# Weather Detectives

## Activity Book

*Activities to learn about the weather, atmosphere, ocean, and more.*

Activities from NOAA's NWS Jetstream, Online School for Weather (weather.gov/jetstream). Activity book compiled by Michael Erb.

# Cases

Feel free to jump around to cases that interest you. Explore and use your imagination! For more information on any of these topics, check out weather.gov/jetstream.

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*More to come!*

# The Atmosphere

Let's explore the weather! Where to start? With the atmosphere, of course!

The atmosphere is all around us. It stretches up toward outer space and is home to all sorts of exciting weather. It's made of gases like nitrogen, oxygen, argon, water vapor, and more. We breathe the oxygen and the water vapor is an important part of the water cycle and weather.

To better understand the atmosphere, let's do some experiments!

The first two experiments will help us explore the **weight of air**. It's easy to forget that the air has weight, but it does!

The weight of the atmosphere above us (the "atmospheric pressure") can tell us about future weather, so in the third experiment, we **build a barometer**, which is a device to measure the weight of the atmosphere. It's like a scale for the sky. You can use the barometer to make weather predictions.

In experiment four, we explore the energy that sets the atmosphere in motion: **heat from the sun**. By heating some areas of the planet more than others, the sun's heat causes wind, rising air, and weather of all sorts.

Water is also an important part of weather and climate, so three experiments explore **the water cycle**.

The final experiment in this section looks at something farther away: a part of the upper atmosphere called the "ionosphere." The ionosphere is important to radio communication, so we **explore the ionosphere** by looking for radio stations during the day and at night.

The atmosphere is our first stop in learning about *wonderful weather*. Feel free to jump to experiments that interest you the most. Use your wits and imagination. Like a detective, pay attention and think about your findings.

Enjoy!

# Case #1: Heavy Air

## Overview

To show that air has weight, the air is removed from one of two balanced balloons throwing the balance off.

| | |
|---|---|
| **TOTAL TIME** | 10 minutes. |
| **SUPPLIES** | Yard/meter stick; two large balloons; string; transparent adhesive or masking tape |
| **PRINTED/AV MATERIAL** | None |
| **TEACHER PREPARATION** | You can have someone hold the string (attached to a year/meter stick) or you may want to have a piece of string hanging from the ceiling before class. |
| **SAFETY FOCUS** | Severe thunderstorm safety |

## Procedure

1. Inflate two balloons so they are the same size.
2. Tape one balloon to each end of the yard/meter stick.
3. Tie a string to the center of the stick and adjust it so the stick balances when held by the string. Tape the string in place to prevent it from slipping.
4. Ask the students, "If one end were heavier, would the heavier end move up or down?"
5. Carefully deflate the other balloon. Try poking the balloon with a pin in its neck to prevent the balloon from tearing apart as it pops.
6. Let both balloons hag freely on the yard/meter stick. Ask the students to explain what happens to the balance.

## Discussion

Air is all around us. This air is composed of atoms and molecules. Despite their small size, the quantity of atoms and molecules exert weight on us known as pressure. Since our bodies are designed to live in this environment, we do not notice the pressure.

Since the inflated balloon now weighs more than the deflated one (due to the air inside of the balloon) it will sink creating an imbalance. Now, imagine the weight of air if that balloon were now 15 miles (24 km) tall.

That is actually what is occurring at this moment in your classroom. When we measure air pressure with a barometer, we are measuring the weight of a column of air 15 miles (24 km) high directly over us.

# Building a Weather-Ready Nation

The weight of molecules also affects the weather. One measure of the severity of a thunderstorm is the wind speed. In addition to the size of hail, the National Weather Service defines a severe thunderstorm as one containing wind speed of 58 mph (50 kt / 93 km/h) or greater.

The weight of all of the molecules in wind of 58 mph (50 kt / 93 km/h) is the force that can create hazardous weather conditions such a blowing down phone and power lines, trees, and make driving hazardous. When the National Weather Service issues a Severe Thunderstorm Warning it means a thunderstorm with wind gusts to at least 58 mph (50 kt / 93 km/h) and/or hail size of 1" (2.5 cm) or greater is occurring or about to occur near you.

Discuss severe thunderstorm safety with your family. Know where your safe rooms are. Know what to do in case all family members are not together. Preparing for a disaster ahead of time helps reduce fear and lets everyone know how to respond during a severe thunderstorm.

Take an American Red Cross first aid and CPR course to learn how to treat burns and administer CPR. You need to know how to respond in an emergency, because severe weather can strike almost anywhere in the country.

*Credit: Activity from NOAA's NWS Jetstream, Online School for Weather (weather.gov/jetstream)*
*Discover more fun at WeatherDetectives.org*

# Case #2: A Pressing Engagement

## Overview

We typically do not "feel" atmospheric air pressure. Why? Since air surrounds our bodies, and all things, the pressure, as a result of the air, is applied equally on all sides. For example, if someone holds an 8½x11" sheet of paper by their hand at arm's length, the weight of the air directly above the sheet is over 1,300 pounds.

Obviously, the paper does not weight that much. Why? That same pressure (14.7 pounds per square inch) is also pressing up on the bottom side of the paper. The equal pressure on all sides cancel each other out so all that is left is the weight of the material that comprises the paper.

Since we do not normally "feel" air pressure, the student will see how the effect of the air pressure on two sheets of paper.

| | |
|---|---|
| **TOTAL TIME** | 2 minutes |
| **SUPPLIES** | Ruler; a sheet of printer paper; newspaper |
| **PRINTED/AV MATERIAL** | None |
| **TEACHER PREPARATION** | None |
| **SAFETY FOCUS** | Thunderstorm safety |

## Procedure

1. Lay a ruler on a table with about 3" (8 cm) hanging over the edge.
2. Lay a sheet of printer paper on the part of the ruler in direct contact with the table.
3. Press the paper against the table until it is flat as possible.
4. Press down on part of the ruler hanging over the edge.
5. Repeat the above steps except replace the printer paper with a large sheet of opened newspaper in the second step.

## Discussion

The student will discover the newspaper was much harder to lift than the printer paper. As the ruler lifted the printer paper, air rush in under the rising paper and thereby quickly allowed the air pressure to equalize on all sides. Essentially, the

weight of the air above the paper had no effect on the difficulty in lifting the paper.

As the ruler lifted the newspaper, the edges of the newspaper remained in contact with the desk. Very little air was allowed to rush in and equalize the pressure on the bottom side of the newspaper. Since there is less air below the paper the pressure is less as well. Now the weight of all the air above the paper now becomes more evident.

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# Case #3: Measure the Pressure - The "Dry" Barometer

## Overview

Barometers using mercury are heavy and fragile. The idea of "dry" barometer was conceived by Gottfried Wilhelm Leibniz around 1700. The idea was to detect pressure changes using sealed bellows. The first working version of an aneroid (without water) barometer was built in 1843 by French scientist Lucien Vidie.

This made the barometer very portable and it became commonly use meteorological instrument. It was still calibrated to the mercurial barometer with readings in inches of mercury.

Even as late as the 1990s, National Weather Service offices still calibrated and verified the accuracy of the aneroid barometer with the mercurial barometer. Using simple items, the student will make a device for indicating air pressure changes, called an aneroid barometer.

| | |
|---|---|
| **TOTAL TIME** | Construction time 10 minutes. Observation time 5-10 days. |
| **SUPPLIES** | Straw; Small metal coffee can; Plastic wrap; Scissors; Index card; Rubber band |
| **PRINTED/AV MATERIAL** | None |
| **TEACHER PREPARATION** | None |
| **SAFETY FOCUS** | Thunderstorms safety |

## Procedure

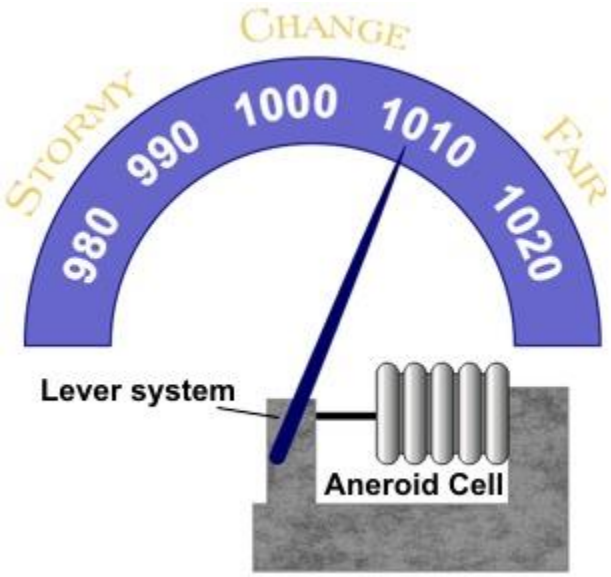
1. Cover the top of the coffee can tightly with the plastic wrap, using the rubber band to hold it in place. (The cover should be a taut, airtight fit.)
2. Position the straw so that it lays across two thirds of the cover with the remaining length of the straw suspended over air. Tape in place.
3. Fold one short end of the index card, about one inch from that end, at a 90° angle. Tape the folded end of the index card to the can behind the straw in such a way that allows you to make marks on the card every day.
4. Record the level of the straw onto the card.
5. For the next 10 days, at the same time each day, record the level of the straw while paying close attention to how changes in the weather affect the straw's level.

# Discussion

What the students have constructed is similar to an aneroid barometer. It is the most common type of barometer for home use.

The aneroid cell volume is very sensitive to changes in atmospheric pressure as it expands and contracts as air pressure decreases or increases. Attached to the aneroid cell is a lever indicating the air pressure. In this case, the aneroid cell is the coffee can.

In this barometer, high pressure in the atmosphere will weigh more the pressure inside the can at the time the barometer was constructed. That added weight will force the plastic wrap into the can, causing the straw tip to rise, indicating higher pressure.




*The basic function of an aneroid barometer*

The opposite will occur when low pressure is in the area. The decrease in weight of air on top of the can will help cause the plastic wrap to rise, therefore lowering the straw tip.

Today, sensitive electronic sensors have replaced the metal aneroid cell in most barometers. Yet, those electronic sensors need to be calibrated to ensure their accuracy. For that calibration, we still use mercurial barometers.

## Building a Weather-Ready Nation

One measure of the severity of a thunderstorm is the wind speed. In addition to the size of hail, the National Weather Service defines a severe thunderstorm as one containing wind speed of 58 mph (50 kt / 93 km/h) or greater.

The force of all of the molecules moving at 58 mph (50 kt / 93 km/h), or more, can create hazardous weather conditions such a blowing down phone and power lines, trees, and make driving hazardous. When the National Weather Service issues a **Severe Thunderstorm Warning** it means a thunderstorm with wind gusts to 58 mph (50 kt / 93 km/h) or greater and/or hail size of 1" (2.5 cm) or greater is occur or about to occur near you.

Discuss severe thunderstorm safety with your family. Everyone should know what to do in case all family members are not together. Discussing disaster response ahead of time helps reduce fear and lets everyone know what to do should a severe thunderstorm occur.

*Credit: Activity from NOAA's NWS Jetstream, Online School for Weather (weather.gov/jetstream)*
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# Case #4: Melts in your bag, not in your hands

## Overview

The earth receives its heat from the sun in the form of radiation. Many in the animal kingdom lay out in the sun to absorb this form of energy to warm their bodies. This form of energy is vital to life on this planet. The student will learn how the sun transfers heat to the earth through radiation.

| | |
|---|---|
| **TOTAL TIME** | 25 minutes |
| **SUPPLIES** | Two (2) small pieces of chocolate, Two (2) small resealable snack bags |
| **PRINTED/AV MATERIAL** | None |
| **TEACHER PREPARATION** | This works best on a hot sunny day. You can also complete this demonstration indoors on a sunny winter day. |
| **SAFETY FOCUS** | Summer weather Safety |

## Procedure

1. Place one piece of chocolate in a bag, seal it and label it with an 'A'.
2. Do the same with the second piece of chocolate but label that bag with a 'B'.
3. Take both bags outside and place bag 'A' in the sun and bag 'B' in the shade. Suspend bag 'A' in such a way to ensure is not touching the ground or located near a wall to limit any transfer of heat by convection or conduction. (If this experiment is done indoors, place bag 'A' in the window, exposed to the sun and keep bag 'B' in the shade.)
4. 20 minutes later, inspect the chocolate in both bags.
5. Ask the students to explain any change in consistency of the chocolate.

## Discussion

Depending on how hot it is, the chocolate in the shade may also be softened or even partially melted. However, the chocolate in bag 'A' will be more melted. The bulk of the heating that takes place in bag 'A' is from direct solar radiation. This radiation is what causes objects, such as the metal on automobiles, to become hot. Radiation also causes sunburns.

# Building a Weather-Ready Nation

Melanoma is the most serious type of skin cancer, and accounts for more than 75% of the deaths due to skin cancer. In addition to skin cancer, sun exposure can cause premature aging of the skin, wrinkles, cataracts, and other eye problems.

When you play outdoors, there are five important steps you can take to protect against UV radiation and skin cancer:

- **Cover up.** Wear clothing to protect as much of your skin as possible. Wear clothing that does not transmit visible light. To determine if clothing will protect you, try this test: Place your hand between the fabric and a light source. If you can see your hand through the fabric, the garment offers little protection against sun exposure.
- **Use a sunscreen**. Experts recommend products with a Sun Protection Factor, or SPF, of at least 15. The SPF number represents the level of sunburn protection provided by the sunscreen. Products labeled "broad spectrum" block both UVB and UVA radiation. Both UVA and UVB contribute to skin cancer.
- **Wear a hat.** A wide-brimmed hat is ideal because it protects the neck, ears, forehead, nose and scalp. A baseball cap provides some protection for the front and top of the head, but not for the back of the neck or the ears where skin cancers commonly develop.
- **Wear sunglasses**. UV-absorbent sunglasses can help protect your eyes from sun damage. Ideal sunglasses do not have to be expensive, but they should block 99 to 100 percent of UVA and UVB radiation. Check the label to make sure they do. Darker glasses are not necessarily the best. UV protection comes from an invisible chemical applied to the lenses, not from the color or darkness of the lenses.
- **Limit direct sun exposure.** UV rays are most intense when the sun is high in the sky, between 10 a.m. and 4 p.m. If you are unsure about the sun's intensity, take the shadow test: If your shadow is shorter than you, the sun's rays are the strongest. Seek shade whenever possible.

**Remember: There is NO SAFE WAY TO TAN, including the use of tanning beds.**

*Credit: Activity from NOAA's NWS Jetstream, Online School for Weather (weather.gov/jetstream)*
*Discover more fun at WeatherDetectives.org*

# Case #5: Sweatin' to the Coldies

## Overview

There are three states of matter; gas, liquid, and solid. Water in our atmosphere exists in these three states constantly. As the temperature of water vapor (a gas) decreases, it will reach the point at which it turns into a liquid (called the dew point or the point at which dew forms). This change of state from a gas to a liquid is called condensation.

Using some ice and a glass, the students will chill the glass to the point where water from the atmosphere will condense on the outside of the glass. This demonstrate the change of state of water vapor to liquid.

| | |
|---|---|
| **TOTAL TIME** | 30 minutes |
| **SUPPLIES** | Glass cups or jars, Ice cubes |
| **PRINTED/AV MATERIAL** | None |
| **TEACHER PREPARATION** | This can be done as a class demonstration or you can divide the students into pairs should you have enough glass jars. You can also shorten this experiment by using crushed ice instead of cubed ice. Crushed ice chills water quicker, causing condensation sooner. |
| **SAFETY FOCUS** | Flash Flood Safety |

## Procedure

1. Fill the cups/jars with ice.
2. Add cold water to the cups/jars.
3. Let the cups/jar set for about 30 minutes.
4. Observe the outside of the glass for condensation.

## Discussion

Ask the students where the water on the outside of the glass came from. The answer is from the atmosphere. As air comes in contact with the glass, it is cooled to below the dew point temperature and the water vapor contained in the air condenses onto the glass.

The amount of water on the side of the glass depends upon the humidity which is the ratio of dry air to moist air. The higher the humidity the more moisture that air contains. The greater the moisture, the greater the water that can condense.

As an aside, you can repeat the process with different types of drinking containers, such as plastic and Styrofoam. Ask the students why there is a difference in the amount of water condensing onto each type.

# Building a Weather-Ready Nation

The amount of moisture in the atmosphere is indicated by the dew point temperature. As the dew point increases, so does the potential for the amount of rain produced by a thunderstorm increase. Stationary or slow-moving thunderstorms produce heavy rain over small areas and increase the risk of flash flooding.

Hilly and mountainous areas are especially vulnerable to flash floods, where steep terrain and narrow canyons can funnel heavy rain into small creeks and dry ravines, turning them into raging walls of water. Even on the prairie, normally-dry draws and low spots can fill with rushing water during very heavy rain.

Take time to develop a flood safety plan-for home, work, or school, and wherever you spend time during the summer. The National Weather Service has additional information about flood safety and a brochure "Floods and Flash Floods...The Awesome Power".

**Preparations at home and work:**

- Determine if you are in a flood-prone area. If you are, know where to go if the water starts to rise. Have an escape route if you have to leave quickly.
- Make a safety kit containing: A flashlight and extra batteries, battery-powered weather radio receiver and commercial radio, extra food and water, first-aid supplies, canned food and a can opener, water (three gallons per person), extra clothing, and bedding. Don't forget special items for family members such as diapers, baby formula, prescription or essential medications, extra eyeglasses or hearing aids, and pet supplies.
- Know how and when to shut off utilities: Electricity, gas, and water.
- Seek sources for obtaining local warning information such as from cable TV or the NOAA Weather Radio.

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# Case #6: The Rain Man

## Overview

What goes up, must come down. Precipitation is the most commonly seen aspect of the hydrologic cycle. Students will learn how the water cycle works using 3-D paper craft activity. The students will see a demonstration the concept of precipitation.

| | |
|---|---|
| **TOTAL TIME** | 30 minutes |
| **SUPPLIES** | Mayonnaise size glass jar, Resealable sandwich bag, Ice cubes, Hot water |
| **PRINTED/AV MATERIAL** | None |
| **TEACHER PREPARATION** | None |
| **SAFETY FOCUS** | Flash Flood Safety |

## Procedure

1. Add about two inches (5 cm) of hot water to the mayonnaise jar.
2. Add the ice cubes to the sandwich bag and seal it.
3. Place the sandwich bag over the mouth of the jar, allowing one end of the bag to form a tip inside of the jar. This will allow the condensed water to collect at one location.
4. After a few minutes, the water (rain) will begin to drip from the sandwich bag, returning to the water.

## Discussion

Water vapor will rise from the hot water and come into contact with the bag fill with ice. The ice will cause the water to condense forming drops which will drop back into the water.

Despite the sometimes-excessive rainfall that occurs, only about 0.3% of all water on the earth is found in the atmosphere. Of that 0.3%, most of the water in the atmosphere is in form of a gas called water vapor.

So, while the hydrologic cycle is essential for life due to the water it brings, the vast amount of water in the cycle is found in the oceans, lakes, and ground water.

# Building a Weather-Ready Nation

- If a flash flood warning is issued, get to higher ground immediately! Follow evacuation instructions, but don't wait for them if you think you are in danger.
- Do not drive across flooded roads or bridges-they may be washed out.
- If your vehicle stalls in water, abandon it and get to higher ground. It takes only a foot or two of rapidly-moving water to sweep away a car.
- Walking or playing around flood waters is dangerous; you can be knocked from your feet in water only six inches deep!

*Credit: Activity from NOAA's NWS Jetstream, Online School for Weather (weather.gov/jetstream)*
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# Case #7: Water Cycle Paper Craft

## Overview

Water moves from the ground to the atmosphere and then returns to the ground, however, the actual path water takes in its cycle is more complicated. There are many stops on water's journey. Students will learn how the water cycle works using 3-D paper craft activity.

| | |
|---|---|
| **TOTAL TIME** | 40 minutes |
| **SUPPLIES** | Scissors, scotch tape or glue, colored pencils |
| **PRINTED/AV MATERIAL** | Water Cycle paper craft (pdf). With labels<br>Without labels (printed on 8½x14" paper)<br>Optional: full color version |
| **TEACHER PREPARATION** | Regular copier paper can be used. For a sturdier model use card stock. The pdf can be scaled down to fit letter-size paper but the model will be very small and more difficult to assemble. You can bypass the coloring part of the activity by printing the full color version. |
| **SAFETY FOCUS** | Flash Flood Safety |

## Procedure

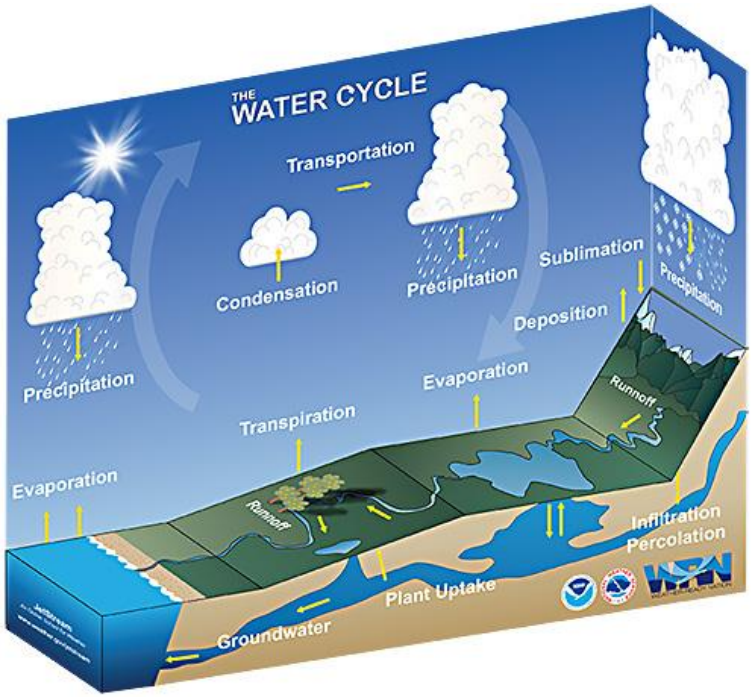
1. The paper craft consists of two sections: the 'earth' and the 'atmosphere'. First have students color their water cycle paper craft. They can use this image as a guide for color choices.
2. If using the un-labeled pdf have the students add labels while you discuss the function of each portion of the water cycle. (see discussion below). The 'surface flow' label in the mountain region should be added upside down so it will display correctly when the paper craft is assembled.


*Water Cycle paper craft: Full color | B&W with labels | B&W without labels.*

3. Carefully cut out both base and atmosphere sections. Cut only along solid lines. DO NOT cut dashed lines.
4. Fold paper craft along dashed lines.
5. Beginning with the base, line up tabs with folds and carefully tape or glue tabs to their corresponding surface. If using glue, use sparingly. Using too much glue will warp the paper.
6. Attach the atmosphere cutout to the back side of the paper craft.
7. Optional: glue small pieces of cotton balls over the clouds on the atmosphere cutout.

# Discussion

The water cycle is more complicated than is depicted in typical diagrams. Often the diagrams show water evaporating over the ocean then moving onshore before precipitating. Actually, evaporation and precipitation occur all over the earth and can occur at the same time in the same location. This process is why humidity increases during precipitation and the liquid evaporates back into water vapor.




*Folded full color version of the paper craft.*

The water cycle and is divided into three main parts:

1. Moisture moving into the atmosphere
2. Moisture moving through the atmosphere
3. Moisture returning to the earth

Since water covers nearly 71% of the Earth's surface, the greatest source for moisture are these huge water bodies.

**Evaporation** is water changing from a liquid to a gas. Evaporation requires a source of heat. The sun is the primary engine for evaporation. On average, about 47 inches of water (120 cm) is evaporated into the atmosphere from the ocean each year. Your body's heat causes water on your skin to evaporate. That why you feel cold when you step out of a pool or shower. Your using your body's heat to dry off.

**Sublimation** is the change of state from ice, a solid, to water vapor, a gas, without becoming a liquid first. Given enough time, snow and ice will disappear by sublimation.

**Transpiration** is evaporation of water from plants and trees into the atmosphere. Nearly all (99%) the water that enters the roots transpires into the atmosphere.

Once in the atmosphere water vapor can undergo the following changes...

**Condensation** is the change of water vapor, a gas, into liquid. We see the end result of condensation as clouds which consists of huge numbers of tiny liquid drops. The clouds can also undergo evaporation, returning the liquid back into a gas.

**Transportation** is the motion of moisture as a result of the wind. Without this movement, the water evaporated over the ocean would not precipitate over land.

The moisture returns to the earth three ways...

**Deposition** changes water vapor directly into a solid (ice), bypassing the condensation process. This process is how frost forms on cloudless winter nights. When the sun rises, most of the frost will again evaporate or sublimate back into the atmosphere.

**Precipitation** returns water to the earth as rain, snow, ice pellets (sleet) and hail.

**Infiltration** is the movement of water into the ground from the surface. Simply put, the ground gets wet and muddy. The moisture then evaporates into the atmosphere or trees and plants use some of the moisture, which they later return to the atmosphere through transpiration.

The water returns to the ocean in one of two ways...

**Percolation** is water seeping down past the soil, deep into the ground water.

**Surface Flow** is water that does not move into the soil but instead runs off into creeks, streams, and rivers to flow back to the ocean.

All of these processes are happening constantly. What is left out of the water cycle above is the human and animal component. Moisture taken in by the body is used to move food and blood around our bodies then eliminated back into the environment in many different ways.

# Building a Weather-Ready Nation

Flash floods are the deadliest natural disaster in the world. They are caused by stationary or slow-moving thunderstorms that produce heavy rain over a small area.

Hilly and mountainous areas are especially vulnerable to flash floods, where steep terrain and narrow canyons can funnel heavy rain into small creeks and dry ravines, turning them into raging walls of water. Even on the prairie, normally-dry draws and low spots can fill with rushing water during very heavy rain.

Take time to develop a flood safety plan-for home, work, or school, and wherever you spend time during the summer. The National Weather Service has additional information about flood safety and a brochure "Floods and Flash Floods...The Awesome Power".

**Preparations at home and work:**

- Determine if you are in a flood-prone area. If you are, know where to go if the water starts to rise. Have an escape route if you have to leave quickly.
- Make a safety kit containing: A flashlight and extra batteries, battery-powered weather radio receiver and commercial radio, extra food and water, first-aid supplies, canned food and a can opener, water (three gallons per person), extra clothing, and bedding. Don't forget special items for family members such as diapers, baby formula, prescription or essential medications, extra eyeglasses or hearing aids, and pet supplies.
- Know how and when to shut off utilities: Electricity, gas, and water.
- Seek sources for obtaining local warning information such as from cable TV or the NOAA Weather Radio.

*Credit: Activity from NOAA's NWS Jetstream, Online School for Weather (weather.gov/jetstream)*
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# Case #8: AM in the PM

## Overview

Demonstrate that AM radio signals can travel many 100's of miles at night. The student will listen to as many radio stations as possible obtaining the call signs and places of origin during the evening (after sunset) hours.

| | |
|---|---|
| **TOTAL TIME** | 30 minutes to two hours during the evening (or early in the morning before sunrise). |
| **SUPPLIES** | Radio with an AM band; Pen/pencil |
| **PRINTED/AV MATERIAL** | Radio Station Reception Form (pdf) |
| **TEACHER PREPARATION** | Supply the students with a list of the **local** AM radio stations. |
| **SAFETY FOCUS** | NOAA Weather Radio |

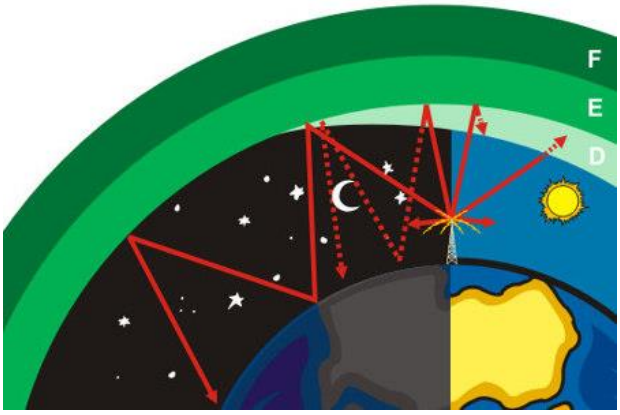
## Procedure

1. Most homes should have some sort of portable AM radio. If not, automobile radios will often work well. (Have the student to ask a parent or guardian to help supervise them while listening to AM radio stations in an automobile. Students without a valid driver's license are not to be left alone with keys to the vehicle.)
2. Search for a radio signal that is not from a local station. (Most will be faint but the reception is usually clear enough to understand.) Stations broadcasting sporting events are easy to identify.
3. Listen for the station identifier "call sign". The call sign is a three- or four-letter identifier beginning with the letter "W" or "K". In the U.S. stations are required to broadcast their call sign within 5 minutes of the top of the hour.
4. Log the call sign and location (city) of the transmission. Also note the quality of the signal. Was it loud? Soft? Fade in and out? etc., and the what was broadcast; news, sports, etc., Was there a lot of static?
5. Search for another signal and repeat.
6. You can compare the students results with the list of clear channel stations. It is entirely possible that students hear broadcasts that are not local *and* not one of the powerful nighttime radio stations.

# Discussion

During the daytime, the distance the AM radio signal travels is the distance the ground wave travels based upon the power of the transmitter. The signal also reaches the ionosphere.

The D-Layer of the ionosphere plays an interesting role. While there are no radio signals reflected off this layer it does absorb AM radio signals. Because of the absorption of the signal, there are also more radio stations transmitting during the daytime and these stations can often transmit at higher power.




Comparison showing how the D-layer affects daytime and night time radio transmissions.

At night, the D-Layer disappears and the transmitted signal can then bounce off the ionosphere and return back to the earth. As a result, some low power stations must cease transmission at sunset while others reduce their transmitted power to reduce interference.

However, there are high power clear channel stations that can broadcast all night. It is these stations the students will most likely find.

## Building a Weather-Ready Nation

NOAA Weather Radio (NWR) is a nationwide network of radio stations broadcasting continuous weather information direct from a nearby National Weather Service office. NWR broadcasts National Weather Service warnings, watches, forecasts and other hazard information 24 hours a day.

Working with the Federal Communication Commission's (FCC) Emergency Alert System, NWR is an "all hazards" radio network, making it your single source for comprehensive weather and emergency information. NWR also broadcasts warning and post-event information for all types of hazards--both natural (such as earthquakes and volcano activity) and environmental (such as chemical releases or oil spills).

Known as the "Voice of the National Weather Service," NWR is provided as a public service by the National Oceanic & Atmospheric Administration (NOAA), part of the Department of Commerce. NWR includes more than 900 transmitters, covering all 50 states, adjacent coastal waters, Puerto Rico, the U.S. Virgin Islands, and the U.S. Pacific Territories. NWR requires a special radio receiver or scanner capable of picking up the signal.

For more information, go to the NOAA weather Radio website.

# The Ocean

Grab your scuba suit. It’s time to explore the oceans!

The oceans are vast. They are full of fascinating creatures, sunken ships, and unimaginable amounts of water.

Oceans are also important to weather!

We start by looking at a basic aspect of ocean water: salt. Unlike most lakes, oceans are filled with saltwater, which was transported there by billions of years of runoff from the land. Salt affects the density of water. Explore this by **floating eggs in fresh and salt water**.

Salt doesn’t affect weather directly, but it's key for understanding *ocean circulations*,

which we explore next. Ocean waters are constantly moving, transporting heat and nutrients around the earth. This is a big influence on many climates around the world, especially ones near the coast.

Ocean currents are driven by two things: wind and density. Surface currents are driven by wind, which we explore by **creating our own wind on the surface of water**. Deeper currents are driven by changes in density; cold and salty water is denser, meaning it will sink more easily. This happens more near the poles. We explore this by **melting colored ice cubes**.

The final activity explores tides, which are driven by gravity from the moon and sun. To better understand the relationship between the earth, moon, and sun, we **recreate orbits with a ball and lamp**.

The oceans are fundamental to Earth's climate. Most of the earth's water is in the oceans, which affects precipitation, temperature, and weather patterns. The oceans also transport heat around the world, affecting climate in many regions. For example, warm ocean currents make Europe warmer!

So, ready to explore the oceans? Let's go!

# Case #9: Salt 'n Lighter

## Overview

Just as air can have different densities, water can have different densities as well. As the salinity of water increases, the density increases as well. Fresh eggs will float saltwater, but will sink in freshwater. This will show that as the salinity increases the density also increases.

| | |
|---|---|
| **TOTAL TIME** | 3 minutes as a demonstration, 10 minutes if students perform the demonstration. |
| **SUPPLIES** | 3 fresh eggs; 3 - 1.5-liter beakers (or quart jars); 6 ounces of salt. |
| **PRINTED/AV MATERIAL** | None |
| **TEACHER PREPARATION** | None |
| **SAFETY FOCUS** | Turn Around, Don't Drown® |

## Procedure

1. Fill each beaker with one liter of tap water (or each quart jar with one pint of water).
2. Add 35 grams of salt to one beaker and 290 grams of salt to a second beaker (½ ounce of salt to one-quart jar and 4½ ounces of salt to a second jar).
3. Ask the students to speculate in which water solution, if any, will the eggs float.
4. Place an egg in each solution and observed which egg floats.

## Discussion

Fresh eggs are more dense than fresh water and therefore will sink. However, as the water's salt content increases, it becomes denser. The eggs float in the two beakers with the added salt.

The solution with the 35 grams of salt represents the salinity of the oceans. The solution with 290 grams of salt added represents the salinity of the Dead Sea. The egg in the beaker with the most salt should float higher than the egg in the less salty solution.

The increased density of salty water increases the weight of water. An egg will be buoyant (float) if the weight of the egg is *less* than the weight of the water it displaces. The egg sinks if it weighs *more* than the weight of the water that is displaced.

Ships float for the same reason. Their physical weight is less than the weight of the water that is displaced. Since the weight of the water is greater, ships float.

Sizes of some large ships and the weight of the that is displaced

| Ship | Year Built | Type | Owner | Length (Feet) | Width (Feet) | Weight (Tons) |
|---|---|---|---|---|---|---|
| Titanic | 1912 | Liner | White Star Line | 883 | 92 | 46,328 |
| Queen Mary | 1934 | Liner | Cunard | 1,019 | 119 | 81,237 |
| Bismark | 1939 | Battleship | Germany | 880 | 120 | 50,000 |
| Missouri | 1944 | Battleship | United States | 887 | 108 | 58,000 |
| Enterprise | 1962 | Aircraft Carrier | United States | 1,101 | 133 | 89,600 |
| Ronald Reagan | 2003 | Aircraft Carrier | United States | 1,092 | 134 | 101,000 |
| Queen Mary 2 | 2004 | Liner | Cunard | 1,132 | 135 | 149,000 |
| Madrid Maersk | 2017 | Container ship | Maersk Line | 1,309 | 192 | 214,000 |
| Harmony of the Seas | 2016 | Cruise ship | Royal Caribbean | 1,188 | 215 | 227,000 |
| Mont* | 1981 | Supertanker | Amber Development Corp. | 1,504 | 226 | 647,000 |
| *a.k.a. Knock Nevis, Jahre Viking, Happy Giant, Seawise Giant | | | | | | |

# Building a Weather-Ready Nation

**Turn Around, Don't Drown**

During periods of very heavy rainfall and flash flooding is occurring, many people risk their lives by driving through flooded roads. People erroneously think their "heavy" vehicle will keep them on the road.

Look once again at the size and weight of the ships in the table above. If these vessels float what would make a person think their puny 2-ton vehicle will not float?

When it comes to flooding, just "Turn Around Don't Drown". Either find an alternative route to your destination or wait until the water subsides. It is not worth the risk to attempt a crossing of a flooded road!

*Credit: Activity from NOAA's NWS Jetstream, Online School for Weather (weather.gov/jetstream)*
*Discover more fun at WeatherDetectives.org*

# Case #10: How it is Currently Done

## Overview

The constant pushing of molecules into each other is the reason we feel wind. As one molecule bumps into another, it transfers energy into the next molecule. This constant pushing on the ocean's surface also transfers energy to the water. This energy transfer is responsible for the motion of the world's ocean currents. Students will make their own ocean currents using straws and black pepper.

| | |
|---|---|
| **TOTAL TIME** | 10 minutes |
| **SUPPLIES** | One coffee stir straw per student; One baking pan (or pie pan) for each group of four students; Coarse ground black pepper. |
| **PRINTED/AV MATERIAL** | None |
| **TEACHER PREPARATION** | None |
| **SAFETY FOCUS** | Rip Current Safety |

## Procedure

1. Fill the baking pan with water to about one inch deep.
2. Position one student on each corner of the pan.
3. Sprinkle some black pepper in one corner of the baking pan.
4. At each corner position, have the students aim their straw along the side of the pan to their left.
5. Have each student gently blow through the straw across the top of the water and observe the motion of the pepper.

## Discussion

Very quickly, the students will see a circulation develop in their pan and observe the pepper move in a clockwise motion. This clockwise motion is the same basic motion of the currents in the Northern Hemisphere.

The persistent high-pressure systems over both Atlantic and Pacific Oceans have created the clockwise motion of the currents in each region. Since wind moves in a clockwise motion in high pressure, the wind transfers some of its energy to the sea surface generating currents.

In the Southern Hemisphere, the wind in high pressure systems moves in a counter-clockwise motion. As a result, the ocean's currents also move in a counter-clockwise direction.

You can also have the students at each corner blow across the water toward each other and observe what happens when opposing currents come together.

# Building a Weather-Ready Nation

Unlike the slow drift of ocean currents, rip currents are powerful, local, channeled currents of water flowing away from shore. They typically extend from the shoreline, through the surf zone, and past the line of breaking waves. Rip currents can occur at any beach with breaking waves, including the Great Lakes.

Rip currents can be killers. The United States Lifesaving Association estimates that the annual number of deaths due to rip currents on our nation's beaches exceeds 100. Rip currents account for over 80% of rescues performed by surf beach lifeguards.

The greatest safety precaution that can be taken is to recognize the danger of rip currents and always remember to swim at beaches with lifeguards. If caught in a rip current:

- Remain calm to conserve energy and think clearly.
- **Never** fight against the current.
- Swim out of the current in a direction **parallel** the shoreline. When out of the current, swim at an angle **away from the current** towards shore.
- If you are unable to swim out of the rip current, float or calmly tread water. When out of the current, swim towards shore.
- If you are still unable to reach shore, draw attention to yourself by waving your arm and yelling for help.

*Credit: Activity from NOAA's NWS Jetstream, Online School for Weather (weather.gov/jetstream)*
*Discover more fun at WeatherDetectives.org*

# Case #11: That Sinking Feeling

## Overview

Ocean water is salty and, in general, cold. Differences in the water density associated with temperature and salinity are vital in shaping the Great Ocean Conveyor. This lesson plan demonstrates how salinity and temperature affect density of water.

| | |
|---|---|
| **TOTAL TIME** | 10 minutes |
| **SUPPLIES** | Fish bowl (or large, deep glass container such as fish tank, bowl or pitcher); Food coloring; Table salt; Ice cube tray |
| **PRINTED/AV MATERIAL** | None |
| **TEACHER PREPARATION** | Make the ice cubes the evening before. Into one-half of the ice cube tray pour fresh, dark food-colored water. Using a different color, pour dark-colored, very salty water into the other half of the tray. Freeze the solutions. |
| **SAFETY FOCUS** | Thunderstorm safety rules |

## Procedure

1. Fill the fish bowl nearly full with tap water. Allow the water to settle for a minute or two.
2. Gently add one cube of each color into the water.
3. Have the students describe and explain what occurs.

## Discussion

In both cases, the colored waters will begin to sink to the bottom of the bowl. This is due to the temperature of water from the melting cube is denser than the surrounding tap water and therefore sinks. However, the colored water from the salty cube should sink faster than the fresh water cube because the addition of salt.

Each winter, in the far North Atlantic Ocean as new sea ice forms, the salt that is left behind in the ocean makes the water very dense. This dense water sinks to the ocean floor and is the "engine" for Great Ocean Conveyor's motion.

# Building a Weather-Ready Nation

Differences in air density help develop thunderstorms. Cold, sinking air can lead to rising, relatively warmer, air and thunderstorms. This often occurs on the West Coast in winter as cold pools of sink air accompany a low pressure system.

A Severe Thunderstorm Warning is an urgent announcement that a severe thunderstorm has been reported or is imminent and warns you to take cover. Severe thunderstorm warnings are issued by local National Weather Service offices. What you can do before a storm strikes...

- Know the county you live in and the names of the major nearby cities or towns. Severe weather warnings and statements are issued by county and reference major cities.
- Check the latest weather forecast and hazardous weather outlook.
- Watch for signs of an approaching thunderstorm.
- If a storm is approaching, keep a NOAA Weather Radio and/or AM/FM radio with you.
- Postpone outdoor activities if thunderstorms are imminent. This is the best way to avoid being caught in a dangerous situation.

*Credit: Activity from NOAA's NWS Jetstream, Online School for Weather (weather.gov/jetstream)*
*Discover more fun at WeatherDetectives.org*

# Case #12: Moonlight Serenade

## Overview

We observe the different angles between the sun, earth and moon by the phases of the moon we see each month. Students, acting as the earth, will see differences in light and dark sides of their hand-held moon.

| | |
|---|---|
| **TOTAL TIME** | 10 minutes |
| **SUPPLIES** | Table lamp (or another light source) for class. (A clear light bulb will work better than a frosted bulb.); Per pair of students: pencil; white Styrofoam ball (approximately two to three inches in diameter). |
| **PRINTED/AV MATERIAL** | Observation form (pdf) |
| **TEACHER PREPARATION** | A room that can be darkened. |
| **SAFETY FOCUS** | Rip Currents |

## Procedure

1. Divide the students into pairs and distribute one observation form to each student.
2. Place a lamp on a table or desk and remove the shade. Turn the lamp on.
3. Stick the Styrofoam ball on the pencil.
4. Darken the room.
5. Have one of the pair of students hold the ball, by the pencil, at arms length blocking out the light from the lamp. Explain they represent the earth, the ball is the moon, and the lamp is the sun.
6. Comparing the light and dark side of the ball, on the observation form, under the "View from Earth" column, have that person draw/shade what their "moon" looks like. Have the student label this as "New Moon".
7. Have the other person mark the location of the moon relative to the earth and sun on the dotted line (representing the Moon's orbit) under the "Position in Space" column.
8. Have the student holding the "Moon" rotate 45° counter-clockwise. Repeat steps 6 and 7. Label this as "Waxing Crescent".
9. Rotate another 45°. Repeat steps 6 and 7. Label this as "First Quarter".
10. Repeat steps 6 and 7 for each additional 45°, labeling them as "Waxing Gibbous", "Full Moon", "Waning Gibbous", "Last Quarter", and "Waning Crescent" respectfully.
11. Have the students switch positions and repeat the process again.

## Discussion

Each student will see their "moon" from two vantages points; from Earth and from "space". They should quickly observe the orbit of the Moon is the reason for the various phases of the moon.

They will also observe the phenomena of eclipses at New and Full Moon positions. At "New Moon", when the Moon is between the Earth and Sun, the Moon will block the Sun's light onto the Earth, called a *solar eclipse*. At "Full Moon", the Earth blocks light from reaching the moon. This is called a *lunar eclipse*.

Explain that since the Moon's orbit is inclined to the Earth's equator that direct alignment of Earth, Moon and Sun occurs typically twice a year, six months apart. The remaining times, the Moon's orbit is positioned either above or below the shadow cast by the Earth.

Also, as the Moon orbits the Earth, its tidal pull also moves around the Earth. As a result, the times of high and low tides changes each day.

When the Moon, Earth and Sun are inline (twice a month), the tidal pull by the Moon and Sun are at their greatest producing "Spring Tides", where the difference in height between the daily high and low tide are at their greatest.

When the Earth, Moon and Sun are at right angles to each other (also twice a month), the difference in height between the daily high and low tides are at their least, called "Neap Tides". The "Spring Tide or Neap Tide" wheel (above right) can be printed and cut-out to help illustrate how the orbit of the moon affects the spring and neap tides.

# Building a Weather-Ready Nation

Rip currents are the leading surf hazard for all beachgoers. They are particularly dangerous for weak or non-swimmers. Rip current speeds are typically 1-2 feet per second. However, speeds as high as 8 feet per second have been measured--this is faster than an Olympic swimmer can sprint! Thus, rip currents can sweep even the strongest swimmer out to sea.

Rip currents can be found on many surf beaches every day. Under most tide and sea conditions the speeds of rip currents are relatively slow. However, under certain wave, tide, and beach profile conditions the speeds can quickly increase to become dangerous to anyone entering the surf.

Learn how to swim!

- Never swim alone.
- Be cautious at all times, especially when swimming at unguarded beaches. If in doubt, don't go out!
- Whenever possible, swim at a lifeguard protected beach.
- Obey all instructions and orders from lifeguards.
- If caught in a rip current, remain calm to conserve energy and think clearly.
- Don't fight the current. Swim out of the current in a direction following the shoreline. When out of the current, swim towards shore.
- If you are unable to swim out of the rip current, float or calmly tread water. When out of the current, swim towards shore.
- If you are still unable to reach shore, draw attention to yourself: face the shore, wave your arms, and yell for help.
- If you see someone in trouble, get help from a lifeguard. If a lifeguard is not available, have someone call 9-1-1. Throw the rip current victim something that floats and yell instructions on how to escape. Remember, many people drown while trying to save someone else from a rip current.

*Credit: Activity from NOAA's NWS Jetstream, Online School for Weather (weather.gov/jetstream)*
*Discover more fun at WeatherDetectives.org*

# What's next?

Congrats! Hopefully you've enjoyed these activities. And I hope you've learned a lot about the earth too!

Good news: there's always more to explore. You can find more fascinating activities and information about the weather, atmosphere, oceans, and more at NOAA's NWS Jetstream, Online School for Weather.

Check it out at weather.gov/jetstream.

So, keep exploring and remember to marvel at the world.

And, as always, have fun!