Clouds in the Kitchen

Compelling Question	**What are clouds made of and how do clouds form?**
Academic Standards	**SOCIAL STUDIES 4.2.4 Describe how physical processes of the Earth's surface impact humans and their environment.** **SCIENCE 5.ESS2.1 Develop a model to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact.** Disciplinary Core Idea: Winds and clouds in the atmosphere interact with landforms to determine patterns of weather. **SCIENCE 6.ESS2.4 Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity.** Disciplinary Core Idea: Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation, and crystallization, and precipitation, as well as downhill flows on land.
Staging the Question	How does rain fall out of the sky? If rain comes from clouds, how can fluffy-looking clouds hold water? Why do some clouds produce rain while others do not?

Supporting Question 1

Besides ice and liquid water, what other types of water occur in the atmosphere? How do we know it exists?

Formative Performance Task 1

Supplies needed: Empty Sprite/7-Up can (reserve soda in a clear glass for next task), stove/hot plate, tongs, metal or glass pie plate, water.

Students will demonstrate the existence of invisible water vapor and learn its role in the water cycle.

Featured Sources 1

OU CIWRO Science Class: Clouds in the Kitchen, mark 1:36-12:48; 14:59-17:35 https://youtu.be/vehXIKsW_9s

Supporting Question 2

How does invisible water vapor turn into clouds we can see?

Formative Performance Task 2

Supplies needed: Clear glass of Sprite/7-Up or other clear carbonated liquid and salt in salt shaker.

Students will observe how aerosol salt particles are needed to form gas bubbles in liquid Sprite, in much the same way aerosols are needed to form liquid droplets in the gaseous atmosphere that includes water vapor.

Featured Sources 2

OU CIWRO Science Class: Clouds in the Kitchen, mark 19:45-23:27 https://www.youtube.com/watch?v=6gs-RJJhZzvA

Supporting Question 3

How does a cloud produce rain? How do scientists observe clouds and measure rain drops?

Formative Performance Task 3

Supplies needed: Flour, cookie sheet, spray bottle with water, and ruler.

Students will simulate their own raindrops, and measure and record their findings. Advanced students may create a graph of their measurements.

Featured Sources 3

OU CIWRO Science Class: Clouds in the Kitchen, mark 23:29-44:02; https://www.youtube.com/watch?v=6gs-RJJhZzvA

Supporting Question 4

What are the shapes of raindrops?

Formative Performance Task 4

Supplies needed: Two supplied raindrop shapes (tear shape and hamburger bun shape)

Students will identify which model looks like a real raindrop. Supplied pictures of raindrops will show that shapes evolve from spherical for small raindrops to oblate sphereoids (hamburger buns) as the raindrops get larger. Advanced students can identify force caused by a balance between surface tension, drag and gravity.

Featured Sources 4

What Shape Is a Raindrop? (mark 2:22-3:52) https://www.youtube.com/watch?v=UNc3pAa6p3Q

Summative Performance Task

Argument

Supplies needed: Warm water in clear bottle or jar, match, ice in a pie plate, blank 3x5 cards, yarn, and tape.

Students will create a cloud formation timeline, explaining each step of how a cloud forms.

Perform this experiment to create a model of a cloud in a bottle: www.jpl.nasa.gov/edu/learn/project/make-a-cloud-in-a-bottle/ With students working in teams, ask them to explain each step of the cloud formation process they see on a 3x5 card. Teams will then put the steps in order by taping the cards to a cut piece of yarn.

Extension (Optional)

Students will demonstrate how cloud formation relates to the water cycle.

Ask the teams to trade "cloud timelines" and create additional 3x5 cards to illustrate the steps needed to finish the water cycle. Students will tie together the ends of the yarn to show the process is a loop, or cycle.

Taking Informed Action (Optional)

Students will investigate types of aerosols in the atmosphere and research the air quality in their community.

https://earthobservatory.nasa.gov/features/Aerosols
https://www.weather.gov/safety/airquality-aqindex
https://www.weather.gov/safety/airquality
https://www.airnow.gov/sites/default/files/2018-04/aqi_brochure_02_14_0.pdf

Teacher Background Sheet

Water exists in three forms in the atmosphere. We see clouds in the sky with the naked eye due to the presence of **ice (solid)** and **water (liquid)**, and see precipitation at the ground in the form of snow, hail, graupel, and rain. Another form of water in the atmosphere, which is invisible to us, is **water vapor (gas)**. Water vapor is a significant part of and the first step of the water cycle. Water vapor is always present in the atmosphere from the **evaporation** of liquid water on the surface to vapor, but its amount can vary considerably. When air rises in the atmosphere where pressures are less, the air **cools** as it loses energy -- air molecules are doing the work to expand the air volume. As water vapor molecules cool in the higher atmosphere, they **condense** onto **aerosol** particles generating tiny liquid water droplets or **freeze** onto aerosols generating ice crystals. As the cloud droplets grow bigger, they collide with each other, generating larger drops. When the drops become large enough, **precipitation** falls from the cloud, most likely in the form of rain or snow. The liquid water or ice can subsequently evaporate or **sublimate**, continuing the water cycle.

As seen in the imploding can experiment, the majority of liquid water molecules are held to the liquid water surface by intermolecular bonds. When the liquid water is heated, the internal energy of the liquid molecules increases so that more are able to escape the intermolecular bonds and become gaseous water vapor molecules in a process called **evaporation**. When the can is removed from the heat source and flipped over in the cool water, the temperature decreases and the molecules have less internal energy. With their reduced energy, some are not able to escape the intermolecular bonds when they collide with the liquid surface, so that they **condense** into liquid water. Thus, there are fewer vapor molecules inside the can and hence less pressure exerted on the can walls compared to the pressure of the air outside the can pressing inwards so that the can is crushed.

As seen in the salt experiment, carbon dioxide is trapped in the soda. When salt is added, the carbon dioxide attaches to the salt and forms bubbles in much the same way that water vapor condenses onto aerosols forming cloud drops in the atmosphere, with the aerosol dissolving in each drop. **Aerosols** are tiny solid or liquid particles in the air. The aerosols provide a surface on which the water vapor can **condense** and form liquid drops. Clouds are visible collections of liquid drops or ice crystals.

When small cloud droplets collide, they form bigger drops, which eventually grow big enough to become raindrops that fall out of the cloud. Raindrops typically measure 0.5 mm to 5 mm, with the largest ones up to 8 mm. Raindrops are an oblate spheroid shape like the tops of hamburger buns.

In the 1950s, scientists measured cloud droplets under microscopes in much the same way as the flour experi¬ment. Now scientists use electronic probes at the ground, on aircraft, or on balloons to measure the sizes and images of cloud particles, ice crystals, and raindrops. This information is used to improve how cloud properties and processes occurring in clouds are represented in weather models, allowing better predictions of rainfall intensity and location, as well as storm evolution.

Suggested lesson time: Three 50-minute periods

Day 1: Compelling Question, Supporting Questions 1 & 2

Day 2: Review of Previous Questions, Supporting Questions 3 & 4, Introduction of Project

Day 3: Summative Performance Task