?
The main processes that facilitate the movement of water throughout the hydrosphere are: evaporation, condensation, precipitation, surface runoff, and absorption. Energy, in the form of heat and light from the sun, and gravity are the two primary drivers that facilitate the mechanisms underlying these processes. Other important factors include (1) properties unique to water (the only compound that occurs naturally on Earth in all three states: solid, liquid, and gas), and (2) the role of density in the movement of water molecules of varying temperatures.

Rationale for the Order of Content

This unit is meant to explore both how water interacts with and drives many processes and systems on Earth, and therefore how water affects living things. Many classrooms decide to teach these interactions through the water cycle. It is important to understand that water does not follows a singular "water cycle." This unit investigates the way that water goes through all these processes indefinitely. In order to give organization to the content, the unit starts with lessons such as properties of water and a crash course in physics so that students are introduced upfront to the various ways we will experience water as it travels through different stages. After this introduction, each process has its own in-depth lesson that allows students to explore all the possible paths water can take from that process. Once all processes are covered, the unit moves into a social and civic perspective to explore water contamination issues. These lessons explore pollution, accessibility, and conservation. At the end, students are asked to create a board game that will ask them to apply their knowledge about the properties of water, its associated physical processes, and the issues with contamination—all in one concrete activity.

Anchoring Phenomenon

In this unit, all of the lessons are connected through the narrative of Ralph the Raindrop. Each lesson tells a part of Ralph's journey in order for students to follow along with one raindrop's journey. Ralph experiences each water cycle process, and students are encouraged to use their own creativity to draw Ralph's journey. In the last lesson, students are given parts of Ralph's journey already illustrated in order to explain pollution, where he meets a troublesome raindrop who has experience with pollution. In the end, their completed comic will give them a comprehensive storyline of how water cycles through, and interacts with, Earth's systems. Note: the fact that the raindrop's name is 'Ralph the Raindrop' should not detract from the fact that a raindrop is composed of 1.67 x 10^{21} (1.67 sextillion) water molecules. These molecules all disperse when the raindrop is evaporated, so 'Ralph' as a combined entity disappears when he goes through evaporation.

Key Science Ideas

OVERARCHING IDEAS

- Total amount of water on Earth remains the same, while the amount of "accessible" water changes
- The Sun and gravity play a critical role in setting the processes of the water cycle in motion

- How water affects LIFE
  - Humans and animals (ALL organisms) use water
  - Water sustains ecosystems
  - Organisms play a role in water's form (e.g., what if there were no plants? Plants convert water to gas [oxygen]), and they play a role in the movement of water and its location (e.g., water gets trapped in plants and leaves through transpiration)
  - Temperature changes accessibility of water (examine different points in Earth's history, polar ice caps)
  - Humans impact water through pollution, and a growing population/increased consumption rate (think outside local perspective in terms of water access)

- How water affects ATMOSPHERE
  - Water droplets exist in the air.
  - Atmosphere responsible for cause and effect relationships through evaporation and precipitation
    - Some pollutants in the atmosphere come down along with precipitation
    - Sunsets are more vividly orange/red when there's more smoke in the atmosphere because when the sun is near the horizon, the light has to travel increasingly longer paths and the particulates in the air scatter most of the sunlight. The higher frequency light rays (blue, violet) scatter the easiest and the lower frequency light rays (red, orange) scatter the least, so the lower frequency colors are what end up reaching our eyes.
  - Water and dust are the main parts of clouds.

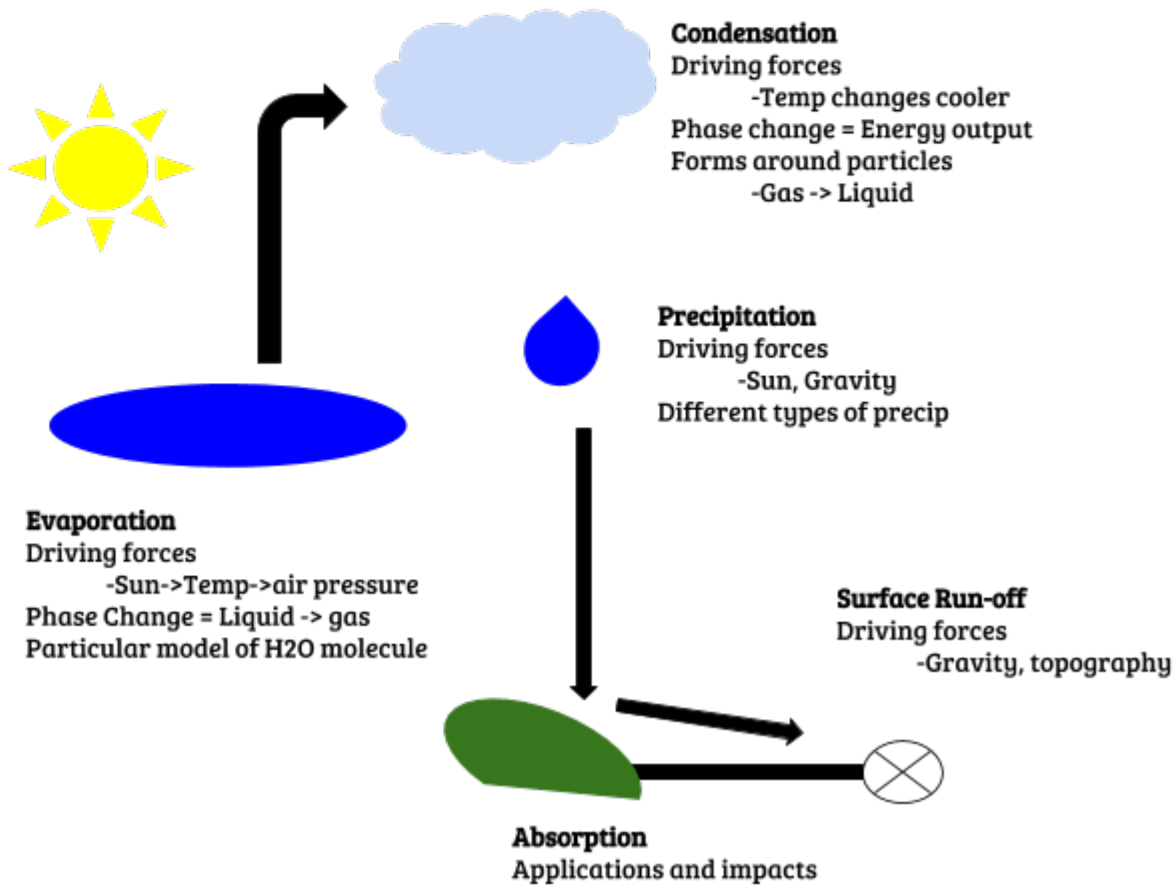
- How water affects LAND
  - Weathering and erosion
    - How do lakes and rivers form?
  - Interactions with topography and composition of land

- Amount of water in soil leads to diversity of flora
- Landforms affect water by trapping, filtering, and directing its flow
- Landslides and other natural disasters (hurricanes, tsunamis).

- How water CHANGES
  - Phase changes require energy - where does it come from? What are the inputs and outputs?
    - Sun's energy and gravity drive the water cycle.
    - Temperature is another way of describing the average kinetic energy (energy of motion)
  - **Freezing** (liquid → solid)
    - liquid (higher kinetic energy) changes to solid (lower kinetic energy)
    - Happens when lower amounts (or none) of Sun's energy results in a reduction in energy
  - **Evaporation** (liquid → gas)
    - Requires energy input, almost always from the Sun
  - **Condensation** (gas → liquid)

    In the atmosphere, there needs to be some kind of tiny, fine particulate matter for the water to condense on. If the air is too clean, there will be no clouds. When water condenses, it releases some energy, which tends to heat up the surrounding air, potentially causing extreme weather patterns. For example, thunderstorms in the summer result when warmer air, which holds more moisture and rises higher, releases more energy when it condenses.
    - Can happen at lots of different temperatures
    - Dew = condensation on ground-level objects.
  - **Melting** (solid → liquid)
    - requires energy input
  - **Deposition/desublimation** (gas → solid)
    - The process behind hail

- How water MOVES
    - **Precipitation** (rain, snow, hail): water falling from the sky because of gravity
    - **Surface runoff**: driven by gravity, topography (shape of the land), and composition of land
    - **Absorption**: driven by gravity, and composition of land



This unit was developed with National Science Foundation funding (Grant #1432591). It is a DRAFT document that will be revised as the unit is piloted and feedback received.

Funded by NSF DUE-IUSE Award #1432591

Explanation

Water is an essential resource for life on Earth, and yet is a limited resource in a closed system (called the "hydrosphere"). This means that water neither enters nor leaves the Earth; there is no new water. The amount of available water plays a large role in determining the types of ecosystems that can be sustained in an area. All living organisms use water in many different ways, and these organisms can contribute to the movement of water as well as changing its form.

Nearly all of Earth's available water is in the oceans. Most freshwater is in glaciers or underground; only a tiny fraction is in streams, lakes, groundwater, and the atmosphere. Rain is the primary source of freshwater for most places in the world. When it comes to the relationship between water and humans, **accessibility** is an important issue. In many places in the world, it hardly ever rains. Even in some places in the United States where it does rain, collecting rainwater is illegal because the government has placed restrictions on our use of natural resources and how they can be processed. Having access to drinkable and usable freshwater is not universal. There are many factors that come into play that determine whether clean freshwater is available to a population of people, but low socioeconomic status is a clear disadvantage in this respect. Lack of access to drinkable water is a problem often accompanied by other issues such as poverty, faulty infrastructure, and pollution (e.g. the corrosion of lead and iron pipes that carry polluted 'drinking' water). It is important that students in the classroom are made aware that many people are affected by this issue.

One way water commonly moves is through our atmosphere, because surface water is often evaporated into the air. **Evaporation** is when water changes from liquid to a gas. Energy from the Sun increases the movement of the molecules in the liquid until they become water vapor molecules. The water vapor molecules (gas) form into droplets (liquid) on dust grains, creating clouds (through a process called **condensation**). When the water condenses, changing from gas to liquid, it releases energy because the water vapor molecules had more kinetic energy (higher temperature) than the liquid water molecules. In order to achieve the lower kinetic energy state (lower temperature), energy must be released. This energy can warm up the surrounding air creating extreme weather patterns such as thunderstorms. If the clouds contain enough water, then gravity will bring the water droplets down as **precipitation**. The form of precipitation (e.g. rain, hail, snow) is dependent on the surrounding temperature and air pressure. Precipitation brings freshwater down to earth as well as some of the pollutants that are present in the air.

The complex interplay between **temperature**, **density**, and **pressure** is useful background information for understanding some of the physical processes mentioned above. For example, matter of varying densities becomes sorted out according to their relative densities because of **gravity**. This is especially relevant when it comes to masses of air with different temperatures. **Warm air** has molecules that move with more energy, thus they are more spread out (**less dense**) and able to carry more moisture or water vapor. The molecules in **cool air**, on the other hand, are less spread out (**more dense**) and therefore less able to carry moisture, resulting in dry air. Thus, warm air rises and cool air sinks, because of the difference between their relative densities.

When warm air and cool air meet, warm air molecules, including Oxygen, Nitrogen, and water vapor molecules, tend to release their excess energy. If the water vapor molecules release enough energy, they go through a phase change and condense, forming water droplets. If they only release enough to cool and vibrate less, the air molecules become more dense, close together, and sink in the atmosphere.

Density and temperature of air molecules creates **air pressure**. Air that is less dense and warmer creates low air pressure, whereas air that is more dense and cooler creates high air pressure. Air lower in the atmosphere is more dense than air above, so air pressure close to the ground is greater than air pressure at higher levels of the atmosphere.

Wind is caused by the movement of air from areas of high pressure to areas of low pressure. If a high pressure area is very close to a low pressure area, or if the pressure difference between two areas is very great, the air can move very quickly, causing very fast winds. Sometimes the rapid cycling or movement of air can cause more drastic weather patterns like hurricanes and tornadoes.

This unit was developed with National Science Foundation funding (Grant #1432591). It is a DRAFT document that will be revised as the unit is piloted and feedback received.

Water also plays a large role in changing the land via **surface runoff**, which can weather and erode the land, creating lakes, rivers and many landforms. The result of **erosion** also depends on how the water interacts with gravity and the topography and composition of the land. This interaction takes place within a **watershed**, which is the area within which water filters through a landscape. The degree to which landscapes **absorb** water in the soil will affect the diversity of flora. Sometimes if a place has too much underground moisture, landslides can occur. Many other natural disasters can be caused by water, such as hurricanes and tsunamis.

Human activities like agriculture, industry, and everyday life have had major effects on the land, vegetation, streams, ocean, air, and even outer space. Humans have the ability to pollute, consume, and conserve water. Many individuals and communities are taking steps to help protect Earth's resources and environments.

Using the Spheres as a Unifying Theme

The units included under this unifying theme are Grade 2: Land and Water, Grade 3: Weather and Climate, Grade 4: Earth's Surface, and Grade 5: Karma of Water. As students progress through the grades, the science curriculum will build off of the knowledge students acquire from the previous grades' units. To help the teachers make the connections between the units, all four units are tied together through the theme of Earth's systems. The Earth is a system in its own right, and most of its processes get their energy from or are influenced by the sun.

The Earth is a system composed of four interconnected subsystems; they are the atmosphere, hydrosphere, geosphere, and biosphere. The geosphere is made up of the Earth's core, molten rock, soil, and sediment. The atmosphere consists of the gases surrounding the Earth. The hydrosphere is all the water on earth; this includes ice, water vapor, and liquid water which can be found in the atmosphere, ground, air, oceans, lakes, rivers, and streams. The biosphere is any living organism found in the atmosphere, hydrosphere, and geosphere. For the most part, the sun does not directly impact the geosphere; however, it's one of the driving forces behind the weather and climate that affect the biosphere, hydrosphere, and atmosphere.

Why should we care about the spheres?

The phenomena that students learn about in Grades 2 through 5 don't happen as distinct, isolated events; rather, they can only be fully understood as part of the interaction between the four spheres. Volcanoes, storms, and floods aren't only features in themselves, but can also be understood as inputs and outputs from one system, or sphere, into others. A sand dune, for instance is an output of the eroding winds of the atmosphere, and an input into the landforms of the geosphere. Thinking about the spheres as systems encourages students and teachers not only to observe phenomena, but to ask, what sphere is this phenomena coming from? Where is it going? For instance, sand dunes can also act as an input into the biosphere through causing desertification and influencing the life forms in a region. Only in understanding spheres as systems do we take in the full interconnectedness of the Earth.

How are the spheres featured in each unit?

In Grade 5: Karma of Water, students will learn about the hydrosphere and its impact on the other three spheres. In this way, this unit ties in all four spheres. Since this unit is about the water cycle, students will learn about the evaporation, condensation, and precipitation processes which involve the hydrosphere and atmosphere. Then, the students will learn about the effects of the hydrosphere. As they did in Grade 2 and Grade 4, students will learn about water erosion and its effects on the biosphere and geosphere. However, students will also learn about the benefits of the hydrosphere such as how water helps living organisms survive. In closing, students will learn about the human impact on the water cycle. Since students learned about pollution in the atmosphere in Grade 4, students will learn about pollution in the hydrosphere in this unit. However, the pollution taught in this unit intersects with the atmosphere because rain becomes polluted by the gases released by humans.

***Science Phenomena Where All Four Spheres are Present*:**

Precipitation
Organisms such as plants

Interactions Between the Spheres:

Living organisms → hydrosphere → biosphere
Evaporation → hydrosphere → atmosphere
Condensation → atmosphere → hydrosphere
Water erosion and weathering → hydrosphere → geosphere
Surface runoff → hydrosphere → geosphere → biosphere
Human actions and pollution → biosphere → atmosphere → hydrosphere

From one perspective, the focus of this unit is how the water cycle interacts with the different spheres. First, students will learn how freshwater is essential for the survival of organisms. Therefore, the biosphere is dependent on the hydrosphere.

Freshwater can be found in a variety of places such as ice caps, rivers, lakes, in the ground, and in the air. In short, water is found in the hydrosphere, geosphere, and atmosphere.

Students will learn that freshwater is a limited resource. Next, students will learn about the process of the water cycle. Specifically, they will learn how water changes phases through the processes of evaporation, condensation, and precipitation. In the evaporation process, the hydrosphere interacts with the atmosphere because the water in the hydrosphere becomes water vapor or gas. For the condensation process, the water vapor in atmosphere meets cold air, causing the water vapor particles to lose energy and condense. As a result, the water is no longer part of the atmosphere, becoming part of the hydrosphere as water droplets. Finally, for precipitation, water droplets change their phase of matter depending on the surrounding air temperature. Thus, precipitation is affected by the atmosphere.

In the later lessons of the unit, students will learn about the effects of the water cycle. For instance, heavy rains can cause natural disasters such as floods and landslides. Thus, in this way, precipitation also affects the geosphere and biosphere. In addition, students will learn about how they impact the biosphere. Unfortunately, due to the growing human population, water consumption has increased even though there is a limited amount of freshwater on Earth. In addition, the biosphere and atmosphere affects the hydrosphere because of the pollution produced by humans pollutes the water.

Interactions of the Spheres by Scientific Phenomena

Scientific Phenomena	**Acting Sphere (s)**	**Modified Sphere (s)**
Since water is neither created or destroyed, the amount of water on Earth remains the same.	Hydrosphere	N/A
Freshwater can be found in a variety of places such as ice caps, glaciers, rivers, lakes, groundwater, soil, and air.	Hydrosphere	Atmosphere Geosphere

All living organisms need freshwater to survive.	Hydrosphere	Biosphere
Evaporation happens when energy from the sun increases the energy in water molecules, so the molecules move more and turn into water vapor.	Hydrosphere	Atmosphere
Condensation happens when water vapor molecules release energy when they come into contact with cool air. As a result, they turn into water droplets and condense to form clouds.	Atmosphere	Hydrosphere
When clouds carry a lot of water droplets, gravity pulls the droplets down to make precipitation.	Atmosphere	Hydrosphere
The type of precipitation that forms (e.g. rain, snow, hail) depends on the surrounding air temperature.	Atmosphere	Hydrosphere
Water erosion and weathering help create rivers and lakes.	Hydrosphere	Geosphere
Heavy precipitation can cause natural disasters such as landslides and erosion. These disasters can cause damage to humans and all life forms.	Hydrosphere	Geosphere Biosphere
Surface runoff can erode or change the shape of the land, carry pollutants, destroy crops, cause floods, etc. This can cause damage to humans and all life forms.	Hydrosphere	Geosphere Biosphere
Organisms affect the water cycle. For instance, plants trap and absorb water to prevent surface runoff. In addition, water is released into the atmosphere through transpiration.	Biosphere Hydrosphere Geosphere	Atmosphere

Humans affect the amount of freshwater available on Earth (e.g. consumption rate, growing population, pollution).	Biosphere	Hydrosphere
Water becomes polluted from chemicals and trash.	Biosphere Atmosphere	Hydrosphere

Interactions of the Spheres in Each Lesson

Lesson	Acting Sphere (s)	Modified Sphere (s)
Lesson 1: Dip Your Toe In-Properties of Water	Hydrosphere	Biosphere
Lesson 2: Crash Course on the Water Molecule	Atmosphere	Hydrosphere
Lesson 3: Evaporation Dries the Nation	Atmosphere	Hydrosphere
Lesson 4: Drip, Drip, Drop-Condensation	Atmosphere	Hydrosphere
Lesson 5: What Goes Up Must Come Down-Precipitation	Atmosphere	Hydrosphere Geosphere
Lesson 6: Slip and Slide-Surface Runoff	Hydrosphere	Geosphere Biosphere
Lesson 7: Soak It All Up-Absorption	Hydrosphere Biosphere	Geosphere Atmosphere Biosphere

Lesson 8: Dirty Dirty-Pollution	Biosphere Hydrosphere	Hydrosphere Atmosphere Geosphere
Lesson 9: Cycle Board Game	Biosphere Atmosphere Hydrosphere	Hydrosphere Geosphere Atmosphere

Lesson 1: Dip Your Toe In – Properties of Water

LESSON BACKGROUND

This lesson lays a foundation for understanding how water moves through the hydrosphere by introducing properties of water that drive the physical processes of "the water cycle." Students learn that water is a limited natural resource that exists in a closed system. Through observation and experimentation, students also discover the distribution of existing water in its various forms and locations.

SCIENCE CONTENT BACKGROUND (for instructors):

Water is an essential resource for life on earth. Water is a limited, renewable resource that exists in a closed system. It neither enters nor leaves the system; there is no new water. Therefore, the water that exists in our current hydrosphere is the same water that has always existed (while practically true, some small amount of water is consistently leaving the Earth and the Earth has periodically received large amounts of water from comet impacts). Nearly all of Earth's available water is found in the ocean. Most freshwater is locked up in glaciers or underground; only a tiny fraction flows in streams, lakes, groundwater, and the atmosphere. Rain is the primary source of freshwater for most places in the world.

Overview of the Lesson

Students explore the importance of water on Earth: its purpose as the sustenance of all life. Students learn that the water that is on Earth is the same water that has *always* been on Earth, and that this water is divided into unequal distributions of salt or freshwater. A visual demonstration of freshwater distribution over Earth's surface and atmosphere emphasizes limited accessibility to this resource.

This unit was developed with National Science Foundation funding (Grant #1432591). It is a DRAFT document that will be revised as the unit is piloted and feedback received.

Focus and Spiral Standard(s)

5-ESS2-2. Describe and graph the relative amounts of salt water in the ocean; freshwater in lakes, rivers, and groundwater; and freshwater frozen in glaciers and polar ice caps to provide evidence about the availability of fresh water in Earth's biosphere.

2-ESS2-3. Map the shapes and types of landforms and bodies of water in an area. [**Clarification Statement**: Examples of types of landforms can include hills, valleys, river banks, and dunes. Examples of water bodies can include streams, ponds, bays, and rivers. Quantitative scaling in models or contour mapping is not expected.]

NGSS Alignment

Disciplinary Core Ideas (DCI)	Crosscutting Concepts (CCC)	Science Practices (SP)
ESS2.C: The Roles of Water in Earth's Surface Processes Nearly all of Earth's available water is in the ocean. Most fresh water is in glaciers or underground; only a tiny fraction is in streams, lakes, wetlands, and the atmosphere. (5-ESS2-2)	**Systems and System Models** A system can be described in terms of its components and their interactions. (5-ESS2-1),(5-ESS3-1)	SP4: Analyzing and Interpreting Data

Learning Targets

1. I can explain that there is **no source of new water** on Earth and that water is a limited natural resource.
2. I can explain that there is an **uneven distribution of saltwater versus freshwater** on Earth.
3. I can recall that **water on Earth is found in different places**, such as underground, in glaciers, in lakes and rivers, and in the air and soil.

WIDA Language Objectives

[Dependent on your students]

This unit was developed with National Science Foundation funding (Grant #1432591). It is a DRAFT document that will be revised as the unit is piloted and feedback received.

Targeted Academic Language
Tier 1: Water, Particle
Tier 2: Cycle, Freshwater, Saltwater
Tier 3:

RESOURCES AND MATERIALS

Quantity	Item	Source
1 per student	Science Journal	Classroom Teacher
	Dinosaur Pee?: Crash Course [https://www.youtube.com/watch?v=o_bbQ0m3wuM]	CMC Website
1 per student	Crash Course: A Glass of Dinosaur Pee Guided Learning Worksheet	Binder
As needed per class	Globe	Classroom Teacher or **Bin**
3 total, 1 per group	1000 milliliter water bottle	Bin
6 total, 2 per group	**1000 milliliter beakers**	**Bin**
3 total, 1 per group	**Graduated cylinder**	**Bin**
3 total, 1 per group	**5 milliliter pipettes**	**Bin**
12 total, 4 per group	**100 milliliter beakers**	**Bin**
3 total, 1 per group	Sharpies	Classroom Teacher
1 per student	Water Distribution worksheet	Binder
	Water Distribution answer key	Binder
As needed	**Sticky notes**	**Bin**
1 per class	Chart paper for "Parking Lot Questions"	Classroom Teacher
1 per student	A booklet of blank comic strips, stapled (around 7 pages)	Classroom Teacher

****Items in bold should be returned for use next year***

Teach To Learn
A collaboration between MCLA, Williams College, and North Adams Public Schools
Funded by NSF DUE-IUSE Award #1432591

LESSON DETAILS

Lesson Opening / Activator

Ask students what they know about water – what is the purpose of water, where is it found, what do we do with water? As some of these answers might overlap, the Science Fellows might construct a cohesive list of student answers on the board or on chart paper. Draw lines where answers connect and tie together. After constructing an inevitably large list, ask students what would happen if there was *no* water. How long can humans survive without water? The answer is three days, scientifically, but we would start feeling the effects of dehydration long before that. No organism on Earth can survive without water, which is why it is important that we study it, learn mechanisms related to it, and how to take care of it.

During the Lesson

1. **Cycle Not Circle**
    a. Ask the students to close their eyes and think of "the water cycle." What do they see or imagine? Do they imagine a starting point or an ending point?
    b. (Anchor: Following a raindrop through various processes and locations). Introduce the character of Ralph the Raindrop, a raindrop whose journey the students will document throughout the unit. Students will record Ralph's journey through weekly comic strips that eventually become a Water Cycle Comic Book.

Student Thinking Alert
Common misconception: there is a starting and ending point in the water cycle. There is not a single path that water takes through the cycle.

2. **Water: A Geriatric Patient**
   Ralph is going to be an important character in our unit and a key component in the understanding of the water cycle.

a. (Science Talk: allow students to voice their ideas, while also being careful to guide the discussion towards the desired conclusion). Ask students how old they think Ralph is, essentially asking how old *any* water is. This conversation can take a variety of forms – where does water come from; what happens to the water we use; is rain *new* water or *old* water?

i.

ii. The learning target of this conversation is to convey that there is **no new water**. The water that is on Earth is the same water that has been on Earth since it first formed. Therefore, water that has been traveling in the water cycle is the same water that was here when we were born, when our parents were born, even when the dinosaurs were born! The same water particles that are in our drinking fountains could be the same particles that were in, well, a dinosaur!

b. Hand out guided learning worksheet on the crash course video and show the class the video for "Dinosaur Pee?: Crash Course" on the CMC website or [https://www.youtube.com/watch?v=o_bbQ0m3wuM] *Although some of the information reaches ahead to what the students* ***will be*** *learning, once again the learning target of this video is that there is no new water.* Check in with students after the video ends to go over guided learning worksheets, provide any missed answers, or clear up any questions they might have.

Teaching Tip

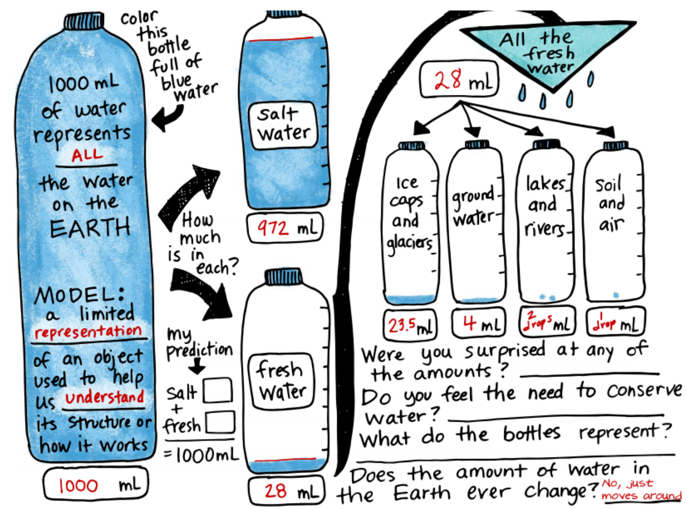
If students have any questions about the water cycle that do come up after watching this video, have them write them in their science journals or on sticky notes that can be posted on the wall or the Parking Lot to be revisited later.
"Parking Lot" is an area of the classroom that students can write any questions they might have concerning content that might not be timely or appropriate for time-sensitive class material.

3. Saltwater versus Freshwater [SP4: Analyzing and Interpreting Data]

a. Bring out a globe and ask students to identify water. Is there a lot of water? Where is most of the water located? Is there a difference between water found in the ocean and water found in lakes and ponds? Want students to realize there is a drastic difference in the amount of available salt versus fresh water.

b. Split students into three groups, where the two Science Fellows and the classroom teacher are the facilitators of the experiment. Each one of the facilitators should have their own set of materials to conduct the experiment.

c. Start with the 1000 mL water bottle and explain that this bottle represents ALL the water on the Earth. *Have students fill out their worksheet accordingly as the experiment proceeds*. **Teachers should label the beakers as appropriate for the lesson while students are making predictions and filling in information. [SP2: Developing and Using Models]**



i. Students should first record predictions and discuss with their facilitators. What made them choose these amounts?

ii. Start by pouring the water into one of the beakers labeled "Salt Water." Address students' predictions if you surpass them while filling it up to **972 mL**. This represents the amount of saltwater on Earth. The remaining **28 mL** represents the amount of freshwater and can be put into the beaker labeled "Fresh Water." Discuss students' thoughts about this new discovery.

iii. Next, break down the freshwater into different deposits on Earth (ice caps and glaciers; ground water; lakes and rivers; soil and air). Students can make predictions on where they think the *most* water would be located versus where the *least* water would be located, and write their ideas on the worksheet in the margins.

iv. Facilitators should measure and place 23.5 mL of water in the "ice caps and glaciers" beaker. The remaining water can be transferred by pipette. Place **1 drop** into the "soil and air" beaker, **2 drops** into the "lakes and rivers" beaker, and the remaining **4 mL** into the "groundwater" beaker.

v. Students may fill out the remaining questions in their science journals, rather than the worksheet to add more detail than the space on the worksheet provides.

Lesson Closing

Allow students to write any lingering questions in their science journals or on sticky notes posted on the board or the Parking Lot. Teachers can consider these questions as jumping off points during other lessons or at teachers' discretion as time provides. Introduce students to Ralph by projecting the PowerPoint or PDF file of "Lesson 1 - Ralph the Raindrop cartoon." Read the cartoon aloud.

The story reads:

"Hello! I am Ralph the Raindrop. Nice to meet you! I live in the Fish Pond at Windsor Lake, North Adams! I'm just hanging out here, waiting for an exciting adventure. I've always heard many wonderful stories of other raindrops' journeys. Everyone here came from all kinds of places! I can't wait to see where I will be going next. Please join me in my exciting journey! Together we will explore what could happen to a simple raindrop, like me!"

Hand out the booklet of blank comic strips to each student. They will keep this booklet with their Science Journal for the rest of this unit.

Assessment

Review students' guided learning worksheets and Water Distributions worksheets.

Lesson 2: Crash Course on the Water Molecule

LESSON BACKGROUND

This lesson helps students model and understand the physical mechanisms behind the processes involved in moving water through different parts of the hydrosphere (such as evaporation, condensation, and precipitation, etc.), which they will explore in later lessons. The activities focus on the concept of density and how it applies to our understanding of phase changes in the context of a particle model of matter. Some of this material may be review for students that retained the information from the physical sciences unit in Grade 5. Teachers can gauge which aspects of the activities are appropriate for the needs and abilities of their students.

SCIENCE CONTENT BACKGROUND (for instructors):

The complex interplay between **temperature**, **density**, and **pressure** is useful background information for understanding the physical processes explored throughout this unit. For example, matter of different densities will become sorted according to their relative densities because of **gravity**. This is relevant for the liquid density experiment in this lesson, where liquids and solid objects become organized according to their relative densities. It is also important when it comes to masses of air with varying temperatures, a catalyst for weather events.

Warm air rises and **cool air** sinks, because of the difference in their relative densities. When warm air (more energy, more spread out) and cool air meet, warm air molecules, including Oxygen, Nitrogen, and water vapor, tend to release their excess energy. If the water vapor molecules release enough energy, they go through a phase change and condense, forming water droplets. If they only release enough to cool and vibrate less, the air molecules become more dense (close together) and sink in the atmosphere.

Density and temperature of air molecules creates **air pressure**. **Wind** happens because air from areas of high pressure move to areas of low pressure. If a high pressure area is very close to a low pressure area, the air can move very quickly, causing very fast winds. Sometimes the rapid cycling or movement of air can cause more drastic weather patterns like hurricanes and tornadoes.

Overview of the Lesson

In this lesson, the activator asks students to consider why certain objects float and others sink. A powerpoint presentation introduces the concept of density and its equation. The first physical experiment asks students to calculate the densities of various liquids and see how their densities predict their order when the liquids are combined in the same container. Students create their own demonstration of the molecular movement of water in the three states to understand the relationship between phase changes and energy.

Teaching Tip

Teacher or Science Fellow should prepare liquids in plastic cups and dye clear liquids (to increase visibility) before the lesson begins.

Focus and Spiral Standard(s)

5-PS1-1. Use a particle model of matter to explain common phenomena involving gases, and phase changes between gas and liquid and between liquid and solid. [**Clarification Statement**: Examples of common phenomena the model should be able to describe include adding air to expand a balloon, compressing air in a syringe, and evaporating water from a salt water solution.] [**State Assessment Boundary**: Atomic-scale mechanisms of evaporation and condensation or defining unseen particles are not expected in state assessment.]

This unit was developed with National Science Foundation funding (Grant #1432591). It is a DRAFT document that will be revised as the unit is piloted and feedback received.

NGSS Alignment

Disciplinary Core Ideas (DCI)	Crosscutting Concepts (CCC)	Science Practices (SP)
	Scale, Proportion, and Quantity Standard units are used to measure and describe physical quantities such as weight and volume. (5-ESS2-2)	SP8: Obtaining, Evaluating, and Communicating Information SP2: Developing and Using Models

Learning Targets

1) I can explain that **all matter has density,** whether it's a solid, liquid, or gas.
2) I can explain that **materials with different densities will become sorted when they interact**, with dense matter sinking and less dense matter floating.
3) I can explain that **energy** plays an important role in the **movement of molecules** and their **phase changes.**

Assessment(s)

Students will be assessed by their participation in the physical demonstrations, their thoughts and answers in the science journals, and their worksheet.

WIDA Language Objectives

[Dependent on the needs of your students]

Targeted Academic Language

Tier 1: State, Matter
Tier 2: Density, Phase Change
Tier 3:

RESOURCES AND MATERIALS

Quantity	Item	Source
1 per class	Rock (exact size doesn't matter, should sink in water)	Classroom Teacher
1 per class	Piece of wood/stick (should be bigger than rock)	Classroom Teacher
1 per class	Container + water in it (size doesn't matter; should fit rock and stick)	Classroom Teacher
5-6 per class	**100mL graduated cylinders**	**Bin**
5-6 per class	**Electronic scales**	**Bin**
5-6 per class	**Funnels**	**Bin**
1 per class	Density Powerpoint	CMC Website
1 per class	Density Video [or https://www.youtube.com/watch?v=vSXTBnnx4OA)]	CMC Website
1 per student	Density Calculation Worksheet	Binder
1 per class	Red, Yellow, and Blue Food Coloring	Bin
6 per class	Plastic cups	Bin
1 per class	**Ping pong ball**	**Bin**
1-2 per class	**Pony (plastic) beads**	**Bin**
1 per class	**Metal nut/bolt**	**Bin**
1 per class	Game dice	Classroom Teacher
Enough for class	Coloring pencils	Classroom Teacher
1 per class	**~250mL of Honey**	**Bin**
1 per class	**~250mL of Light Corn Syrup**	**Bin**
1 per class	~250mL of Dish Soap	Bin
1 per class	~250mL of Whole Milk	Classroom Teacher
1 for class	**~250mL of Vegetable Oil**	**Bin**
1 for class	~750mL of Water	Classroom Teacher

This unit was developed with National Science Foundation funding (Grant #1432591). It is a DRAFT document that will be revised as the unit is piloted and feedback received.

1 for class	Water Video [or https://www.youtube.com/watch?v=tuE1LePDZ4Y]	CMC Website

****Items in bold should be returned for use next year****

LESSON DETAILS

Lesson Opening/ Activator

In front of the class, set up a clear container with water (size is not very important). Show the class the piece of wood and the rock. Before placing objects in water, have the students Think-Pair-Share on the following questions: What do you think is going to happen? For example, will one sink and one float, will they both sink, will they both float? After some discussion, put the piece of wood and rock in the water at the same time (the wood will float and the rock will sink). Students should attempt to construct an explanation for the results they observe. Think-Pair-Share with a partner and write down any notes in science journals.

Student Thinking Alert
Common misconception: the density of a substance depends on its size. The density of a substance is the same regardless of the object's size because we divide mass by volume (the amount of space something takes up).

Density Powerpoint

The following notes are also included in the note section of each slide in the powerpoint

Slide 1: There are two equally sized cubes side by side.

1. **Ask** the class whether the cubes (represented as squares) have the same amount of space in them (they do). This means that the squares have the 'same volume', **click** next for this label to appear. **Click** next again.

2. Square A has 10-15 circles in it, Square B only has 6. **Ask** the class which square has more matter or stuff in it. **Click** next to reveal the circle around Square A. This means that Square A has more mass, **click** next to reveal the labels 'more mass' and 'less mass' under the corresponding squares.

3. **Tell** the class that since the cubes occupy the same amount of space, or have the same volume, and one clearly has more stuff than the other, we can say which one has more stuff per volume. **Ask** the class which that is, then tell them that that is how we measure density. Square A is 'more dense' than Square B. **Click** next to reveal these labels. **Click** for the next slide.

4. **Ask** the class if they've ever heard of **population density**. If a student has, ask them to try to explain it. Then **explain** to students that this is how we can compare how many people there are in a certain amount of space. **Ask** the students to guess which square represents New York City, and which represents North Adams. **Click** next to reveal.

5. If you picked a certain amount of space, like 1 mile squared, and compared the number of people living in New York City in that amount of space to the number of people living in North Adams in the same 1 square mile, NYC would have many more people!

Slide 2: This slide will have the equation for density on it. Tell the class that in the next activity they will be calculating the densities of some liquids by measuring their mass, which is the amount of matter or stuff in it, and dividing by the amount of space they take up, their volume. This will allow us to compare the densities of the different liquids.

Density Video
This video is on the CMC website, [or https://www.youtube.com/watch?v=vSXTBnnx4OA]. The video on the website is preferred because it has been cut so that only the relevant information is viewed, starting from 0:18 and ending at 3:25. Tell the students that in the next activity, we will be figuring out the densities of a bunch of mystery liquids!

This unit was developed with National Science Foundation funding (Grant #1432591). It is a DRAFT document that will be revised as the unit is piloted and feedback received.

During the Lesson

> **Teaching Tip**
> Make sure students read the value of the graduated cylinder at eye-level, not from above. They must ensure that the bottom of the curve (meniscus) is the value they record.

Density Calculation Activity **[SP8: Obtaining, Evaluating, and Communicating Information]:**

This activity demonstrates the physical consequences of density for liquids, solids, and a gas (air). Divide the class into groups of 4-5, with a maximum of 5 groups. Each group has a scale, a 100 mL graduated cylinder, a funnel, and a liquid substance. Each student has their own worksheet.

The following activity was adapted from this website, and the actual densities of the liquids used is included here:

https://www.stevespanglerscience.com/lab/experiments/density-tower-magic-with-science/

Calculating Density

1. Each group measures the density of two liquids. Everyone measures the density of water, and each group has a specific liquid they will calculate for the class.

> **Teaching Tip**
> Students should pour out the water after their group has finished measuring it and try their best to remove all of the water from the cylinder.

2. Measuring water: first have each group simultaneously measure the mass of the empty 100mL graduated cylinders. Since we only want to measure the mass of the liquid, we need to 'zero' or tare the scales, so that the scales ignore the weight of the graduated cylinders. Next, remove the graduated cylinders from the scale, have the students divide work for the following tasks: holding the graduated cylinder steady, holding the funnel steady, pouring the liquid into the cylinder, measuring or saying stop when the liquid has reached 100mL, and place the cylinder back onto the scale.

3. **[SP4: Analyzing and Interpreting Data]** Instruct students to individually fill out their worksheets, which will help them calculate the density of water. If students struggle with dividing by 100, you can work through it on the board. Have students compare their answers for the density of water with the rest of their group. The correct

answer is 1 g/mL or 1 g/cm^3; answers close to 1 (0.97-1.03) can be rounded to 1; answers outside of that range should be rechecked. If there are outliers this is a good time to talk about possible sources of error in their measurements, and how we might deal with discrepant data (not just throwing it out).

4. Groups should then calculate the density of their own liquid. To add an element of mystery, the liquids can be put into plastic cups (clear liquids should be dyed with food coloring) without labels. The procedure should be the same as the water measurement; the scale should be re-zeroed with the cylinder, and they should pour in 100mL of their liquid. The worksheet will help calculate the density of their liquid.

5. Have each group talk amongst themselves to guess their mystery liquid (no tasting!). Once all of the groups have made their predictions, reveal the true identity of each liquid to the whole class.

Combining Liquids

After all of the groups measure the densities of their liquids, have them visit with other groups to fill in their worksheet of the densities of all the liquids.

1. Next they will write predictions, based on the information on the worksheet, about what will happen when we put all of these liquids in the same cylinder. The following questions should be asked to initiate students' thinking: Will they mix? Which liquids will be at the bottom, which will be at the top? Remind them to think about the wood and the rock from the lesson activator.

2. Without telling the students, place the groups in the following order: **honey**, **corn syrup**, **dish soap**, **whole milk**, **water** (teacher pours), and **vegetable oil**. Each group will pour roughly ¼ cup of their liquid into the large cylinder at the front of the class. Alternatively, have students use their density calculations to order their groups by most to least dense.

3. The liquids need to be poured in the correct order in order to achieve the nice result pictured to the right without having to wait a long time for the liquids to sort themselves.

4. Instruct the students to pour the liquid into the cylinder **slowly, without letting the liquid touch the sides**. Pause between each layer to let the liquids settle.

Dropping Objects

1. Take the four objects in the bin (ping pong ball, metal nut/bolt, plastic beads, game dice) and tell the students that you will be dropping them each individually. Ask the students to write the predictions on their worksheet about which layers the objects will settle into.

2. Release the objects one a time so they slide gently as possible through the liquids and fall along the side of the container. Release them at different spots around the container to avoid causing too much turbulence in the same location. This also puts the objects toward the outside of the cylinder so that the students can see precisely which layer they settle on. Let the upper layers settle completely between each release. Release them in this order: **metal bolt**, **game dice**, **plastic beads**, **ping pong ball**.

3. Have them complete the fill in the blank statements on the worksheets once they see the results.

Activity Debrief

1. **Ask** the students to go to a fresh page of their science journals and write the heading "Density."
   In debriefing this activity, we want the students to understand two major ideas. The first is that <u>all matter has density</u>**,** whether it's a solid, liquid, or gas. The second is that when materials with different densities interact in the presence of gravity, something interesting happens - matter becomes sorted according to its relative density - dense matter sinks and less dense matter floats!

This unit was developed with National Science Foundation funding (Grant #1432591). It is a DRAFT document that will be revised as the unit is piloted and feedback received.

2. **Ask** the students to write down the equation for density on a page of their science notebook (they can copy it from the worksheet that they were using for the activity).

3. Then **ask** students to think-pair-share with a partner about the following question: Does all matter have density? Remind the students that mass = amount of matter. Have them write their answer down with a justification.

4. **Explain** that all matter does have density because density is mass within an amount of space and mass is matter. All matter occupies some amount of space, so all matter has density!

5. Next **ask** students to think-pair-share about this question: What force might have caused the denser liquids and solids to sink and the less dense liquids and solids to float?

6. Highlight (or explain, if students don't come up with) the important force behind this is gravity!

Why should they care about it? We will see in the next activity that density and gravity play important roles as water changes between different phases of matter. **Ask** the students to think about what they saw in the density experiment and how it might relate to air. Where was air in the cylinder? **Answer**: It was at the top! It was the least dense compared to the liquids and solids.

Phase Change Activity [SP2: Developing and Using Models]:
This activity will be a physical demonstration of water molecules in different states of matter (solid, liquid, and gas).

First show the students the video Changing water- States of matter from the CMC website [or https://www.youtube.com/watch?v=tuE1LePDZ4Y]. Stop the video at 3:03, the rest of the video goes over what they learn in other lessons. Students should be split up equally into three groups, one for each state. Because they will be learning about the names of the processes behind phase changes in later lessons, in this activity we will be focusing on what is happening at the molecular level.

Representing the Movement of Water in Different Phases

1. Tell students that they will be acting as individual water molecules in different states of matter. With their bodies, they should demonstrate the level of energy and organization of the water molecules in that state.

2. Have students talk to other members of their group to see if they can figure out for themselves how to represent their state.

3. One important **correction** that will likely have to be made is that the molecules in the solid should be regularly patterned and strongly bonded, whereas the molecules in the liquid and gas should be irregularly patterned.

4. The students in the gas group should deduce that they will need to spread out since their movement will be the most energetic - that is why gas molecules are far apart from each other! This is why gasses are almost always less dense than liquids and solids.

5. **Challenge**: have the group distinguish between warmer and cooler pockets of the states. The connection that they should make is that warmer means more energy, which means more movement and spreading out!

6. After the demonstrations are over, have the students return to their desks and think-pair-share to answer the following two questions in their science journals:
    a. In which state of matter do the molecules have the most energy?
    b. What might have to change for a water molecule to go through a phase change and become another state of matter?

Lesson Closing
Draw Ralph in the three states of matter with his other water molecule friends in the comic strip booklet! One square for each state: liquid, solid, and gas.

Assessment
Students will be assessed by their participation in the physical demonstrations, their thoughts and answers in the science journals, and their worksheet.

Lesson 3: Evaporation Dries the Nation

LESSON BACKGROUND

This lesson introduces students to the process of evaporation—the forces that drive the process, the phase change of a water molecule, and its impacts/examples in daily life. It is important for students to understand the underlying mechanisms of the processes that water undergoes so that they can better explain *why* water is so crucial to Earth's systems and our lives. Furthermore, understanding water changes at the molecular and particle level builds on and applies previous knowledge about particulate matter.

SCIENCE CONTENT BACKGROUND (for instructors):

Evaporation requires energy input (usually from the Sun) to change water from a liquid state to a gas state. The energy from the Sun increases the energy in the water molecules at the surface of the liquid, which causes those molecules to move more. Increased energy turns the molecule to a gas (vapor), and increased movement spreads the particles out, causing a decrease in density so the molecules rise in the air (in the form of vapor).

Overview of the Lesson

Students explore the process of evaporation by conducting experiments to observe and interpret how increasing temperature (introducing energy) causes a reduction of liquid (and a subsequent increase in gas). Kinesthetic models and activities allow students to understand what is occurring at the molecular level as a water molecule goes through this phase change (liquid → gas), as well as learn about examples of evaporation that occur in their daily lives.

Focus and Spiral Standard(s)

5-ESS2-1. Use a model to describe the cycling of water through a watershed through evaporation, precipitation, absorption, surface runoff, and condensation.

5-PS1-1. Use a particle model of matter to explain common phenomena involving gases, and phase changes between gas and liquid and between liquid and solid. [**Clarification statement**: Examples of common phenomena the model should be able to describe include adding air to expand a balloon, compressing air in a syringe, and evaporating water from a salt water solution.]

7.MS-ESS2-4. Develop a model to explain how the energy of the sun and Earth's gravity drive the cycling of water, including changes of state, as it moves through multiple pathways in the Earth's hydrosphere.[**Clarification statement**: Examples of models can be conceptual or physical.]

NGSS Alignment

Disciplinary Core Ideas (DCI)	Crosscutting Concepts (CCC)	Science Practices (SP)
ESS2.C: The Roles of Water in Earth's Surface Processes Nearly all of Earth's available water is in the ocean. Most fresh water is in glaciers or underground; only a tiny fraction is in streams, lakes, wetlands, and the atmosphere. (5-ESS2-2)	**Systems and System Models** A system can be described in terms of its components and their interactions. (5-ESS2-1),(5-ESS3-1)	SP4: Analyzing and Interpreting Data

Learning Targets

1. I can explain how **water changes phases from liquid to gas**, and why this process of evaporation is important.
2. I can find examples of **how water evaporates** in my everyday life.

Assessment

Participation in class and group discussions and activities. Check science journals and worksheets for understanding of application "what if?" questions.

WIDA Language Objectives

[Dependent on the needs of your students]

Targeted Academic Language

Tier 1: Liquid, Gas, Energy, Solid
Tier 2: Evaporation, Molecule
Tier 3: Phase-change

RESOURCES AND MATERIALS

Quantity	Item	Source
2 per group	**500 ml Beaker**	**Bin**
1 per group	**Hot Plate**	**Bin**
1 per group	**Graduated Cylinder**	**Bin**
1 per student	Science Journals	Classroom Teacher
1 container	Vanilla ice cream	T2L Liaison
2 bottles	Rootbeer	T2L Liaison
1 per student	**Plastic cups**	**Bin**

****Items in bold should be returned for use next year****

LESSON DETAILS

Lesson Opening/ Activator

Rootbeer Floats

This activity is a hands on (and edible) demonstration of phase changes. Students will observe the reaction between a solid and liquid to form gas.

1. Give each student a plastic cup. Place a scoop of vanilla ice cream into a plastic cup. Pour root beer into cup, and watch foam form.

2. Ask students for observations and inferences - What do you notice? What do you think is happening? Prompt with questions leading towards the topic of phase change - "How do you think something (foam) formed that wasn't there before? What is it called when two different things interact to make something new?" This activity is meant to spark questions and intrigue, but not deliver the important/big answers - yet! If there's time, have students sketch their observations in their science journals as they enjoy their root beer floats.

During the Lesson

Evaporation in a Cup [SP4: Analyzing and Interpreting Data]: This activity engages students to observe evaporation in action.

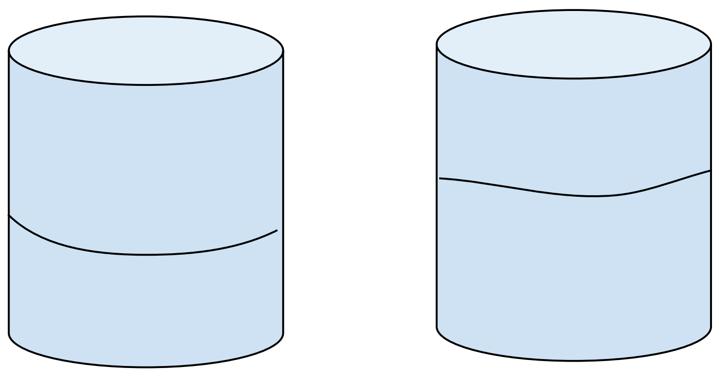
1. Split class into groups of 3-4 students. Distribute two beakers to each group. Before actually conducting the experiment, explain the setup: each beaker will contain the same volume of water, and we're going to heat one

beaker up (on the hot plate) and let the other one sit at room temperature. Ask students to discuss in their groups and have each write down one prediction in their science journal. What do you think you will observe in the two beakers as one is heated up (on the hot plate) and the other is not?

2. Teacher and science fellow or students should measure out 100 mL of water with graduated cylinder for each groups' beakers (depending on class needs). Place one beaker on the hot plate and heat for 10 minutes; the other beaker should remain on the table nearby (to make comparison observations).
3. As one beaker heats up, have students draw and write comparison observations of the two beakers in their science journals.

4. Once the beaker is sufficiently heated, remove from hot plate and measure contents of each beaker (there should be less liquid in the hot beaker than control).

5. Facilitate discussion about what was just observed. Ask, since there was a reduction of liquid in the hot beaker, what happened? Where did the water go? If the students correctly infer (based on experimental procedure) that the heat caused the reduction of liquid, inquire further and ask students why? Why would the presence of heat reduce the amount of water in the beaker? If the point is not made by students, emphasize that the water did not just disappear, but that it is no longer in liquid form. What form do you think it changed into?



What's happening to the H_2O molecules?

This activity allows students to understand the process of a phase change from liquid → gas using a kinesthetic model, and the role that energy plays. **[SP2: Developing and Using Models]**

1. Recall the demonstration from last lesson where students learned about the different phase states of water molecules. Tell them that they will now demonstrate how molecules change from a liquid to a gas using their bodies.

2. Pose a question to the class about what phase state they just observed in the beakers? Have students discuss in their groups, and come up with a physical demonstration (using their bodies as water molecules) of what happened when the water was heated up. Prompt them with questions like: "What do the water molecules look like when there is extra heat/energy? How do you think the molecules' movement might change?

Teaching Tip
Some components to look for in their models: energy from the sun increases the energy at the surface of the liquid, causing the water molecules to move around more (shake/vibrate); particles spread out, become less dense, and move up into the atmosphere in the form of gas.

3. Have one or two groups present to the class, and *explain why* they chose the model and phase change they did. The Science Fellow can move around to the different groups to act as the Sun, giving off energy, and prompting the water molecules to respond accordingly.

4. (Science Talk: whole class discussions). After the informal presentations, conduct a class discussion. Start off by officially (and explicitly) introducing the term *evaporation* to label the process the class has just been describing/demonstrating. Ask students what they think causes evaporation (they can refer back to previous experiments i.e. temperature change/increase). Afterwards, reinforce that the Sun is a driving force in supplying

energy (in the form of heat), which increases temperature and causes the phase change. This allows water in its gas state to move into the atmosphere.

5. Have students answer questions on worksheet to solidify and help retain this knowledge.

Evaporation in Real Life

1. Emphasize that this process of water changing from a liquid to gas state happens all the time and all around us.

2. Ask if anyone can think of a situation in their daily lives when this phase change might happen? Have students discuss in pairs for 3-5 minutes, then ask some pairs to share, and write some examples on the board. Examples to emphasize/elaborate on:
Hot tea cooling off over time: Molecules on the surface of the liquid evaporate, and carry energy (in the form of heat) away.

3. Why do we sweat? Perspiration on the surface of the skin/body evaporates, taking heat away from body to help you cool off.

4. Wet clothes dry in the sun.

Lesson Closing

(Science Talk: support and make visible student thinking by having them answer "what if" questions in peer groups). Have students discuss with the person sitting next to them, "What would happen if there was no evaporation?" Teacher and science fellows can walk around and gauge discussions - if needed, prompt with more specific questions like, "What if water never changed from liquid → gas state? What would happen if there was no water in the atmosphere?" Have each student write 1-2 sentences summarizing the ideas from their group discussions in their science journal. These are hard questions, and it's okay if students don't all have the same or "right answer," but check answers to make sure students are engaging deeply with questions, and are at least understanding (or starting to understand) that evaporation is a crucial process for moving water (which then goes on to become rain, etc.), and has practical impacts in our individual body systems.

This exercise is meant to give students the opportunity to critically apply what they just learned about water by considering how changes in the process would impact us.

Ralph the Raindrop's journey - Explain that we first met Ralph as a water molecule living in the Fish Pond. It's the first day of summer, and with temperatures rising, Ralph evaporates into the atmosphere. Where will his travels take him next? Have each student draw this stage of Ralph's journey in their comic strip.

"Ralph the Raindrop" Continued:
It was a sunny day in North Adams. Ralph the Raindrop was peacefully floating around in Fish Pond when he felt the warm sun rays shine on him.

"It feels so nice to be warmed up!" said Ralph.

Suddenly, Ralph and others started vibrating rapidly. Ralph was no longer a raindrop, but he was water vapor!

"Whoa! What happened to us?" asked Ralph, confused.

"We are no longer liquid! We are gas! This means that we get to go on an adventure!" answered others.

And before he could blink an eye, Ralph was floating up in the air!

"Wow! We are flying!" exclaimed Ralph. "I feel so light!"

What will happen next?

Assessment

Participation in class and group discussions and activities. Check science journals and worksheets for understanding of application "what if?" questions.

This unit was developed with National Science Foundation funding (Grant #1432591). It is a DRAFT document that will be revised as the unit is piloted and feedback received.

Lesson 4: Drip, Drip, Drop - Condensation

LESSON BACKGROUND

In the previous lessons (Lessons 2 and 3), students learned about the physics and chemistry behind water phases and the mechanism of evaporation. Following the next part of Ralph the Raindrop's story, students explore the mechanism of condensation as water changes from gas to liquid state. Students connect this process as the foundation for other processes in the water cycle.

SCIENCE CONTENT BACKGROUND (for instructors):

Condensation is the phase change from gas to liquid and is critical to the water cycle for its role in cloud formation. Energy from sunlight increases the kinetic energy of water molecules when they evaporate into water vapor. Water vapor molecules release energy upon encountering cooler air, thus increasing the kinetic energy of the air molecules. As the movement of the water molecules slows down (lower kinetic energy), they change from gas to liquid state. This is how water vapor turns into microscopic liquid droplets in the cool air. In order to condense, the tiny droplets stick to particulate matter in the air (or a surface on the ground) and, after many droplets have condensed and combined, they become visible water drops.

Overview of the Lesson

In this lesson, students explore the process of condensation. Students engage with questions of everyday life phenomena caused by condensation, such as morning dew and water droplets, or "sweat" on a water bottle. After continuing the Ralph the Raindrop story, students represent clouds with the Cloud-in-a-Jar activity and are encouraged to connect the story to their real life observations to discover the mechanisms of condensation. Then, students learn about different types of clouds and defining characteristics.

Focus and Spiral Standard(s)

5-ESS2-1. Use a model to describe the cycling of water through a watershed through evaporation, precipitation, absorption, surface runoff, and condensation.

5-PS1-1. Use a particle model of matter to explain common phenomena involving gases, and phase changes between gas and liquid and between liquid and solid. [**Clarification statement**: Examples of common phenomena the model should be able to describe include adding air to expand a balloon, compressing air in a syringe, and evaporating water from a salt water solution.]

7.MS-ESS2-4. Develop a model to explain how the energy of the sun and Earth's gravity drive the cycling of water, including changes of state, as it moves through multiple pathways in the Earth's hydrosphere. [**Clarification statement**: Examples of models can be conceptual or physical.]

NGSS Alignment

Disciplinary Core Ideas (DCI)	Crosscutting Concepts (CCC)	Science Practices (SP)
ESS2.C: The Roles of Water in Earth's Surface Processes Nearly all of Earth's available water is in the ocean. Most fresh water is in glaciers or underground; only a tiny fraction is in streams, lakes, wetlands, and the atmosphere. (5-ESS2-2)	**Systems and System Models** A system can be described in terms of its components and their interactions. (5-ESS2-1),(5-ESS3-1)	SP8: Obtaining, Evaluating, and Communicating Information SP2: Developing and Using Models

Learning Targets

1. I can explain **how clouds form**.
2. I can explain **how gas transforms into liquid** through the process of condensation.

Assessment(s)

Students' knowledge will be assessed by their entries in their Science Journal and their comic strips.

WIDA Language Objectives

(Dependent on the needs of your students]

Targeted Academic Language

Tier 1: Droplets, Water Vapor, Clouds
Tier 2: Condensation
Tier 3: Particulates, Aerosol, Cumulus, Cirrus, Stratus

RESOURCES AND MATERIALS

Quantity	Item	Source
1 per group	**Glass jar with lid (exp: mason jar)**	**Bin**
1 per group	**Pyrex measuring cup or beaker**	**Bin**
1 per group	Heated/boiled water	Classroom Teacher
2-3 per group	Ice cubes	Classroom Teacher
2	Ice Cube Tray	Classroom Teacher
2 containers	Hairspray	Bin
1 per student	Blank comic strip	Classroom Teacher
As students need	Colored pencils	Classroom Teacher
As students need	Markers	Classroom Teacher
	"Water Cycle Song for Kids" https://www.youtube.com/watch?v=uT-tVEQuKKc	CMC Website
	"What are Clouds Made of?" https://www.youtube.com/watch?v=DigBbR3FeP8	CMC Website

****Items in bold should be returned for use next year****

LESSON DETAILS

Lesson Opening/ Activator

Have students close their eyes and picture the following story in their heads.

You wake up to the sound of your alarm clock ringing. It's time to go to school. You decide to wear your new sandals today because you want to impress your friends. You walk out of your home and walk through the grass to save some time. But oh no! The grass is soaking wet, and now your feet are also wet. Did it rain last night? You look around, but the ground seems completely dry.

What could have happened? (Take a brief pause to ask the question. Tell them to think about the answer as they move on and listen to the next scenario.)

You are now at school. You are really thirsty and decide to drink water from your water bottle. The water bottle was cooled in the fridge last night so that you can enjoy a nice, cool drink at school. As you take out your water bottle, your hand gets covered with cold water! Surprised, you check to see if your water bottle has spilled all over your backpack. But the water bottle is tightly shut, so no water could have spilled. The surface of the water bottle is covered with cold water droplets, though.

What could have happened?

Have students come up with some explanations to both scenarios. In both cases, how did water get on the grass or the side of the water bottle? Tell them they will explore and find answers to these mysterious phenomena.

During the Lesson

Ralph the Raindrop Story Continued [SP8: Obtaining, Evaluating, and Communicating Information]

1. Return back to the Ralph the Raindrop story.

2. Have students quickly summarize what happened so far with Ralph the Raindrop. He evaporated into the air, so where will Ralph go now?

3. Continue the story of Ralph the Raindrop:

Ralph the Raindrop was floating around in the air as a molecule of water vapor. He felt so light and joyful! He could see the whole city of North Adams in one view! As he was admiring the view, he met other water vapor friends! While he was getting to know others, Ralph noticed that the air was getting cooler and cooler.

"Hey! What's that over there?" yelled a water vapor.

Ralph looked over to find a small particle of dust floating nearby. Curious water vapors gathered around the dust particle.

"Brrr! It's getting pretty cold! Let's cuddle up while we are all here marveling at this mysterious particle," said another.

All of the water vapor molecules gathered tightly together in the cold air, and suddenly, they all became water droplets!

"Whoa guys! We are not gas molecules anymore! Look at us! We are tiny water droplets now!" yelled Ralph excitedly.

Seeing this, other water vapor molecules joined them to also turn into water droplets. "Quick! Find more particles! That's the only way we can become water droplets!" said the water vapors waiting to become water droplets.

And together, all the water droplets became what was called….

A cloud!

Part 2

(Science Talk: after posing questions, let students provide answers without judgment from the teachers, to give them a chance to provide evidence for their ideas. As such, follow up questions/statements like "Tell me more" and "Why do you think that?" provide opportunities for students to support their ideas with concrete evidence.)

Take a brief break away from the story to ask the following questions: What is a cloud? What do clouds look like? What would they feel and taste like? Do you think we can jump around in clouds because they look so soft and fluffy? Have them come up with a few initial ideas.

Then, steer the students back to the story and ask the following questions:

Q: Which phases of water are water vapor and water droplets?

A: Water vapor is gas, and water droplets are liquid.

Q: What happened to the air surrounding Ralph and others?

A: The air became colder.

Q: What was necessary to pull all the molecules of water vapor together?

A: Dust particles

Ask them to come up with a sentence or two explaining how clouds form using the information from the story and have them write it down in their Science Journal (sample: *A lot of water vapor gathers around a dust particle in the cold air to become tiny water droplets, which creates a cloud*).

Cloud-in-a-Jar Activity

This activity allows students to explore and observe closely the process of cloud formation. [SP2: Developing and Using Models]

1. Divide the class into groups of 3-4.

2. Hand out a glass jar with lid, 2-3 blocks of ice cubes, and a beaker/pyrex measuring cup of heated/boiled water to each group (Boiled water will be more effective, but heated water is fine depending on safety concerns for students).

3. Provide cans of hairspray at the front of the classroom, and let students take turns using the hairspray.

4. Pour the heated water inside the glass jar, filling up to about ⅓ of the jar.

5. Spray the hairspray into the jar.

6. Close the lid of the jar.

7. Place the ice cubes on the top of the lid.

8. Observe what happens inside the jar. Do you see clouds forming? Draw AND write your observations in your Science Journal.

9. After cleaning up, guide the students back to their original seats. Now they will connect their Cloud-in-a-Jar activity with Ralph the Raindrop story. What similarities are there between the two? What do the different components of the model represent? (*ice cubes = cold air, heated water = water vapor, hairspray = air particles*).

10. To explain the following, go back to the PowerPoint slides with Ralph the Raindrop cartoon and follow the slides to show the scenes that correspond with the explanation. Why did we need heated water? As we learned from the previous lesson on evaporation, heat energy turns liquid water into gas. Because warm air rises, the water vapor rises up to the sky (That's how Ralph ended up in the sky!). There are many water vapor molecules in the air that came from evaporation.

    What role did the dust particles play in the formation of a cloud? In order for the water vapor to turn into liquid droplets, they need to stick to suspended air particulates (sometimes called aerosols). Therefore, if the air was totally clean, there would be no clouds! These “dust” particles can be made of dust, salt, and other tiny particles. The cold temperature makes water vapor stick together around the particles, release their energy into the air, and become water droplets. That’s why Ralph and other water vapor molecules had to cuddle up together around the particles to become water droplets! This process is called <u>condensation</u>!

MCLA NAPS Williams
Teach To Learn
A collaboration between MCLA, Williams College, and North Adams Public Schools
Funded by NSF DUE-IUSE Award #1432591

Kinesthetic Activity: Condensation Game--Let’s Become Clouds! [SP2: Developing and Using Models]

The goal of this game is for the water vapor molecules to become water droplets by tagging the particles.

1. Pick roughly 4 students to be dust particles (let them hold up a card that says “Particles”) and the rest of the class will be molecules of water vapor.

2. This is similar to the game of musical chairs. Water vapor molecules must find a particle to hold onto in order to become water droplets and eventually become a cloud. Each particle can initially have 6 water vapor molecules.

3. Play Water Cycle Song for Kids/How Clouds are Formed video on the CMC Website (or from YouTube (https://www.youtube.com/watch?v=uT-tVEQuKKc)) and have the water vapor students walk around (**no running!**).

4. Abruptly stop the video at unexpected moments so the water vapor students can find a particle to hold onto. If a particle has a full set of water vapor, then no one can join that group and must find another particle.

5. Take out any leftover water vapors and have them become the DJ (let them take turns stopping the song). After each round, each particle can have one less water vapor, making the game more challenging.

6. At the end of the game, have everyone join hands to show that eventually water vapor molecules will find particle and all join together to become a cloud.

MCLA NAPS Williams
Teach To Learn
A collaboration between MCLA, Williams College, and North Adams Public Schools
Funded by NSF DUE-IUSE Award #1432591

Types of Clouds

Not all clouds look the same. Project the video *What are Clouds Made of*? from the CMC website [or (https://www.youtube.com/watch?v=DigBbR3FeP8], and have students write and draw the different types of clouds in their science journals.

Three main types of clouds:

1. **Cirrus**: located in the high level in the sky; thin and wispy
2. **Cumulus**: located in the mid to low level in the sky; big and puffy
   - White in color on good days
   - Grey during thunderstorms (also called cumulonimbus)
3. **Stratus**: located in the low level in the sky; flat and cover much of the sky; usually means rainy, drizzly days

Next, take the students outside or by the window to get a clear view of the sky. What kinds of clouds can we see? What evidence can we offer to support our answer?

Extension

Introduce more types of clouds: look at specific types of clouds within each category of cloud.

Lesson Closing

Have students continue their "Ralph the Raindrop" comic book. They will have to incorporate the following vocabulary words: water vapor, water droplets, particle, condensation, temperature, and cloud.

Assessment

Students' knowledge will be assessed by their entries in their Science Journal and their comic strips.

This unit was developed with National Science Foundation funding (Grant #1432591). It is a DRAFT document that will be revised as the unit is piloted and feedback received.

Lesson 5: What Goes Up Must Come Down – Precipitation

LESSON BACKGROUND

Precipitation is the next phase of the water cycle that students will explore. Precipitation is unique from the previously discussed physical processes in that there is no phase change that occurs - water droplets make up clouds and water droplets fall to the Earth as precipitation. However, there *may be* a phase change that happens when precipitation falls in the form of hail or snow, both solids. Students gain insight into mechanisms driving these processes. Students also consider how the hydrosphere (the sum of all water on Earth) shapes and interacts with the geosphere (the sum of all land on Earth).

SCIENCE CONTENT BACKGROUND (for instructors):

Precipitation is driven by the Sun's energy and gravity. If clouds contain enough water, gravity brings the water droplets down as **precipitation**. The form of precipitation (e.g. rain, hail, snow) depends on the surrounding temperature and air pressures. Falling precipitation brings freshwater, as well as some pollutants from the atmosphere, down to earth. Pollutants may be smoke or certain chemicals. Rain is also responsible for shaping the land through water erosion, like in the form of landslides, a devastating natural disaster.

Overview of the Lesson

Students learn about the two driving forces behind precipitation through creating a rainstorm. Students are reminded that rainwater in the atmosphere is freshwater. They also explore how precipitation can impact the land.

Focus and Spiral Standard(s)

5-ESS2-1. Use a model to describe the cycling of water through a watershed through evaporation, precipitation, absorption, surface runoff, and condensation.

5-ESS2-2. Describe and graph the relative amounts of salt water in the ocean; freshwater in lakes, rivers, and groundwater; and freshwater frozen in glaciers and polar ice caps to provide evidence about the availability of fresh water in Earth's biosphere.

7.MS-ESS2-4. Develop a model to explain how the energy of the sun and Earth's gravity drive the cycling of water, including changes of state, as it moves through multiple pathways in the Earth's hydrosphere. [**Clarification statement**: Examples of models can be conceptual or physical.]

NGSS Alignment

Disciplinary Core Ideas (DCI)	Crosscutting Concepts (CCC)	Science Practices (SP)
ESS2.C: The Roles of Water in Earth's Surface Processes Nearly all of Earth's available water is in the ocean. Most fresh water is in glaciers or underground; only a tiny fraction is in streams, lakes, wetlands, and the atmosphere. (5-ESS2-2)	**Systems and System Models** A system can be described in terms of its components and their interactions. (5-ESS2-1),(5-ESS3-1)	-SP7: Engaging in an Argument from Evidence -SP2: Developing and Using Models

Learning Targets

1. I can explain that when water condenses within a cloud, it becomes **heavy and falls down as precipitation.**
2. I can recall that **water in the atmosphere is a form a freshwater**.
3. I can explain how **precipitation affects and shapes the land**.

Assessment

Review students' science journals and cartoons.

WIDA Language Objectives

[Depending on the needs of your students]

Targeted Academic Language

Tier 1:

Tier 2: Condense, Precipitation

Tier 3:

RESOURCES AND MATERIALS

Quantity	Item	Source
1 per student	Science Journal	Classroom Teacher
15 per class	**Mason jars (12 oz or more)**	**Bin**
5 cans per class	Shaving cream	Bin
2 containers	Blue food coloring	Bin
6 per class	**Glass jar**	**Bin**
6 per class	**Ceramic dinner plate**	**Bin**
3 per class	**Ice cube trays**	**Bin**
1 per class	**Large beaker**	**Bin**
1 per class	**Hot plate**	**Bin**
	Landslide video: https://www.youtube.com/watch?v=W4KWxglDL3o	CMC Website
	Photographs of the face of Mt. Greylock	CMC Website

*** Items in bold should be returned for use next year ***

LESSON DETAILS

Lesson Opening / Activator

(Science Talk: Lead the students in an open-ended dialogue, allowing them to recall and build on the ideas from previous lessons). In our previous lesson, we discussed the process of **condensation**. We now know that **evaporation** of water molecules leads to **condensation** in the form of clouds.

Ralph started off in North Adams, he was evaporated into the air, and, when we last checked in with him, he was floating along in a cloud across the Atlantic Ocean. ***So what now*?** Ask the students if they have any predictions as to what is going to happen next to Ralph, and explain that they will be exploring the physical processes that Ralph will be facing next.

During the Lesson

Characteristics of Precipitation

1. Ask, "What kind of water is rain?" With the students' prior knowledge, they should be able to explain that water in the atmosphere is freshwater, although it might carry some other components that it picks up on its journey down to earth, making it not "pure" or "clean".

2. Ask students to recall what happens during **condensation** (what phase change happens during condensation?). Is there a phase change that happens from **condensation** to **precipitation**? Water droplets exist in clouds and often fall to earth as water droplets -- rain! However, there are other forms of precipitation. What causes water droplets to become **solid**, such as hail? Cold air causes the water droplet to freeze on its descent to Earth's surface. Discuss the types of precipitation that can occur and in what condition they occur using the cheat sheet below. Students explore the driving forces that cause water droplets "fall" in the next activity.

This unit was developed with National Science Foundation funding (Grant #1432591). It is a DRAFT document that will be revised as the unit is piloted and feedback received.

<u>Types of Precipitation</u>:

Rain → Warm weather.

Sleet → Starts out as snow, but the temperature is above freezing near the ground, causing the snowflakes to melt but not quite turning into rain; sleet exists between rain and snow.

Snow → Cold weather, below 32° Fahrenheit or 0° Celsius.

Hail → Caused by water freezing in the air, water droplets are carried high enough by updrafts that they freeze.

Hands-On Rainstorms **[SP2: Developing and Using Models]**

Gravity's Role Activity

1. Divide class into groups of 3-4. Distribute the materials to each group: a mason jar, shaving cream, blue food coloring.

2. Fill the mason jar with water, leaving an inch or two of space at the top.

3. Squirt the shaving cream on top of the water until it fills the remaining space on the top of the jar. Have students record observations in their science journals. What does the water represent? What does the shaving cream represent? How might we change the model to better represent the actual process of precipitation?

4. Pose the question: **how do clouds make it rain?** Answers should include that the clouds become heavy with water droplets, so the rain begins to fall. How much heavier (*i.e, how many drops of food coloring*) does the cloud need before it begins to rain? Allow students time to make predictions in their science journals.

5. Students can begin dropping food coloring (one drop at a time) into their "clouds." Have students draw and record their observations.

   How many drops did it take before it "rained"? Compare with other groups in the class, and find the class average (*use of calculator is permitted!*). What conclusions can you draw from this data? **Gravity** is a driving force in precipitation, as it pulls the heavier water droplets to the ground.

The Sun's Role Activity

- Divide class into groups of 4-5. Distribute the materials to each group: glass jar, plate, and ice cubes.
- One of the teachers should heat up a large beaker of water - *enough water that each group can fill their jar ⅓ of the way full, or about two inches deep*. Heat water until it is steaming.

- Have one student from each group retrieve the hot water in their glass jars. Another student should place the plate on top of the jar. **Wait a few moments before moving on to the next step**. Students should draw observations in their science journals.

- Another student can add the ice cubes to the plate. All students should watch closely to observe what happens inside the glass jar. Students should draw and record their observations in science journals.

- Ask questions to draw out student ideas. What is happening? Why is this happening? One potential description: The **sun's energy**, in the form of **heat**, is another driving force in precipitation. The cold plate causes the moisture in the warm air, which is inside the jar to **condense** and form water droplets. This is the same process that happens in the atmosphere. Warm, moist air rises and meets colder air high in the atmosphere. The water vapor **condenses** and forms **precipitation** that falls to the ground.

Rain and the Land

This activity transitions to the aftermath of precipitation. Large amounts of rain can cause erosion and even landslides, shaping the land in permanent ways. Landslides are a particular type of natural disaster that is related to massive amounts of rain.

1. Project the video from the CMC Website [https://www.youtube.com/watch?v=W4KWxglDL3o] featuring a landslide that occurred in 2005. Note how the dirt is flowing, almost like water; the video is fairly short and can be shown more than once if needed. The video should be **muted**.

This unit was developed with National Science Foundation funding (Grant #1432591). It is a DRAFT document that will be revised as the unit is piloted and feedback received.

2. Ask the students what is happening, or what caused this to happen? Landslides are defined as a rapidly moving mass of debris, rock, earth, and/or mud triggered by intense and/or **prolonged rainfall**, earthquakes, freezing, coastal/river weathering, and human influence. Thus, too much rain can prove to be a dangerous thing.

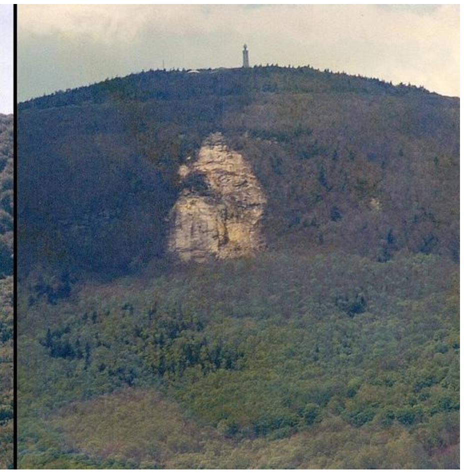
3. Rain saturating soil makes it heavier, thus making it more vulnerable to the force of gravity which causes landslides.

4. Gravity, rain, and weak soil are the "ingredients" of a landslide. Landslides can happen all over the world and cause thousands of fatalities and millions of dollars worth of property damage. This is a good reason why we study them!

5. Rainfall is remotely sensed to predict areas particularly susceptible to landslides.

6. What other important landslides does the class know about? A good example of a landslide that the class might be familiar with is the 1901 and 1990 landslides on Mt. Greylock that caused the face of a Native American Chief to appear!

7. Show the class images of the face of Mt. Greylock. Images have been provided on the Thumb Drive, or you might look up images on Google if you prefer.



Lesson Closing

Discuss where Ralph is now - the last time we saw him, he was floating in a cloud and made his way to the country of Spain. He has now fallen to the ground, through precipitation. Read the next passage of Ralph's narrative and have each student draw this stage of Ralph's journey in their comic strips.

“Ralph the Raindrop” Continued:
“Hey everyone! Look down!” exclaimed a water droplet in the cloud.

Ralph looked down. Wow! They were traveling across the world!

“Wow! This cloud is like a massive bus. We can go anywhere the wind takes us!” said Ralph, excitedly.

Ralph noticed that as the cloud travelled, more and more water droplets joined.

“Hop on! You don’t want to miss the adventure, do you?” said all the water droplets in the cloud to new water droplets.

After days of traveling across the ocean, the cloud was now over land.

“What is this place?” asked Ralph.

“Why, this is Spain! We are now in Europe!” answered a water droplet.

“Wow, I’ve never been to Spain before! And look! We are getting even bigger and bigger!” said Ralph. “And heavier and heavier, too.”

But now, there were so many water droplets in the cloud that some droplets started falling out!

Ralph, too, fell out of the cloud. “Time to go on to the next part of our journey! I’ll see you guys around!” said Ralph.

Assessment
Review students’ science journals and cartoons.

Lesson 6: Slip and Slide - Surface Run-off

LESSON BACKGROUND

The previous lessons demonstrated how water can travel to different locations through evaporation, condensation, and precipitation. This lesson shows how water travels on land by the process of surface run-off.

SCIENCE CONTENT BACKGROUND (for instructors):

Gravity drives surface runoff. Surface runoff can erode or change the shape of the land, and carry pollutants to different locations. The presence of plants reduces the amount of runoff. A watershed is a defined location that has the ability to direct the course of water to different bodies of water or places. Without proper precautions, surface runoff can create many problems such as flooding in highly populated areas (which is why we have drains in our streets), movement of land, such as landslides, and movement of farming land, which can destroy crops (which is why many farmers use surface covers to prevent erosion of their land).

Overview of the Lesson

In this lesson, students explore how a watershed works by creating a physical model. Students also explore real life solutions to problems that surface runoff causes by building models and through discussion.

Focus and Spiral Standard(s)

5-ESS2-1. Use a model to describe the cycling of water through a watershed through evaporation, precipitation, absorption, surface runoff, and condensation. [**State Assessment Boundary**: Transpiration or explanations of mechanisms that drive the cycle are not expected in state assessment.]

5-ESS3-1. Obtain and combine information about ways communities reduce human impact on the Earth's resources and environment by changing an agricultural, industrial, or community practice or process. [**Clarification Statements**: Examples of changed practices or processes include treating sewage, reducing the amounts of materials used, capturing polluting emissions from factories or power plants, and preventing runoff from agricultural activities.]

7.MS-ESS2-4. Develop a model to explain how the energy of the sun and Earth's gravity drive the cycling of water, including changes of state, as it moves through multiple pathways in the Earth's hydrosphere. [**Clarification statement**: Examples of models can be conceptual or physical.]

NGSS Alignment

Disciplinary Core Ideas (DCI)	Crosscutting Concepts (CCC)	Science Practices (SP)
ESS3.C: Human Impacts on Earth Systems Human activities in agriculture, industry, and everyday life have had major effects on the land, vegetation, streams, ocean, air, and even outer space. But individuals and communities are doing things to help protect Earth's resources and environments. (5-ESS3-1)	**Systems and System Models** A system can be described in terms of its components and their interactions. (5-ESS2-1),(5-ESS3-1)	-SP1: Asking Questions and Defining Problems -SP2: Developing and Using Models -SP3: Constructing Explanations and Designing Solutions

Learning Targets

1. I can explain how **surface runoff happens** and how **it interacts with the land** around it.
2. I can explain how **living things interact with surface runoff**.

Assessment(s)

Watershed worksheet

WIDA Language Objectives

[Dependent on the needs of your students]

Targeted Academic Language

Tier 2: Gravity, Surface Runoff, Watershed

Tier 3: Topography

RESOURCES AND MATERIALS

Quantity	Item	Source
	Lesson 6 powerpoint	CMC Website
1 per student	Lesson 6 worksheet	CMC Website
1 per student	Sheet of paper	Classroom Teacher
1 per group	**Spray bottle**	**Bin**
1 container	**Blue food dye**	**Bin**
1 per student	Paper plate	Bin
1 per group	**Masking Tape**	**Classroom Teacher**
1 per group	**Pack of markers (minus blue markers)**	**Bin**
1 per group	Pack of colored pencils	**Bin** and Classroom Teacher
	Various Art Supplies (felt, pipe cleaners, legos, popsicle sticks, cotton balls, etc)	**Bin** and Classroom Teacher
1 per group	**Watering Can**	**Bin**
1 per group	**Large Baking Tray**	**Bin**
	Plastic Building Blocks	**Bin**
1	Bag of Soil	Bin

****Items in bold should be returned for use next year****

LESSON DETAILS

Lesson Opening/ Activator

1. Project Lesson 6 powerpoint and hand out the worksheet. The first slide shows many landscapes, and students should create a list in the space provided on their worksheet about all the similarities they see within the pictures.

2. After a few minutes of brainstorming, ask the students to think-pair-share about observations. Ask partners to come up with one word that could describe all of the featured landscapes. (Their answers should be centered around water, bodies of water and the collection of water).

3. The next slide is a fill in the blank definition of a watershed. The goal is for the students to finish the sentence, so it reads "A watershed **collects** water and **directs** it to **bodies** of water"(bold are the answers that the students need to supply) and the students follow along on the worksheet. Remind students that we last saw Ralph the raindrop as a cloud that started raining. Ask: What happens when he makes contact with the ground? Where does all the rain go after a storm? Why do certain places flood and others don't?

During the Lesson

Watershed Activity [SP2: Developing and Using Models]

Before starting the lesson, make sure all supplies are ready to be distributed. Materials: several pre-filled spray bottles with tap water dyed blue (via food coloring), a sheet of paper, a worksheet, and paper plate per student.

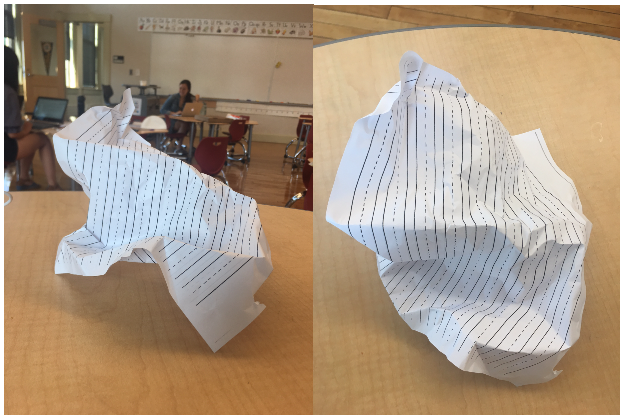
1. Split class into small groups - each student works individually, but share materials to minimize waste.

2. Once students are in small groups, hand one spray bottle to each group and a sheet of paper, worksheet and paper plate to each student.

3. Each student crumples their sheet of paper (but don't crumple it up too much because it will make the activity harder later on).

4. Each student then smooths out the paper, so that it is no longer a crumpled ball, but not flat. Place paper on paper plates, then tape the edges down to the plate.

Example pictures:



5. Ask the students to describe what their crumpled paper looks like, steer them in the direction of Earth's landscape, then ask them to find their highest "mountain" (peak) and their lowest "valley," and mark it with different colored markers, except blue.

6. Ask students to identify any other landforms(ex. **smaller mountains(hills), potential rivers, lakes, canyons, plains**) that they recognize and to make note of them. Tell the students to record findings on their Watershed worksheet by drawing both a top view of their landscape and a side view, making notes in the lines provided.

7. Ask students to imagine a hypothetical rainstorm above their landscape: identify where water might collect and label them. Also record these predictions on worksheet.

8. Turn the hypothetical situation into a "real" rainstorm and have each student take turns misting their paper (but warn the students not to soak their paper). Record how the water traveled on their landscape - where did the water collect to form rivers, lakes or other bodies of water?

9. Record findings in the "After the rain" section of the worksheet and draw both a top and side view of the landscape.

In Your Life [SP1: Asking Questions and Defining Problems] [EP1: Constructing Explanations and Designing Solutions]

1. Set landscapes aside to dry, and start a conversation about how observed water patterns would affect communities that might live in similar landscapes. Brainstorm and write down suggestions or ideas for preventions and protections. Ask students to write ideas in a small paragraph under the "In our community" heading on the lines provided.

2. How do we address flooding of city streets?
   Ask the students to brainstorm (in small groups) ways to reduce flooding, and present ideas to the rest of the class. Give each group a baking tray (landscape) and some blocks (buildings) and tell them that the tray represents their city, and they must find a way to reduce flooding. Draw and record their end product on worksheets.

Teaching Tip
Push students to provide evidence for why their ideas would help prevent flooding or runoff. This is a chance for them to draw on prior knowledge, personal experience, and previous lessons.

3. How can we prevent runoff in agricultural communities?
   Ask the students to brainstorm (in small groups) ways to prevent runoff, and present ideas to the rest of the class. Take the blocks from each group and add dirt into their trays - allow students to explore how they might reduce runoff in this altered situation, and record end product on the worksheet.

Lesson Closing

Ralph the Raindrop:

There will be two different scenarios to this part of the story, and students can select which scenario they draw.

SPLAT. After a long time of falling out of the cloud, Ralph finally reached the ground. More raindrops joined him and now they formed a small puddle on a streets in Spain. Eventually, the puddle overflowed with more incoming raindrops, such that Ralph started flowing away, down the street!

"Whoa! Where am I going now?"

Scenario 1:

Ralph kept flowing down the street to the stream, to the river, and eventually, to the Mediterranean Sea.

"Ahh… It's been awhile since I've last been to the ocean. But the ocean is so big, where can I go from here?"

After months of traveling, Ralph made his way all the way to the Arctic.

"It's getting really cold here! I need a place to stay," said Ralph.

"Hey Ralph!" said a voice.

"Who is it?" asked Ralph.

"It's me, Isabel the Iceberg! I sent many postcards to you in the past, remember? It's great that you came for a visit!" said Isabel. "Here! Come closer, and you can cuddle up with other water molecules and stay at my home for awhile."

Ralph and other water molecules gathered close together, and, tada! They were now inside Isabel the Iceberg's home as frozen ice!

Scenario 2:

Ralph kept flowing down the street until he reached the soft soils of a garden.

"Mmm, it smells so fresh! Are those herbs?" said Ralph, taking a huge sniff.

It didn't take long for the soft soil to quickly absorb Ralph. Ralph was now in the soil!

Continue the Ralph the Raindrop cartoon in the comic book.

Assessment

Review Watershed worksheet

Lesson 7: Soak It All Up - Absorption

LESSON BACKGROUND

In the previous lesson, students learned that water can travel to different locations through surface run-off. This lesson shows other possibilities for water after hitting the Earth's surface: absorption and transpiration. This illustrates the interaction between water and life (plants).

SCIENCE CONTENT BACKGROUND (for instructors):

Absorption is the process when water is taken into the soil. After absorption, water can be distributed to plants through their root systems. Once inside plants, water is pulled upward through the plants' stems, to be used for plant sustainability. Water can also leave the plants through a process called transpiration. Transpiration is the mechanism through which plant leaves release water back into the atmosphere as water vapor. This is done in conjunction with the release of oxygen from the plants.

Overview of the Lesson

Students explore the process of absorption and briefly touch on transpiration through several hands-on activities. Students learn through kinesthetic models and experiments how these processes work. Experiments include the celery rainbow, transpiration explanation, and the path of water experiments. **Ask students to bring in plastic water bottles for this lesson. Teacher and Science Fellows should also bring some in to ensure there are enough.**

Focus and Spiral Standard(s)

5-ESS2-1. Use a model to describe the cycling of water through a watershed through evaporation, precipitation, absorption, surface runoff, and condensation.

NGSS Alignment

Disciplinary Core Ideas (DCI)	Crosscutting Concepts (CCC)	Science Practices (SP)
ESS2.C: The Roles of Water in Earth's Surface Processes Nearly all of Earth's available water is in the ocean. Most fresh water is in glaciers or underground; only a tiny fraction is in streams, lakes, wetlands, and the atmosphere. (5-ESS2-2)	**Systems and System Models** A system can be described in terms of its components and their interactions. (5-ESS2-1),(5-ESS3-1)	-SP2: Developing and Using Models

Learning Targets

1. I can identify what **materials/objects absorb water**.
2. I can explain the **process of water absorption.**

Assessment(s)

Review Science journals and summary paragraphs

WIDA Language Objectives

[Dependent on the needs of your students]

Targeted Academic Language

Tier 1: Run-off

Tier 2: Absorption, Transpiration, Evaporation

RESOURCES AND MATERIALS

Quantity	Item	Source
6 per group	9 oz. Plastic Water Bottles	**Bin** and Classroom Teacher
6 pieces per group	**String**	**Bin**
1 per group	**Single-Hole Hole Puncher**	**Bin**
1-2 per group	Scissors	Classroom Teacher
1 bag	Potting Soil	Bin
2 Bags	*Real* Moss	Bin
	Leaves/sticks	Classroom Teacher
3 hearts	Celery	Teacher or CMC coordinator
1 package	Food Coloring	Bin
3 per group	Clear Plastic Cups	Bin
1 per student	Plastic Baggies	Bin
1 per student	**Rubber Bands**	**Bin**

****Items in bold should be returned for use next year****

LESSON DETAILS

Lesson Opening/ Activator

Lead a short discussion about absorption. Ask, "When you hear the word 'absorption' what does it make you think of? How do you think absorption plays into the water cycle?" Use student ideas to explain that plants and the ground absorb a lot of water. Plants and the ground act a lot like a sponge, but eventually the water turns into water vapor and goes back into the atmosphere. When plants release water vapor it is called **transpiration**. It's the reason why plants don't expand much when they absorb a lot of water.

This unit was developed with National Science Foundation funding (Grant #1432591). It is a DRAFT document that will be revised as the unit is piloted and feedback received.

During the Lesson

Transpiration Explanation

While outside, students should also collect dead leaves and sticks for the next experiment

1. Distribute a plastic bag and an elastic band to each student.

2. Take the students outside and ask them to place the plastic bag around a couple of leaves of a plant that they can reach and tie it tightly with the elastic band.
   Before going inside, students should collect some sticks and dead leaves for the next experiment

3. When the class comes back inside, allow them to record observations from outside, and write down predictions in their science journals about what they may see in the plastic bags in a few days.

4. Explain that the students will return to this experiment later in the lesson/unit as they learn more about transpiration. It may take up to a couple of days for the desired effect to appear (water droplets should be forming on the inside of the bag).

5. When the class returns to this experiment later on, have students observe what they see and offer explanations for those observations. They should be able to notice water droplets on the inside of their bags due to transpiration.

Rainbow Celery Project

Prior to the start of this activity the celery should already be cut so that each group gets three pieces. The celery should be cut one inch up from the bottom then placed in water

1. Distribute three pieces of celery and three clear plastic cups to each group of 3-4 students.

2. Have the students fill each cup with water. The Science Fellows or classroom teacher places 5 drops of each color of food coloring into each group's cups (1 color per cup).

3. Students can mix up the water with the celery and then leave them in the cups afterwards. Students will then think-pair-share their predictions of what will happen to the celery while it sits in the water.

Teaching Tip

Have students get as specific and detailed as possible in their predictions. For example, if they say the celery will turn color, have them predict how far up it will turn color, where the color will be, etc.

4. Now let the celery sit in the water for the rest of the class period. If needed, leave cups out for the rest of the week to revisit. Students should write down any predictions or questions they may have about the lesson in their science journal. Now is the perfect time to discuss the process of transpiration. Ask the class what happens to water when a plant absorbs it. Does it get stuck there? Does the plant release the water back into the atmosphere? The teacher can then describe that transpiration is when the **water in plants is released into the air as water vapor**.

The Path of Water Experiment [SP2: Developing and Using Models]:

prior to the lesson, ask students to bring in two plastic water bottles each and have the teacher and science fellows bring in extras because students may forget

1. Distribute 6 water bottles to each group of 3-4 students

2. Have the students cut off the bottoms of three of the water bottles about 4 inches above the base (mark it with a sharpie prior to them cutting if that makes it easier).

3. On the other three water bottles, trace the shape of a rectangle that is two inches wide and covers most of the length of the water bottles. Once the rectangle has been traced onto the bottle, ask the students to the ***CAREFULLY*** cut out the rectangle with scissors.

4. Have the students fill two bottles half way up with soil and the third with only thin layer of soil. Place the moss in one half-filled bottle. Place the leaves and sticks in the bottle that has a thin layer of soil. The third bottle only contains soil.

5. Now, with the three bottoms of bottles, have the student mark two spots that are directly across from each other with a sharpie. They will then hole punch those marks and tie a piece of string to each hole.
6. For the construction, tie the two end of string to the opening/neck of the bottle.

7. Before starting the experiment, ask the students to predict what will happen when they pour water into the bottles. They can present their ideas to the class if they would like.

8. For the experiment, have the students place the bottles on the edge of their desks (or some other suitable location) and make sure they are careful not to knock them over. Pour about a cup of water into the open rectangle of all three bottles. Observe the differences of the water between the three bottles.

At the end of this activity, have a conversation about how the presence of land helps to filter the water it absorbs. If they look back at the water bottles, ask them why the water emerges in different colors? Explain that the bottle containing moss has cleaner water because **the roots hold together the soil, and absorb some of the minerals,** so any run off water is cleaner. The other bottles absorb as much water as they can but still have a backwash effect where the soil and other particulates flow out.

Lesson Closing

(Science Talk: student should be able to communicate their ideas clearly in writing, but may need sentence starters or prompts to support their thinking). At the end of the lesson, ask students to write a 5 sentence summary about their activities. They should focus on what they learned, the main concepts of the lesson, and anything that surprised them from the lesson.

Next, continue reading the next part of Ralph the Raindrop story and have each student choose a scenario and draw in their comic book.

Scenario 1

"It's dark in here, I can't see a thing!" exclaimed Ralph, moving around aimlessly in the wet soil.

Suddenly, Ralph felt a force pulling him towards something. Before he knew, he was soaked up by the roots of a plant! Now he was traveling up the plant.

Ralph kept traveling up, and eventually, he saw a small ray of light above him.

"Hmm, I wonder what's up there?" wondered Ralph and moved closer to the light.

This unit was developed with National Science Foundation funding (Grant #1432591). It is a DRAFT document that will be revised as the unit is piloted and feedback received.

Now, Ralph was outside! He had turned into water vapor again.

"Wow, I'm back to being a water vapor? I can fly again now!"

And Ralph flew up into the sky, waiting to join a cloud again.

<u>Scenario 2</u>

Ralph was hanging out inside the plant when he heard some noises outside. It felt like he was being moved around! After days of traveling without a clue of where he was going, Ralph finally arrived to his destination at Morocco.

"Okay, now what?" wondered Ralph.

Suddenly, Ralph heard footsteps and some strange noises of an animal. It was Calvin the Camel!

"I sure am hungry right now. Ooh! A nice fresh plant. I'm going to eat it," said Calvin. Calvin quickly ate up the plant, and now Ralph was inside the stomach of Calvin.

"Oh, a friend of mine who had once been eaten by a camel told me what would happen. I'm probably going to end up in the humps of this camel for water storage!"

And surely enough, that's what happened.

Assessment

Review the students' science journals and summary paragraphs

Lesson 8: Dirty Dirty - Pollution

LESSON BACKGROUND

The previous lessons focused on the mechanisms of the water cycle, with the purpose of emphasizing how the chemical and physical processes of water phase changes explain the phenomena of the water cycle. In this lesson, students explore how the environment and living things, including humans, are impacted by the water cycle. Since water's role and impact is so pervasive, contaminations at different points in the cycle have resounding and lasting consequences.

SCIENCE CONTENT BACKGROUND (for instructors):

Pollution is a byproduct of human activity because we produce trash and release human-made chemicals into our natural environment. Since no new water is created on earth, contamination makes the already scarce amount of viable, clean water even scarcer. In order to keep our water safe, we have private reserves, but there is still a lot that humans can do to protect and prevent pollution in our environment.

Overview of the Lesson

In this lesson, students explore how to clean water of certain pollutants like oil, soil, and trash. They discuss certain cleaning solutions for pollution, as well as ways to prevent, protect against, and reduce the amount of pollution we make.

Focus and Spiral Standard(s)

5-ESS3-1. Obtain and combine information about ways communities reduce human impact on the Earth's resources and environment by changing an agricultural, industrial, or community practice or process. [**Clarification Statements**: Examples of changed practices or processes include treating sewage, reducing the amounts of materials used, capturing polluting emissions from factories or power plants, and preventing runoff from agricultural activities.] [**State Assessment Boundary**: Climate change or social science aspects of practices such as regulation or policy are not expected in state assessment.]

This unit was developed with National Science Foundation funding (Grant #1432591). It is a DRAFT document that will be revised as the unit is piloted and feedback received.

NGSS Alignment

Disciplinary Core Ideas (DCI)	Crosscutting Concepts (CCC)	Science Practices (SP)
ESS3.C: Human Impacts on Earth Systems Human activities in agriculture, industry, and everyday life have had major effects on the land, vegetation, streams, ocean, air, and even outer space. But individuals and communities are doing things to help protect Earth's resources and environments. (5-ESS3-1)	**Systems and System Models** A system can be described in terms of its components and their interactions. (5-ESS2-1),(5-ESS3-1)	SP2: Developing and Using Models - SP8: Obtaining, Evaluating, and Communicating Information

Learning Targets

1. I can explain **different ways that water can become polluted**.
2. I can **prevent and protect from pollution** and **reduce the amount polluted water** in our environment.

Assessment(s)

Review of students science journals and cartoon booklets.

WIDA Language Objectives

[Dependent on the needs of your students]

Targeted Academic Language

Tier 1: Pollution, Sewage, Fertilizer

Tier 2: Pesticide, Herbicides

RESOURCES AND MATERIALS

Quantity	Item	Source
	Air pollution Image	CMC Website
	"Lesson 8 Ralph the Raindrop Cartoon"	CMC Website
	Water Pollution Experiment https://www.youtube.com/watch?v=hwRsJeQrJHo&feature=youtu.be	CMC Website
1 per group	**Glass Baking Tin**	**Bin**
1 bag	**Pebbles**	**Bin**
1 per group	**Spray bottle**	**Bin**
4 per group	Clear cups	Bin
3 per group	**Blocks (to represent houses)**	**Bin**
2 bottles per group	**Different Colored Sugar Sprinkles**	**Bin**
	Clay or playdough	Bin
1 Bottle	**Vegetable oil**	**Bin**
1 per group	**Small Rubber Toy animal**	**Bin**
1 per group	**Dish cloth**	**Bin**
1 per group	**Table Spoon**	**Bin**
1 cup per group	Soil	Bin
	Trash (ex. Plastic bottles, wrappers, old containers, old newspaper)	Classroom Teacher
1 per group	**Tongs**	**Bin**
1 per group	**Strainer**	**Bin**
1 per group	**Bucket for trash**	**Bin**

	Non latex gloves	Bin
	Paper Coffee Filters	Bin
1 per group	**Water filter**	**Bin**
1 per group	**Bucket for filtered water**	**Bin**
1 per student	Science journal	Classroom Teacher
1 per student	"Pollution Solution: What's the Problem?"	Binder

****Items in bold should be returned for use next year****

LESSON DETAILS

Lesson Opening/ Activator

Anchoring phenomena: Project picture of air pollution in China, and ask students to take a few minutes to write down any observations about the picture. Facilitate a preliminary discussion - ask students to share observations, and ask if any have inferences or explanations for what's going on. Explicitly mention "pollution" (if not done by students), and gauge previous knowledge. What is pollution? Ask more questions to prompt more intrigue, but not all answers need to be given at this moment. Does the air look like this all the time? Does it look like this where you live? Just because we can't see air pollution, does that mean it's not there?

Emphasize that since we have spent the past few lessons understanding how water changes and moves throughout Earth's systems, we are now going to **learn about the human impacts** when there is contamination within the systems. Pose the question, "How might air pollution impact the water cycle?" Students should be able to draw on previous lessons to craft an answer resembling the following: If the air is polluted, then pollutants can get into our water through condensation, or into our land when it precipitates because the rain will bring those pollutants down with it.

Show the next part of Ralph's story, which is illustrated in a powerpoint. Read the story aloud and then ask the students how they think they could help Rudy become clean? (All ideas are welcome)

During the Lesson

Our Water Supply [SP2: Developing and Using Models] [SP8: Obtaining, Evaluating, and Communicating Information]

1. Split students into small groups of 3-4 and hand out materials. 1 baking tin, 1 cup of pebbles, 3 empty clear cups, 3 blocks, 2 bottles of different colored sugar sprinkles, 1 spray bottle of water, clay or playdough, 1 clear cup filled with a small amount of oil, a toy animal, a dish cloth, a table spoon, 1 cup of dirt, 1 bucket for trash, water filter papers, water filter, and a bucket for filtered water **for each group**.

2. First fill each baking tin with pebbles on a slope and place 3 blocks evenly spaced apart to represent houses. (watch video for demonstration: https://www.youtube.com/watch?v=hwRsJeQrJHo&feature=youtu.be)

3. Use the spray bottle to simulate rain and once you collect a good amount at the bottom use the clear cup to collect the water. Write observations.

4. Next have students sprinkle one color of sugar sprinkles over a chosen house and explain to them that these are to represent pesticides and how they interact with our water.

5. Repeat step C.

6. Next have students sprinkle the other color on one of the remaining two clean houses and tell them this color is to represent fertilizer and how it interacts with our water.
7. Repeat step C.

8. Compare all water samples and write comparisons down.

Oil Spill

(demo) http://www.kitchencounterchronicle.com/oil-spill-clean-experiment-kids/

1. Empty the tin of all the pebbles and put them away.

2. Have students use the clay to create shoreline along the outside.

3. Pour the water that remains in the spray bottle into the tin and add water if needed.

4. Put a small amount of oil directly in the center of the baking tin. Write down any observations.

5. Then have the students place their toy animal in the oil spill, write observations and then brainstorm ways to help the animal's situation (including how to get it out and clean).

6. Then tell the students they can use any tools (except the water filter and filter papers) at their station to get the oil out of the water safely, trying to avoid the shoreline as much as possible and that they are to document which tools they use and their effects during the process.

Water Pollution Plant

(demo) http://jdaniel4smom.com/2017/01/water-pollution-experiments-kids.html

1. Next we will ask students to pick up their "trash" bucket and pour that into their water tin along with the sample cups and water they used and the soil.

2. Ask the students if they would want to drink this water. Lead a class discussion on why not?

3. Then ask them to use their tools again to try and make the water drinkable, again they should document which tools they use and their effects.

4. At the end each group should have run their water through the water filter at least once. Now go to the sink and get a cup of fresh water and ask the students to bring their water up to compare and to write these comparisons down.

5. Next lead a discussion about these differences. Make sure the students understand that the while the activity was fun, it is **much easier to keep water clean than to clean it**. Also include that there are water treatment plants that have sophisticated ways of purifying water to make tap water drinkable at home, and we do not suggest they try the purifications methods used today at home (because these methods are not useful at removing microscopic bacteria and pollutants).

Suggested break point for part 2

http://www.kcedventures.com/blog/teaching-kids-to-conserve-water
http://www.pbs.org/parents/adventures-in-learning/2016/05/water-conservation-awareness-activity/
(Research) http://www.shareitscience.com/2015/10/water-conservation-science-demonstration.html?spref=pi

Lesson Opening/ Activator

Discuss the recent water contamination in nearby town of North Bennington (take 15 minutes the day before to have students read this article, or send it home as homework night before)
https://www.nytimes.com/2016/03/15/nyregion/vermont-town-is-latest-to-face-pfoa-tainted-water-scare.html
Ask if any students have heard about local pollution or water contamination? Read the article as a class - identify the problem, discuss the plan of action and solutions that were implemented. Emphasize that contamination from a long time ago can impact generations into the future.

Explain that this lesson will focus on the human impact on natural resources like water, and ways that communities try to lessen negative impacts on resources.

During the Lesson

What Can We Do?

Start a discussion about different types of water pollution (human-made or natural) and what negative effects are. Have Science Fellow(s) follow along by making a list on one side of the board. Students are welcome to share all ideas to be discussed within the class as to whether or not it is pollution but here a list of concepts that should be on the list and if they are not then teachers should bring them into the discussion:

- Acid rain- When sulfur dioxide gets into rain, it can turn bodies of water acidic and can kill plants and animals
- Sewage- introduces harmful bacteria to both humans and animals
- Farm animal waste- large herds can produce waste that gets into runoff
- Pesticides and herbicides- these harmful chemicals can get into bodies of water through runoff or spills
- Construction or natural disaster- introduces silt and shifts parts of the environment
- Factories- the chemicals they may use can be dumped into rivers and oceans

On the other side of the board have students then brainstorm the ways to protect, prevent, and reduce the effect of these types of pollution. All answers are welcome but some examples are included below.

1. Save water
2. Don't use chemicals on your outside lawn
3. Less grease down the kitchen drain
4. Don't litter

Transition the conversation to other human impacts on natural resources by asking, "What other threats do we pose to water besides pollution?"

You can have students recall the activity from Lesson 1 demonstrating how *small* of a percentage of the Earth's water is actually usable for humans. Do you think we'll run out of clean water? Does everyone have the same access to clean

This unit was developed with National Science Foundation funding (Grant #1432591). It is a DRAFT document that will be revised as the unit is piloted and feedback received.

water? **(The two other main problems we are trying to draw out are conservation and accessibility, but it's okay to not deliver these answers explicitly yet, until after the next activity)**.

Water Conservation Activity

1. Split students into small groups of 3 or 4. Give each group a sheet of wax paper, 4 pieces of tape, a straw, and a glass of water
2. Have the students tape the sheets of wax paper down to the table
3. Instruct the students to put the straw in the cup of water and place a finger on top of the straw in order to move water to the wax paper
4. Place a droplet of water on the paper.
5. Then have each student take a turn to blow through their own straw tell them they need to move the droplet across the paper without having it break into other droplets
6. Then have each student slurp up their own droplet to conserve water.
7. After all students take turns leading a discussion on how the activity went, explain that this represents how some people need to transport clean water long distances because they do not have access to clean water. It also represents how hard it can be to conserve clean water.

Draw out crucial points from conversation:

- Conservation and accessibility are two other major problems posed to water as a natural resource.
- We have a limited supply of fresh, clean water, and different people in different places across the world have drastically different access to water.
- Emphasize that what we experience here (being able to turn on a faucet and have water immediately) is not the experience for many people. Some communities have to walk miles and carry water on their backs.

Research project

This project gives students the opportunity to investigate ways communities reduce and mediate human impact on water.

1. Divide class up into pairs, groups, or individual (at teacher's discretion). Ask students to recall the three main issues we discussed about water as a natural resource: pollution, conservation, and accessibility. Each research group will explore a more specific solution in their chosen broad category.

9. Pass out the guiding worksheet for each student to fill out, along with a computer for each group. Explain that each group will gather information on ways different people or communities have tried to protect against their issue. After choosing a specific solution, they should write the goal down in their own words. Next, describe the plan of action in words, and draw a sketch of how the plan might be implemented.

10. Pairs should discuss how this plan of action would be spread to as many people as possible (in order to increase impact/success of the solution), and write down a few notes.

2. Have some (or all) groups share and present their findings

    i.

Here are some online resources students can use:

1. http://www.borregosolar.com/press/north-adams-celebrates-completion-of-3-5-megawatt-landfill-solar-projects-installation-and-being-100-percent-solar-powered
2. http://www.safewaternetwork.org/ongoing-innovation/preserving-water-sources-future-generations
3. http://www.sswm.info/category/implementation-tools/water-use/hardware/optimisation-water-use-home/reduce-water-consumptio

    i.

Extension

Take students on a field trip to either the North Adams or the Williamstown Water Treatment Centers. This will require some planning in advance.

Visit this website so the students can see the water quality of their location or other locations of their choice. This website lists all the contaminants found in the water in a specific location.
https://www.ewg.org/tapwater/#.WYCP8YjyvIU

Lesson Closing

Lead a discussion on how students can reduce their water pollution at home. Write a list on the board. Later that week, ask who actually tried to reduce water at home and how it worked out.

Assessment

Ask the students if they know how to help Rudy any better than they did before. Will he ever be as clean as Ralph? Have them write ideas in their science journals. Then, have students draw in their solution to Rudy's situation in their cartoon booklet. This concludes their cartoon booklet.

Lesson 9: Cycle Board Game

LESSON BACKGROUND

This lesson pulls together the first eight lessons of the unit by asking students to create their own board game based on a water molecule's "journey." They integrate and apply knowledge from the past few weeks to understand the "big picture" of how water changes phases and moves through Earth's systems by creating different pathways or actions for the water molecule. Creating their own game and generating questions places the cognitive load on students and asks them to think critically about important and big ideas from the unit.

SCIENCE CONTENT BACKGROUND (for instructors):

Since this is an Evaluate lesson (from the 5E model), all the science content from every preceding lesson applies.

Overview of the Lesson

Note: This lesson features an optional add-on in which the classroom materials get swapped between two (or more) classrooms. This is not a necessary component of the lesson, but could be an interesting twist to the board game.

The class will be creating a board game to show the many paths that a water molecule like Ralph can take. Students design a game board, as well as question and consequence cards that either themselves or another 5th grade class will use. Students later play the game to quiz themselves and think critically about the big ideas and concepts that were taught in the previous lessons. There is also an alternative game of Jeopardy! described below that can be used to achieve the same goals.

Focus and Spiral Standard(s)

5-ESS2-1. Use a model to describe the cycling of water through a watershed through evaporation, precipitation, absorption, surface runoff, and condensation.

5-ESS3-1. Obtain and combine information about ways communities reduce the impact on the Earth's resources and environment by changing an agricultural, industrial, or community practice or process. [**Clarification Statement**: Examples of changed practices or processes include treating sewage, reducing the amounts of materials used, capturing polluting emissions from factories or power plants, and preventing runoff from agricultural activities.] [**State Assessment Boundary**: Assessment does not include social science aspects of practices such as regulation or policy.]

Learning Targets

1. I can explain and **reflect upon the knowledge** I learned throughout the previous lessons.
2. I can **create a model** that represents the **physical processes and components of the water cycle.**

Assessment(s)

Assess students' participation in the creation of the cards for either game and playing the games.

WIDA Language Objectives

[Dependent on the needs of your students]

Targeted Academic Language

(Review words from past lessons)

RESOURCES AND MATERIALS

Quantity	Item	Source
1 per class	Pack of index cards	Bin
	Black and red pens	Classroom Teacher
1 per class	**Game board**	**Bin**

This unit was developed with National Science Foundation funding (Grant #1432591). It is a DRAFT document that will be revised as the unit is piloted and feedback received.

5 per class	Magnets, or game pieces	Classroom Teacher
1 set per class	**Examples of question and consequence cards**	**Bin**
1 set per class	**Examples of Jeopardy! question cards**	**Bin**
1 per class	Pack of post-its	Bin
	Colored pencils/Markers	Classroom Teacher
1 per group	“Question Tracker” Worksheet	Binder

****Items in bold should be returned for use next year****

LESSON DETAILS

Lesson Opening/ Activator

At this point, students should have adequate knowledge of the physical processes and components of the water cycle. It is time to put that knowledge to the test and push the students’ creative limits!

During the Lesson

Board Game

The board can either be the electronic version or the physical poster board located in the bin. The color coded key for the board game is as follows:

- Precipitation = Blue
- Evaporation = Orange
- Condensation = Pink
- Absorption = Green
- Surface Runoff = Yellow
- Pollution = Black (These spaces offer bonus learning.)

Cards for the game will be designed by the students. (*Alternatively, cards have been provided for the game; however, we find it extremely beneficial for students' to develop critical thinking about these topics through the design of questions and answers on their own*.)

Creation of the Game Cards

1. Divide students into 5 groups. Each group is responsible for one of the processes in the water cycle. **These students will later play the game in the same groups, as they will be the "experts" of their particular process.** Pass out index cards.

2. Each group is responsible for writing up 13 cards, 5 cards based on content questions and 5 cards based on content consequences, and 3 cards based on "pollution solutions" that will be used for the board game. Teachers and Science Fellows should circulate to help students brainstorm and develop questions.

A consequence card for absorption might be: "You have been absorbed into a plant that needs you for nourishment! Skip your next turn to help the plant." A question card for precipitation might be: "What are the driving forces of precipitation? *Sunlight and gravity*." If students seem stuck, prompt them with questions like, "what is important to know about your process? What are the big ideas? What are things that could go wrong in your process?"

The process should be labelled on the front of the card. Questions should be written in black, while the answers can be written in red on the back of the card.

Optional: The classroom teacher or teachers could **SWAP** cards between classes to ensure that students who *wrote* that board game's cards will not be *playing* with that set of cards.
Once each group has completed their questions, and they have been checked by the classroom teacher or Science Fellows, it's time to **play**!

1. The new deck from the opposite classroom should be shuffled, both consequence and question cards. Split the cards up into piles based on their process - precipitation in one pile, condensation in another, etc.

2. Students should be divided into teams - the same teams that were created during the creation of the questions.

3. Hand out the “Question Tracker” worksheet to each group.

4. Each group should start at the branch that has their color tile.

5. One student from the first group should roll a die and move forward that many spaces. The colored space correlates with a colored “Process” card pile the student should take from. (*The black splat spaces represent the pollution pile.*)

6. The teacher should read the question or the consequence to the students in the group. If it is a question card, give them a couple minutes to discuss amongst their group what the answer is. If it is a consequence card, follow through with the directions on the card.

7. If the group gets the question right, have them color in one of the points on their star with the appropriate color. Students can also record how many pollution questions they get right as a bonus. If the group gets the question wrong, their turn is over and they do not fill in their star.

8. A group wins when they have answered a question from each category correctly, and have each point on their star colored in.

Alternative: Jeopardy!

This activity is an alternative to the board game that will require less extensive art supplies and crafting, but asks students to synthesize and apply information from the past few lessons similarly to the board game.

In this activity, students will create their own Jeopardy! game questions.

1. Create 5 category columns (Evaporation, Condensation, Precipitation, Surface Run-off, and Absorption), each with point values of 200, 400, 600, 800, and 1000.

2. Divide the class into 5 teams. Each team will be assigned to one of the five categories. They may come up with a team name that has to do with that category. Pass out 5 index cards to each group, and each team will label each card with the point values of 200, 400, 600, 800, and 1000.
    - Each team will be generating questions - see **"Creation of the Game Cards"** above in board game activity for guidelines as to how and what kinds of questions should be generated. *However, in this alternative, there wouldn't be consequence cards.*
    - As with Jeopardy! the game show, questions should become harder the more points that they are worth.

3. Once each group has completed their questions, and they have been checked by the classroom teacher or Science Fellows, organize the cards as appropriate at the front of the room.

4. Teams should be organized into the same groups as those who came up with the questions, **and those students may not pick from their own category until absolutely necessary.**
    - Teachers should play the host, and award points to the teams. The team with the most points after all questions are answered, wins.

Lesson Closing

As a wind-down activity after playing either game, have students pair up and discuss what the most challenging part of these activities were. They might also talk about their favorite parts and their least favorite parts about either the design of the games or playing the games.

Assessment

Assess students' participation in the creation of the cards for either game and playing the games.

Unit Activity Planner

Teach To Learn
A collaboration between MCLA, Williams College, and North Adams Public Schools
Funded by NSF DUE-IUSE Award #1432591

Activity	Learning Target(s)	Science Connection to Phenomena	MA Standards
Lesson 1 Cycle not Circle	I can explain that there is **no source of new water** on Earth and that water is a limited natural resource.	Water is a limited natural resource that exists in a closed system. It travels throughout the hydrosphere through the various processes of the water cycle, but water is neither created or destroyed on a large scale.	
Lesson 1 Saltwater vs Freshwater	I can explain that there is an uneven distribution of saltwater versus freshwater on Earth.	There is a drastic difference in the amount of available salt versus fresh water. This is important because humans and most mammals need freshwater to survive, and the vast majority of water on Earth is saltwater.	**5-ESS2-2.** Describe and graph the relative amounts of salt water in the ocean; freshwater in lakes, rivers, and groundwater; and freshwater frozen in glaciers and polar ice caps to provide evidence about the availability of fresh water in Earth's biosphere. **2-ESS2-3**. Map the shapes and types of landforms and bodies of water in an area. [**Clarification statements**: Examples of types of landforms can include hills, valleys, river banks, and dunes. Examples of

			water bodies can include streams, ponds, bays, and rivers. Quantitative scaling in models or contour mapping is not expected.]
Lesson 2 Density Powerpoint, Video, and Calculation Activity	I can explain that all matter has density, whether it's a solid, liquid, or gas. I can explain that when density interacts with gravity - matter sorts itself out according to its relative density.	Understanding relative density and its relationship to gravity is critical for students to appreciate how matter in various states (solid, liquid, and gas) interacts with matter of different densities, which is the basis of many physical phenomena that students should be familiar with, including weather patterns (winds, precipitation, etc.) and natural disasters (hurricanes, tornadoes, storms, etc.).	**5-PS1-1**. Use a particle model of matter to explain common phenomena involving gases, and phase changes between gas and liquid and between liquid and solid. [**Clarification statement**: Examples of common phenomena the model should be able to describe include adding air to expand a balloon, compressing air in a syringe, and evaporating water from a salt water solution.]
Lesson 2 Phase Change Activity	I can explain that energy plays an important role in the movement of molecules and their phase changes.	A model showing that gases are made from matter particles that are too small to see and are moving freely around in space, juxtaposed with a model showing that liquids and solids are constituted by the same	**5-PS1-1**. Use a particle model of matter to explain common phenomena involving gases, and phase changes between gas and liquid and between liquid and solid. [**Clarification statement**:

		particles in different organizations, will help students understand the important role energy plays in the states and phase changes of matter (PS1.A).	Examples of common phenomena the model should be able to describe include adding air to expand a balloon, compressing air in a syringe, and evaporating water from a salt water solution.]
Lesson 3 Evaporation in a Cup	I can explain how water changes phases from liquid to gas, and why this process of evaporation is important	Evaporation requires energy input to change water from a liquid to a gas state. The increase of energy in the water molecules at the surface of the liquid causes those molecules to move more. Increased energy turns the molecule to vapor, and increased movement spreads the particles out, causing a decrease in density so the molecules rise in the air (in the form of vapor).	**5-ESS2-1.** Use a model to describe the cycling of water through a watershed through evaporation, precipitation, absorption, surface runoff, and condensation. **7.MS-ESS2-4.** Develop a model to explain how the energy of the sun and Earth's gravity drive the cycling of water, including changes of state, as it moves through multiple pathways in the Earth's hydrosphere. [**Clarification statement**: Examples of models can be conceptual or physical.]

Lesson 3 What is happening to the H_2O molecules?	I can explain how water changes phases from liquid to gas, and why this process of evaporation is important.		**5-PS1-1**. Use a particle model of matter to explain common phenomena involving gases, and phase changes between gas and liquid and between liquid and solid. [**Clarification statement**: Examples of common phenomena the model should be able to describe include adding air to expand a balloon, compressing air in a syringe, and evaporating water from a salt water solution.]
Lesson 4 Cloud in a Jar	I can explain how clouds form.	Condensation is the phase change from gas to liquid and is critical to the water cycle for its role in cloud formation. Upon encountering cooler air, gas molecules release energy. Thus gas molecules, which move quickly and erratically, move slower as liquid. The evaporated water vapor turns into miniscule liquid droplets in the cool air. Next, the tiny	**5-ESS2-1.** Use a model to describe the cycling of water through a watershed through evaporation, precipitation, absorption, surface runoff, and condensation.
Lesson 4 Condensation Kinesthetic Activity	I can explain how gas transforms into liquid through the process of condensation.		**5-PS1-1**. Use a particle model of matter to explain common phenomena involving gases, and phase changes between gas and liquid and between liquid and solid. [**Clarification statement**:

		droplets stick to particulates in the air or a surface and become visible, big droplets.	Examples of common phenomena the model should be able to describe include adding air to expand a balloon, compressing air in a syringe, and evaporating water from a salt water solution.] **7.MS-ESS2-4.** Develop a model to explain how the energy of the sun and Earth's gravity drive the cycling of water, including changes of state, as it moves through multiple pathways in the Earth's hydrosphere. [**Clarification statement**: Examples of models can be conceptual or physical.
Lesson 5 Characteristics of Precipitation	I can recall that water in the atmosphere is a form a freshwater.	Precipitation is unique from other physical processes in the water cycle in that there is no phase change that occurs - water droplets make up clouds and water droplets fall as precipitation. However, there *may be* a phase change when	**5-ESS2-2.** Describe and graph the relative amounts of salt water in the ocean; freshwater in lakes, rivers, and groundwater; and freshwater frozen in glaciers and polar ice caps to provide evidence about the availability of fresh water in Earth's biosphere.

Lesson 5 Hands-On Rainstorms	I can explain that after water condenses and it becomes heavy enough within a cloud, it falls down in the form of precipitation	precipitation falls in the form of hail or snow, solids. Temperature is a major driving force of this phase change. The hydrosphere (the sum of all water on Earth) shapes the geosphere (the sum of all land on Earth) through precipitation in important ways..	**5-ESS2-1.** Use a model to describe the cycling of water through a watershed through evaporation, precipitation, absorption, surface runoff, and condensation. **7.MS-ESS2-4.** Develop a model to explain how the energy of the sun and Earth's gravity drive the cycling of water, including changes of state, as it moves through multiple pathways in the Earth's hydrosphere. [**Clarification statement**: Examples of models can be conceptual or physical.]
Lesson 5 Rain and the Land	I can explain how precipitation affects and shapes the land.		**5-ESS2-1.** Use a model to describe the cycling of water through a watershed through evaporation, precipitation, absorption, surface runoff, and condensation.
Lesson 6 Watershed activity	I can explain how surface runoff happens and how it interacts with the land around it.	Gravity is a natural driver of surface runoff. Surface runoff can erode or change the shape of the land, carry pollutants to	**5-ESS2-1.** Use a model to describe the cycling of water through a watershed through evaporation, precipitation,

This unit was developed with National Science Foundation funding (Grant #1432591). It is a DRAFT document that will be revised as the unit is piloted and feedback received.

		different locations. A lack of plants creates higher amounts of runoff. A watershed is a place on earth that has the ability to direct the course of water to different bodies of water or places.	absorption, surface runoff, and condensation. **7.MS-ESS2-4.** Develop a model to explain how the energy of the sun and Earth's gravity drive the cycling of water, including changes of state, as it moves through multiple pathways in the Earth's hydrosphere. [**Clarification statement**: Examples of models can be conceptual or physical.]
Lesson 6 In Your Life	I can understand how living things interact with surface runoff.	Without proper precautions, surface runoff can create many problems such as flooding in highly populated areas (the reason for drains on the street), movement of land, such as landslides, and movement of farming land, which can destroy crops (the reason farmers use surface covers to prevent erosion of their land).	**5-ESS3-1.** Obtain and combine information about ways communities reduce human impact on the Earth's resources and environment by changing an agricultural, industrial, or community practice or process. [**Clarification Statements**: Examples of changed practices or processes include treating sewage, reducing the amounts of materials used, capturing polluting emissions from factories or power plants, and

			preventing runoff from agricultural activities.]
Lesson 7 The Path of Water Experiment	I can explain the process of water absorption.	Absorption is the process when water is taken into the soil and then distributed to all the plants through their roots system. Transpiration is how the plants release the water back into the atmosphere as water vapor.	**5-ESS2-1**. Use a model to describe the cycling of water through a watershed through evaporation, precipitation, absorption, surface runoff, and condensation. **7.MS-ESS2-4.** Develop a model to explain how the energy of the sun and Earth's gravity drive the cycling of water, including changes of state, as it moves through multiple pathways in the Earth's hydrosphere. [**Clarification statement**: Examples of models can be conceptual or physical.]

This unit was developed with National Science Foundation funding (Grant #1432591). It is a DRAFT document that will be revised as the unit is piloted and feedback received.

Lesson 8 Water Contamination Activity	I can explain different ways that water can become polluted.	Pollution is a byproduct of human activity because we produce trash and release chemicals into our natural environment. Since no new water is created on earth, contaminations make the scarce amount of viable, clean water even scarcer.	**5-ESS3-1.** Obtain and combine information about ways communities reduce human impact on the Earth's resources and environment by changing an agricultural, industrial, or community practice or process.
Lesson 8 What Can We Do? Water Conservation Activity and the Research Project	I can explain how to prevent and protect from pollution and reduce the amount polluted water in our environment.	Conservation and accessibility are two other major problems posed to water as a natural resource - we have a limited supply of fresh, clean water, and different people in different places across the world have drastically different access to water.	**5-ESS3-1.** Obtain and combine information about ways communities reduce human impact on the Earth's resources and environment by changing an agricultural, industrial, or community practice or process. [**Clarification statement**: Examples of changed practices or processes include treating sewage, reducing the amounts of materials used, capturing polluting emissions from factories or power plants, and preventing runoff from agricultural activities.]
Lesson 9	I can explain and reflect upon	Through creating a board	**5-ESS3-1.** Obtain and combine

This unit was developed with National Science Foundation funding (Grant #1432591). It is a DRAFT document that will be revised as the unit is piloted and feedback received.

Board Game Activity	the knowledge I learned throughout the previous lessons. I can create a model that represents the physical processes and components of the water cycle.	game, and the playing cards that accompany it, students will have to think critically about the most important facts and questions pertaining to various aspects of the water cycle. The activity also implores students to consider both positive and negative consequences that can arise throughout the processes involved in the water cycle, making the connection between the water cycle and their everyday life.	information about ways communities reduce human impact on the Earth's resources and environment by changing an agricultural, industrial, or community practice or process. [**Clarification statement**: Examples of changed practices or processes include treating sewage, reducing the amounts of materials used, capturing polluting emissions from factories or power plants, and preventing runoff from agricultural activities.]

NGSS Alignment

Performance Expectations	Disciplinary Core Ideas (DCI)	Crosscutting Concepts (CCC)	Science Practices (SP)
5-ESS2-2. Describe and graph the relative amounts of salt water in the ocean; freshwater in lakes, rivers, and groundwater; and freshwater frozen in glaciers and polar ice caps to provide evidence about the availability of fresh water in Earth's biosphere. **5-PS1-1**. Use a particle model of matter to explain common phenomena involving gases, and phase changes between gas and liquid and between liquid and solid. **5-ESS2-1.** Use a model to describe the cycling of water through a watershed through evaporation, precipitation, absorption, surface runoff, and condensation.	**ESS2.C**: The Roles of Water in Earth's Surface Processes Nearly all of Earth's available water is in the ocean. Most fresh water is in glaciers or underground; only a tiny fraction is in streams, lakes, wetlands, and the atmosphere. (5-ESS2-2) **ESS3.C:** Human Impacts on Earth Systems Human activities in agriculture, industry, and everyday life have had major effects on the land, vegetation, streams, ocean, air, and even outer space. But individuals and communities are doing things to help protect Earth's resources and environments. (5-ESS3-1	**Scale, Proportion, and Quantity** Standard units are used to measure and describe physical quantities such as weight and volume. (5-ESS2-2) **Systems and System Models** A system can be described in terms of its components and their interactions. (5-ESS2-1),(5-ESS3-1)	SP1 - Asking Questions and Defining Problems SP2 - Developing and Using Models SP4 - Obtaining, Evaluating, and Communicating Information SP5 - Using Mathematics and Computational Thinking SP6 - Constructing Explanations and Designing Solutions

This unit was developed with National Science Foundation funding (Grant #1432591). It is a DRAFT document that will be revised as the unit is piloted and feedback received.

5E Instructional Model Background

This instructional model exists as a set of phases for science instruction that starts with students' prior knowledge in order to reconstruct a new knowledge with deeper understanding. The *Engagement* phase is first, in which teachers and students begin to mull over questions, prior knowledge and understanding, and potential frustrations they might have with a topic. This phase is meant to be informal – this is the start of the lesson. The second step involves *Exploring* phenomena, which acts as an introduction to the larger concepts that engages students in a hands-on approach. After exploration, *Explanation* of scientific concepts begins. To further student understanding, *Elaboration* is next, in which students are presented with even more challenging activities and problems. Following the learning process comes *Evaluation*, as deemed necessary by learning goals and defined achievements. The model is based on scientific research about how children learn and is meant to be followed chronologically, although some steps may be repeated.

This unit was developed with National Science Foundation funding (Grant #1432591). It is a DRAFT document that will be revised as the unit is piloted and feedback received.

Science Talk and Oracy in T2L Units

Science talk is much more than talking about science. In line with the science and engineering practices, students are expected to make a claim that can be supported by scientific evidence. The MA STE Standards (and the NGSS) value the importance of engaging in an argument from evidence. NGSS defines how this practice takes form in the real world: *"In science, reasoning and argument are essential for identifying the strengths and weaknesses of a line of reasoning and for finding the best explanation for a natural phenomenon. Scientists must defend their explanations, formulate evidence based on a solid foundation of data, examine their own understanding in light of the evidence and comments offered by others, and collaborate with peers in searching for the best explanation for the phenomenon being investigated."*

Students are asked to participate in articulate and sensible conversations in which they are able to communicate their ideas effectively, listen to others to understand, clarify and elaborate ideas, and reflect upon their understanding. These forms of talk can be developed using scaffolds such as the A/B Talk protocol (below) and strategies for class discussions (from the Talk Science Primer, link below). Oracy is developed in the physical, linguistic, cognitive, and social-emotional realms; each of these realms can be expanded upon over time in order to develop a thoughtful speaker. Being able to display appropriate body language, use proper tone and grammar, be thoughtful and considerate thinkers, and allow space for others thoughts and opinions are all important facets of oracy to work on and through with students. Incorporating the appropriate scaffolding is an important aspect of fostering these skills. Techniques for teaching effective science talk often include modeling, discussion guidelines, sentence-starters, and generating roles, while gradually putting more responsibility on students to own their thinking and learning.

Part of creating a safe school environment for students is allowing them a space that is comfortable enough for them to express ideas and ask questions, while being validated for their thoughts and questions; students should be feel comfortable and confident when speaking and listening for understanding. Effective talk is an important part of being an active, intelligent member of a community and society. Successful development in oracy is important for future employability and general well-being of adults.

The following resources should be helpful examples of how to employ effective use of progressive oracy and science talk in your classrooms.

- Oracy in the Classroom: https://www.edutopia.org/practice/oracy-classroom-strategies-effective-talk
- Science Talk Primer: https://inquiryproject.terc.edu/shared/pd/TalkScience_Primer.pdf

A/B Talk Protocol

Adapted from https://ambitiousscienceteaching.org/ab-partner-talk-protocol/

1. Share your ideas

Partner A

- I think ______ happened because…
- Evidence that supports my idea is…
- The activity we did with ______ helps me know more about ______ because…
- One thing I'm wondering about is…

2. Listen to Understand

Partner B

a. I heard you say ______. What makes you think that?
b. I heard you say ______. What if ______?
c. Can you explain the part about ______ again?
d. What do you mean when you say ______?

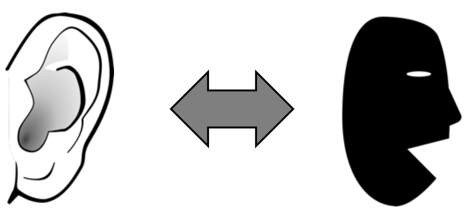
3. Clarify and elaborate

Partner A

Answer partner's questions or ask for clarification in order to understand a question.

4. Repeat steps 2 & 3 until all questions are answered

5. Switch roles and repeat steps 1-4



6. Reflect on your understanding in writing

a. My idea about ______ changed when my partner said ______.
b. I will add ______ to my idea about ______ because…
c. I still have questions about…
d. I may be able to answer my question(s) if I could investigate ______.

This unit was developed with National Science Foundation funding (Grant #1432591). It is a DRAFT document that will be revised as the unit is piloted and feedback received.

RESOURCES AND MATERIALS MASTER LIST

Lesson 1

Quantity	Item	Source
1 per student	Science Journal	Classroom Teacher
	Dinosaur Pee?: Crash Course [https://www.youtube.com/watch?v=o_bbQ0m3wuM]	CMC Website
1 per student	Crash Course: A Glass of Dinosaur Pee Guided Learning Worksheet	Binder
As needed per class	Globe	Classroom Teacher or **Bin**
3 total, 1 per group	1000 milliliter water bottle	Bin
6 total, 2 per group	**1000 milliliter beakers**	**Bin**
3 total, 1 per group	**Graduated cylinder**	**Bin**
3 total, 1 per group	**5 milliliter pipettes**	**Bin**
12 total, 4 per group	**100 milliliter beakers**	**Bin**
3 total, 1 per group	Sharpies	Classroom Teacher
1 per student	Water Distribution worksheet	Binder
	Water Distribution answer key	Binder
As needed	**Sticky notes**	**Bin**
1 per class	Chart paper for “Parking Lot Questions”	Classroom Teacher
1 per student	A booklet of blank comic strips, stapled (around 7 pages)	Classroom Teacher

This unit was developed with National Science Foundation funding (Grant #1432591). It is a DRAFT document that will be revised as the unit is piloted and feedback received.

Lesson 2

Quantity	Item	Source
1 per class	Rock (size doesn't matter, should sink in water)	Classroom Teacher
1 per class	Piece of wood/stick (should be bigger than rock)	Classroom Teacher
1 per class	Container + water in it (size doesn't matter, should fit rock and stick)	Classroom Teacher
5-6 per class	**100mL graduated cylinders**	**Bin**
5-6 per class	**Electronic scales**	**Bin**
5-6 per class	**Funnels**	**Bin**
1 per class	Density Powerpoint	CMC Website
1 per class	Density Video (if file doesn't work: https://www.youtube.com/watch?v=vSXTBnnx4OA)	CMC Website
1 per student	Density Calculation Worksheet	Binder
1 per class	Red, Yellow, and Blue Food Coloring	Bin
6 per class	solo cups	Bin
1 per class	**Ping pong ball**	**Bin**
1-2 per class	**pony (plastic) beads**	**Bin**
1 per class	**Metal nut/bolt**	**Bin**
1 per class	Game dice	Classroom Teacher
Enough for class	Coloring pencils	Classroom Teacher
1 per class	**~250mL of Honey**	**Bin**
1 per class	**~250mL of Light Corn Syrup**	**Bin**
1 per class	~250mL of Dish Soap	Bin
1 per class	~250mL of Whole Milk	Classroom teacher

1 for class	**~250mL of Vegetable Oil**	**Bin**
1 for class	~750mL of Water	Classroom Teacher
1 for class	Water Video https://www.youtube.com/watch?v=tuE1LePDZ4Y	CMC Website

Lesson 3

Quantity	Item	Source
2 per group	**500 ml Beaker**	**Bin**
1 per group	**Hot Plate**	**Bin**
1 per group	**Graduated Cylinder**	**Bin**
1 per student	Science Journals	Classroom Teacher
1 container	Vanilla ice cream	Classroom Teacher or CMC liaison
2 bottles	Rootbeer	Classroom Teacher or CMC liaison
1 per student	**Plastic cups**	**Bin**

Lesson 4

Quantity	Item	Source
1 per group	**Glass jar with lid (exp: mason jar)**	**Bin**
1 per group	**Pyrex measuring cup or beaker**	**Bin**
1 per group	Heated/boiled water	Classroom Teacher
2-3 per group	Ice cubes	Classroom Teacher
2	Ice Cube Tray	Classroom Teacher

2 per class	Hairspray	Bin
1 per student	Blank comic strip	Classroom Teacher
As students need	Colored pencils	Classroom Teacher
As students need	Markers	Classroom Teacher
	"Water Cycle Song for Kids" https://www.youtube.com/watch?v=uT-tVEQuKKc	CMC Website
	"What are Clouds Made of?" https://www.youtube.com/watch?v=DigBbR3FeP8	CMC Website

Lesson 5

Quantity	Item	Source
1 per student	Science Journal	Classroom Teacher
15 per class	**Mason jars (12 oz or more)**	**Bin**
5 cans per class	Shaving cream	Bin
2 containers	Blue food coloring	Bin
6 per class	**Glass jar**	**Bin**
6 per class	**Ceramic dinner plate**	**Bin**
3 per class	**Ice cube trays**	**Bin**
1 per class	**Large beaker**	**Bin**
1 per class	**Hot plate**	**Bin**
	Landslide video: https://www.youtube.com/watch?v=W4KWxglDL3o	CMC Website
	Photographs of the face of Mt. Greylock	CMC Website

This unit was developed with National Science Foundation funding (Grant #1432591). It is a DRAFT document that will be revised as the unit is piloted and feedback received.

Teach To Learn
A collaboration between MCLA, Williams College, and North Adams Public Schools
Funded by NSF DUE-IUSE Award #1432591

Lesson 6

Quantity	Item	Source
	Lesson 6 powerpoint	CMC Website
1 per student	Lesson 6 worksheet	CMC Website
1 per student	Sheet of paper	Classroom Teacher
1 per group	**Spray bottle**	**Bin**
1 container	**Blue food dye**	**Bin**
1 per student	Paper plate	Bin
1 per group	**Masking Tape**	**Classroom Teacher**
1 per group	**Pack of markers (minus blue markers)**	**Bin**
1 per group	Pack of colored pencils	**Bin** and Classroom Teacher
	Various Art Supplies (felt, pipe cleaners, legos, popsicle sticks, cotton balls, etc)	**Bin** and Classroom Teacher
1 per group	**Watering Can**	**Bin**
1 per group	**Large Baking Tray**	**Bin**
	Plastic Building Blocks	**Bin**
1	Bag of Soil	Bin

Lesson 7

Quantity	Item	Source
6 per group	9 oz. Plastic Water Bottles	**Bin** and Classroom Teacher
6 pieces per group	**String**	**Bin**

1 per group	**Single-Hole Hole Puncher**	**Bin**
1-2 per group	Scissors	Classroom Teacher
1 bag	Potting Soil	Bin
2 Bags	*Real* Moss	Bin
	Leaves/sticks	Classroom Teacher
3 hearts	Celery	Classroom Teacher or CMC Liaison
1 package	Food Coloring	Bin
3 per group	Clear Plastic Cups	Bin
1 per student	Plastic Baggies	Bin
1 per student	**Rubber Bands**	**Bin**

Lesson 8

Quantity	**Item**	**Source**
	Air pollution Image	CMC Website
	"Lesson 8 Ralph the Raindrop Cartoon"	CMC Website
	Water Pollution Experiment https://www.youtube.com/watch?v=hwRsJeQrJHo&feature=youtu.be	CMC Website
1 per group	**Glass Baking Tin**	**Bin**
1 bag	**Pebbles**	**Bin**
1 per group	**Spray bottle**	**Bin**
4 per group	Clear cups	Bin
3 per group	**Blocks (to represent houses)**	**Bin**

This unit was developed with National Science Foundation funding (Grant #1432591). It is a DRAFT document that will be revised as the unit is piloted and feedback received.

2 bottles per group	**Different Colored Sugar Sprinkles**	**Bin**
	Clay or playdough	Bin
1 Bottle	**Vegetable oil**	**Bin**
1 per group	**Small Rubber Toy animal**	**Bin**
1 per group	**Dish cloth**	**Bin**
1 per group	**Table Spoon**	**Bin**
1 cup per group	Soil	Bin
	Trash (ex. Plastic bottles, wrappers, old containers, old newspaper)	Classroom Teacher
1 per group	**Tongs**	**Bin**
1 per group	**Strainer**	**Bin**
1 per group	**Bucket for trash**	**Bin**
	Non latex gloves	Bin
	Paper Coffee Filters	Bin
1 per group	**Water filter**	**Bin**
1 per group	**Bucket for filtered water**	**Bin**
1 per student	Science journal	Classroom Teacher
1 per student	"Pollution Solution: What's the Problem?"	Binder

Lesson 9

Quantity	Item	Source
1 per class	Pack of index cards	Bin
	Black and red pens	Classroom Teacher
1 per class	**Game board**	**Bin**
5 per class	Magnets, or game pieces	Classroom Teacher
1 set per class	**Examples of question and consequence cards**	**Bin**
1 set per class	**Examples of Jeopardy! question cards**	**Bin**
1 per class	Pack of post-its	Bin
	Colored pencils/Markers	Classroom Teacher
5 total, 1 per group	"Question Tracker" Worksheet	Binder

This unit was developed with National Science Foundation funding (Grant #1432591). It is a DRAFT document that will be revised as the unit is piloted and feedback received.