ARM

CLIMATE RESEARCH FACILITY

Education and Outreach Lesson Plan

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Grade levels 3-6

Water cycle
Cloud formation
Precipitation patterns
Air pressure

Water Cycle

Objectives

Learn how water moves from the earth, to the sky, and back to the earth in an on-going cycle; observe evaporation and investigate how temperature affects the rate of evaporation.

Background information

Water can exist in three possible states: solid (ice), liquid (drinking water), and gas (steam rising from a hot cup of coffee).

The earth has a limited amount of water, and that water moves from the earth, to the sky, and back down to the earth in what we call the water cycle. The parts of the water cycle are evaporation, condensation, precipitation, and collection.

Evaporation is when the sun heats up the water in rivers, lakes, or the ocean and turns it into vapor (also called steam). Vapor rises from the river, lake, or ocean and goes into the air.

Water vapor in the air gets cold and changes back into liquid, forming clouds. This is called **condensation**. This can be demonstrated by pouring water into a glass with ice on a hot day. Water droplets form on the outside of the glass. This occurs because water vapor in the warm air turns back into liquid when it touches the cold glass.

Precipitation occurs when so much water has condensed that the air cannot hold it anymore. Water falls back to the earth in the form of rain, snow, or hail. If you continue the condensation demonstration, so much water will condense on the glass that it won't be able to hold it all. At that point, water will start dripping down the glass to create a small puddle, and you've created "precipitation."

When water falls back to the earth as precipitation, there are several places it can **collect**:

In oceans, lakes, rivers or streams
On land where it overflows into oceans, lakes, rivers or streams
On land where it soaks into the earth
In bodies of water or on land where it freezes and becomes ice.

Activities:

Observing evaporation:
Students can observe evaporation right in the classroom. Provide students with a ruler and a jar filled with water. You may want to divide the class into groups of five and allow each group their own jar of water. Students will observe the water level throughout the day, taking measurements every hour. Each student in the group can take a turn measuring the water level and recording it on the observation sheet. Students will also record the time of each observation.

Experimenting with the rate of evaporation
Using the scientific method, students will investigate if temperature affects the rate of evaporation. Provide students with 2 jars filled with water. Students will place one jar in direct sunlight and the other jar in the shade (this can also be done in a classroom with large windows). Using a ruler, students will measure the water level of both jars every hour throughout the day.

Observing Evaporation
(student worksheet)

You can observe evaporation right in your classroom. Work with your classmates to perform the following observations. Don't forget to record the data!

WHAT YOU NEED

- Jar
- Water
- Ruler

WHAT TO DO

1. Fill half the jar with water.
2. Measure the amount of water you are starting out with by placing the ruler next to the jar. Record the time starting measurement on the chart below.
3. Measure the water every hour for the next 6 hours and record the time and each measurement on the chart below.

	Start	1 hour	2 hours	3 hours	4 hours	5 hours	6 hours
Time							
Water level measurement							

Write a short summary about your observations:

Experimenting with the rate of evaporation

(student worksheet)

In the last activity, you observed that water will evaporate over a long period of time. Now let's determine if there is something we can do to make the water evaporate faster. Based on the information you have learned so far, do you think **temperature** affects the **rate** of evaporation? Let's use the scientific method to find out.

WHAT YOU NEED

2 jars
1 ruler
Water

WHAT TO DO

1. Measure 3 cups of water in each of the jars.
2. Place one of the jars outside in **direct sunlight** and place the other jar outside in the **shade**.
3. Use a ruler to record the water levels for each jar. Record the water level at the beginning of the experiment and then once every hour for 6 hours.

Hypothesis: From which jar do you think the water will evaporate fastest and why do you think this?

_____

_____

_____

_____

_____

_____.

Record data: Use the following charts to record the water level measurements. Use one chart for the jar in the sunlight and the other chart for the jar in the shade.

Jar in shade	Start	1 hour	2 hours	3 hours	4 hours	5 hours	6 hours
Time							
Water level measurement							

Jar in sunlight	Start	1 hour	2 hours	3 hours	4 hours	5 hours	6 hours
Time							
Water level measurement							

Results: Did the water evaporate faster from the jar in the sunlight or the jar in the shade?

_____

_____

Conclusion: What does this experiment tell you about the rate of evaporation?

_____

_____

_____

_____

Cloud Formation

Objective:

Students will expand on their knowledge of the water cycle and learn how clouds form. They will learn that three things are necessary for cloud formation: cooling of air, water vapor and condensation nuclei. Students will participate in an activity in which they observe and record information about the conditions necessary for cloud formation.

Background information

Heat from the sun warms water that is collected on the surface of the earth and causes evaporation. Water evaporates into the air. As this water is lifted high into the atmosphere, it cools. The higher it goes, the colder the air is. In the cool air of the troposphere, water collects (condenses) on tiny particles in the air, known as condensation nuclei. Many things can serve as condensation nuclei, including dust, pollen, smoke and salt from ocean spray.

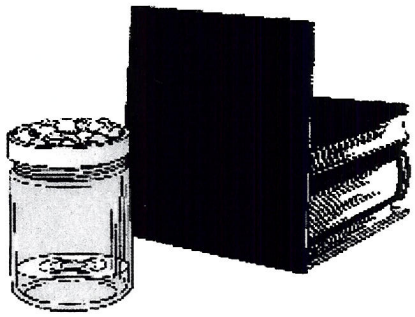
Clouds are composed of water droplets (ice crystals). As the water vapor condenses on the condensation nuclei, it takes the form of tiny water droplets. Many water droplets together compose clouds. Eventually, enough water droplets condense and become large and heavy enough to fall as precipitation.

Activity:

Making clouds

The objective of this activity is to investigate the conditions that must be present for clouds to form. Teacher supervision is necessary for this activity; however it may be easier to divide the class into two groups and perform the activity with each group seperately. The following materials are needed:

1. 1 liter (or larger) clear glass jar with lid (large mouth jars work best)
2. Ice cubes or crushed ice
3. Hot water **Caution:** Even very warm water will do. Do not use water that is hot enough to burn your skin
4. Matches
5. Can of aerosol spray (air freshener is suggested)
6. Black construction paper
7. Safety goggles
8. Flashlight (optional)



Procedure

1. Fill the jar with hot water. Do not use water that is hot enough to burn skin.
2. Pour out most of the hot water, but leave about 2 centimeters of water in the bottom of the jar. Hold the black paper upright or prop it up against some books behind the jar.

3. Turn the lid of the jar upside down and fill it with ice. Now place the lid on the jar as shown below. Observe the jar for 3 minutes. If you have a flashlight, darken the room, and shine the flashlight on the jar while you observe it. Students will record their observations in the box titled "Control" on the student worksheet.
4. Pour the water out of the jar and repeat steps (1) and (2).
5. Prepare the lid so that you can immediately cover the mouth of the jar during the next step.
6. Move all loose papers away from the jar, put on your safety goggles then strike a match and drop the burning match into the jar. Cover the mouth of the jar immediately (with the ice-filled lid). Students will record their observations on the student worksheet in the box marked "Match." Students should be warned to be very careful around matches.
7. Pour out the water in the jar and repeat steps (1) and (2).
8. Spray a very small amount of the aerosol in the jar and immediately cover the mouth of the jar with the ice-filled lid. Explain that the aresol serves as condensation nuclei. Ask students to name other forms of condensation nuclei that exist in the air.
9. Observe what happens in the jar for three minutes and ask students to record their observations on the student worksheet in the box marked "Aerosol."

Students will complete the activity by answering the following question, which are printed on the student worksheet:

1. In all the trials of this experiment, the jar contained water vapor and cooled air. Where did each come from?
2. Did a cloud form the first time you put the lid over the mouth of the jar? How about the second and third times?
3. Define *aerosol.*
4. Based on the definition of aerosol, would you classify smoke as an aerosol?
5. Based on your observations and your answers, what is the other condition besides moisture and cool air necessary for cloud formation?

3. Turn the lid of the jar upside down and fill it with ice. Now place the lid on the jar as shown below. Observe the jar for 3 minutes. If you have a flashlight, darken the room, and shine the flashlight on the jar while you observe it. Students will record their observations in the box titled "Control" on the student worksheet.
4. Pour the water out of the jar and repeat steps (1) and (2).
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Students will complete the activity by answering the following question, which are printed on the student worksheet:

1. In all the trials of this experiment, the jar contained water vapor and cooled air. Where did each come from?
2. Did a cloud form the first time you put the lid over the mouth of the jar? How about the second and third times?
3. Define *aerosol.*
4. Based on the definition of aerosol, would you classify smoke as an aerosol?
5. Based on your observations and your answers, what is the other condition besides moisture and cool air necessary for cloud formation?

Making Clouds

(student worksheet)

Where do clouds come from?
How do they form?

Three things are necessary for cloud formation:

1. **Cooling of air**
2. **Water vapor**
3. **Condensation nuclei**

Work with your teacher and fellow students to make clouds right in your classroom! Record your observations from the Cloud Making activity in the chart below:

Trial	My observations
Control	
Match	
Aerosol	

Now put on your thinking cap and answer these questions on a separate sheet of paper!

1. In all the trials of the experiment, the jar contained water vapor and cool air. Where did each come from?

2. Did a cloud form the first time you put the lid over the mouth of the jar? How about the second and third times?

3. Look up the word aerosol in a dictionary and write down the definition. Do you think smoke is an aerosol?

Precipitation Patterns

Objective

Students will learn that precipitation is an important aspect of weather and climate. Students will also gain experience graphing monthly precipitation patterns for several locations.

Background information

The amount of rain, sleet, snow or hail which falls in a specified time is expressed as the depth of water it would produce on a large, level, impermeable surface. Usually it is expressed in millimeters although inches may sometimes be used. Precipitation is measured daily (24 hours) by means of a rain gauge.

Scientists measure and record precipitation in order to learn more about the weather and climate patterns of a particular area. Creating archives of these precipitation patterns also helps scientists determine what is generally "normal" and what is out of the ordinary. Scientists are not the only people who are interested in precipitation patterns; for example, people involved in agriculture care a great deal about how much precipitation falls in one year because their crops are directly affected. Severe droughts and floods are something everybody should be concerned about.

It is important to realize how much the weather impacts our lives. On a daily basis, we consider the weather when we want to go for a hike, ride a bike, or take a trip to the beach. On a larger scale, the weather affects our world in terms of food supply, health and safety, and economy.

Activities

Essay writing:
Students can be challenged to investigate one case of extreme weather such as a hurricane, tornado, or drought and write about the different ways people were affected by the weather. For example, Hurricane Katrina in 2005 – how did it affect public health and safety, economy and the overall cost of living? Students can use Internet, newspaper or magazine resources to investigate the impacts of their case. The objective of this activity is to make students aware of how much impact the weather has on our lives.

Graph precipitation patterns:
The ARM Program has research facilities located in the Tropical Western Pacific. Scientists from the ARM Program study rainfall patterns from across the Pacific. Students will calculate the total rainfall for each location listed on the *Monthly Rainfall across the Pacific Basin* chart found on the student worksheet. Students will then graph the monthly rainfall for each location. The data is provided on the student worksheet, and students will needed graph paper, rulers, and colored pencils (optional).

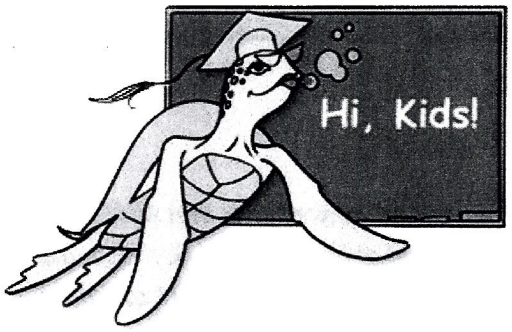
Graphing Rainfall Patterns

(student worksheet)

This chart contains rainfall measurements for six different locations. The measurements are in millimeters, and there is a recording for each month of the year. Can you locate these places on a map or globe?

Monthly Rainfall (mm) Across the Pacific Basin

	Darwin, Australia	Port Moresby, PNG	Manus, PNG	Nauru	Christmas Island, Kiribati	Guayaquil, Ecuador
January	341	178	270	315	330	239
February	338	193	260	206	280	249
March	274	170	305	180	280	277
April	121	107	287	94	230	117
May	9	64	215	53	180	28
June	1	33	308	155	180	8
July	2	28	335	193	100	5
August	5	18	291	193	50	0
September	17	25	257	122	30	3
October	66	36	230	99	30	8
November	156	48	240	152	180	3
December	233	112	311	239	230	51
TOTALS					**2100**	



Which is the wettest place? Which is the driest place? You can answer these questions by adding up the monthly rain measurements for each location. The measurements for Christmas Island are added up for you as an example, but you will have to figure out the rest! **Can you help Teacher Turtle do the math?** Record your answers on the graph.

Answers:

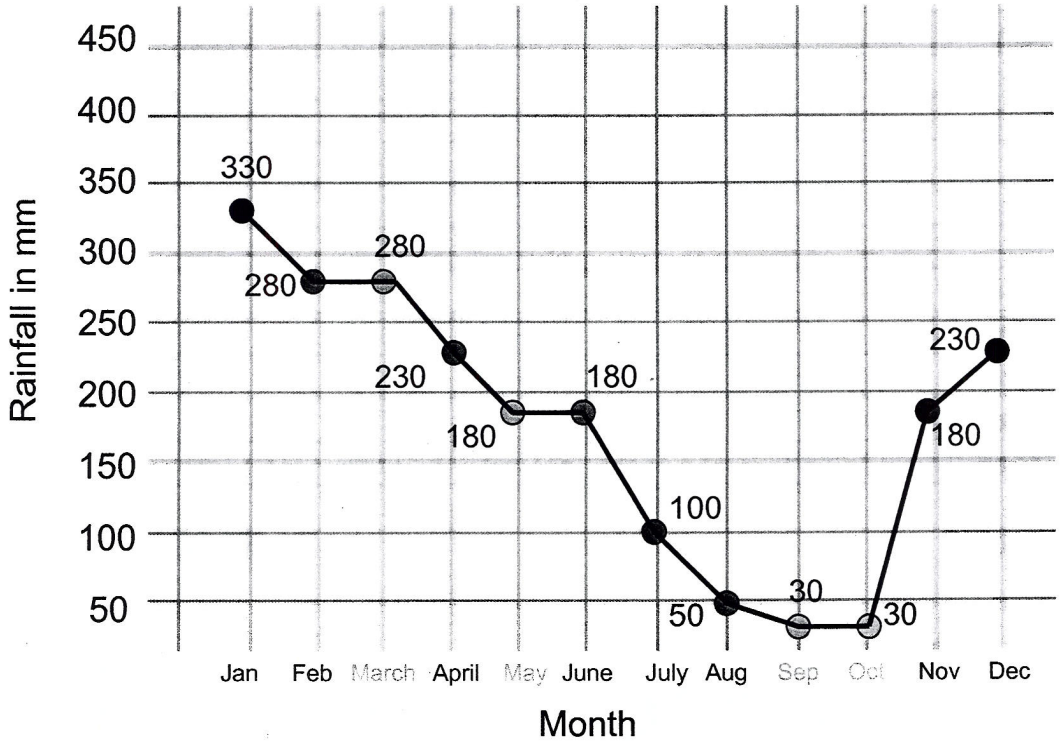
The wettest place is _____

The driest place is _____

Graphing Rainfall Patterns

Graphs and charts are great because they help us organize the information we are studying. Sometimes, complicated information is difficult to understand and needs an illustration or picture to help make it simpler. You will often see graphs and charts in newspapers, school books, and magazines.

Look at the Monthly Rainfall (mm) Across the Pacific Basin chart. During which months do the wet seasons occur? When do the dry seasons occur? **Work with a classmate to make graphs for the rainfall patters of each place.** Your graphs will help you see when the wet and dry seasons occur. Here is an example graph of the rainfall measurements for Christmas Island:



What does the graph show?

According to the graph, Christmas Island experiences a wet season during the months of November, December, January, February, March, April, May and June. *During which three months does Christmas Island get the MOST amount of rain?*

_____

The graph also shows that Christmas Island experiences a dry season during the months of July, August, September and October. *During which three months does Christmas Island get the LEAST amount of rain?*

_____

Air Pressure

Objective

Students will learn the basic concepts of air pressure by conducting two simple experiments. The first experiment illustrates that air does indeed have weight – a concept some students may find difficult to grasp. In the second experiment, students will see how air pressure is exerted equally in all directions.

Background information

There is a blanket of air around the Earth called the atmosphere, and the weight of all that air around us is called air pressure. The air in the atmosphere is kept close to the Earth by gravity – the force that pulls everything on Earth to the ground. Without gravity, everything on Earth would float around like we see when astronauts travel to outer space. Just as gravity gives weight to a desk a pencil or even something as light as a piece of paper, it also does the same thing to air.

Air pressure is not the same every where we go. The air pressure at the top of a very high mountain is less than at the beach (sea level). Above the height of mountains and into the layer of the atmosphere called the stratosphere, the air pressure will decrease until it reaches about zero.

Air pressure also varies over time, and these temporal differences are usually caused by the temperature of the air. Cool air is denser (heavier) than warm air. Warm air is less dense (lighter) than cool air and will therefore rise above it. Areas of high pressure can be caused when cool air is sinking and pressing on the ground. At this time, the weather is usually dry and clear. In contrast, when warm air rises, it causes a region of low pressure. With low pressure, the weather is often wet and cloudy.

Changes in air pressure bring changes in the weather and make winds blow. Air usually moves from areas of high pressure to areas of low pressure, and this produces winds. This can be easily remembered with the phrase: *Winds blow high to low.* Changes in air pressure are measured on an instrument called a barometer.

This background information comes from the Clouds R Us.com web site. If you are interested in directing your students to the web site, the link is www.cloudsrus.com.

Activity One

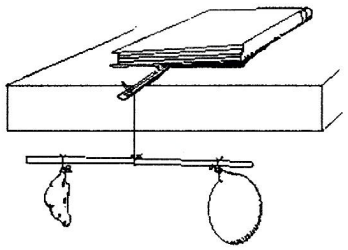
Weighing the Air

It may be hard for students to believe that air has weight. This can be illustrated with a simple experiment using two balloons. Students will test to find out if a balloon is heavier or lighter once air has been blown into it. Divide the students into groups and provide each group with the following materials:

- 1 heavy book
- 1 dowel
- 1 long straw
- 3 pieces of string or yarn about 12 inches long
- 2 small balloons

Procedure

- Place the dowel on a desk so that the majority of the length is over the edge of the desk. Use a heavy book to weigh the dowel down so that it doesn't fall or roll off the desk.
- Tie one end of a piece of string or yarn around the middle of the straw. Tie the other end of that same piece of string around the edge of the dowel. This will serve as a makeshift balance.
- Tie an empty balloon to each end of the straw. What happens? *The two balloons should balance evenly at each end.*
- Now remove one balloon and blow air into it. When you have done that, tie it back onto the end of the straw. Is there any change? *The end with the blow-up balloon on it should dip downwards. This is because the air in the balloon is making it heavier.*



Activity Two

Observing atmospheric pressure

In this experiment, students will investigate the effects of atmospheric pressure. Prior to beginning this activity, students should understand that 1) air has weight and exerts pressure on everything with which it comes in contact and 2) air pressure is exerted equally in all directions. Divide the class into groups and provide each group with the following materials:

- Sturdy paper cup
- Large index cards
- Straight pin
- Water
- Sink or catch tray
- Procedure and student worksheet (attached)

Note: Teachers may need to assist students who have trouble getting the activity to work. It is important that students work carefully and slowly. A break in the seal between the cup and card allows air into the cup, causing the water to fall. If students have trouble getting a seal between the cup and the index card, have them moisten the card slightly before placing it on the cup.

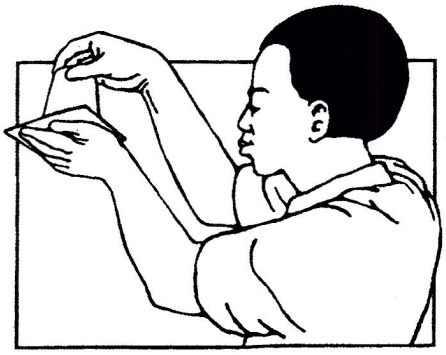
Procedure

Trial 1

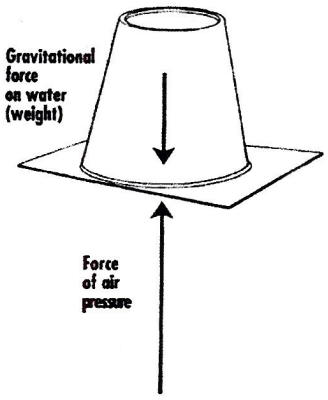
1. Working over a sink or a catch basin, fill a cup to the rim with water. In the box marked "Trial 1 Prediction," suggest what will happen when you turn the cup over. Explain your prediction.
2. Turn the cup over. What happened?

Trial 2

1. Fill the cup again. Cover it with the index card, and make sure that you have created a water seal around the rim of the cup, so no air can seep in. In the box marked "Trial 2 Prediction," suggest what will happen when you turn the cup over with the index card covering it. Explain your prediction.
2. While holding the index card on top of the cup, carefully turn the cup over. Hold the cup around the rim at the bottom so that the cup is not deformed (bent) and remove the hand holding the card. What happened?



Trial 3



Trial 3

1. Using the straight pin, carefully make a hole in the bottom of the cup and remove the pin. Write down your prediction first before you try.
2. Record your observations.

Questions

1. In Trial 1, what caused the water to fall out of the cup?
2. In Trial 2, what held the index card to the cup? What prevented the water from falling out of the cup, as it had done in Trial 1?
3. Explain why the water and the index card fell from the cup in Trial 3 of the activity.
4. Based on your observations, in which direction(s) is air pressure being exerted? Draw a picture representing your explanation and explain the phenomenon of air pressure in your own words.
5. Try to explain why we usually do not feel the pressure of the atmosphere around us. When do we feel air pressures?

Air Pressure

(student worksheet)

Use the following table to write down your predictions before each trial. Then, after each trial, write down what happened and why you think it happened.

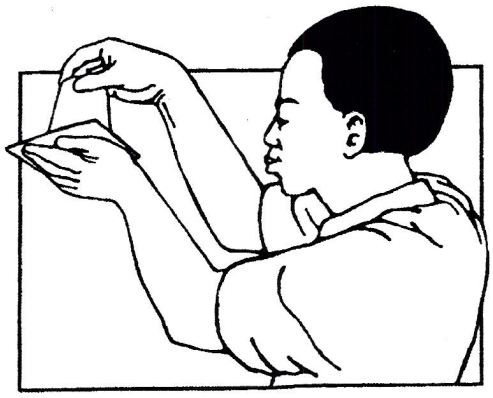
Trial	Prediction	Explanation
1		
2		
3		

Procedure

Trial 1

1. Working over a sink or a catch basin, fill a cup to the rim with water. In the box marked "Trial 1 Prediction," write down what you think happen when you turn the cup over.
2. Turn the cup over. Explain what happened in the box marked "explanation."

Trial 2



1. Fill the cup again. Cover it with the index card, and make sure that you have created a water seal around the rim of the cup, so no air can seep in. In the box marked "Trial 2 Prediction," write down what will happen when you turn the cup over with the index card covering it. Explain your prediction.
2. While holding the index card on top of the cup, carefully turn the cup over. Hold the cup around the rim at the bottom so that the cup is not bent and remove the hand holding the card. Explain what happened in the box marked "explanation."

Trial 3

1. Using the straight pin, carefully make a hole in the bottom of the cup and remove the pin. Write down your prediction first before you try.
2. Write down what happened in the "explanation" box. Why do you think this happened?

Think about it!

1. In Trial 1, what caused the water to fall out of the cup?
2. In Trial 2, what held the index card to the cup? What prevented the water from falling out of the cup, as it had done in Trial 1?
3. Explain why the water and the index card fell from the cup in Trial 3 of the activity.
4. Based on your observations, in which direction(s) is air pressure being applied? Draw a picture to describe your thoughts.