Activity 5: How Do We Know?

What You Will Do: Make additional weather sensors; set up a home weather station

Big Idea

Our understanding of the climate system is improved through observations, theoretical studies, and modeling.

(Climate Science Principle 5)

What You Will Need*

Wind Vane Materials

Adult partner
1 – Broomstick or long wooden dowel, about 1 inch diameter
1 – Aluminum baking dish, about 6 x 9 inches
1 – Wood stick, about 3/4 inch square and 12 inches long
1 – Nail, about 1 inch long
1 – Metal washer with a hole slightly larger than the nail
Duct tape
Small saw or serrated knife
Scissors strong enough to cut the aluminum baking dish
Ruler or tape measure
Silicone or other glue that will stick to aluminum
Leather gloves
(Optional) Hand drill, and small drill bit slightly larger than the nail

Barometer Materials

1 – Ruler, about 30 cm (12 in)
1 – Clear drinking glass, glass jar, or other container with sides tall enough to support the ruler
1 – Clear plastic drinking straw or piece of clear plastic tubing, about 30 cm (12 in) long
Clear tape
Modeling clay or chewing gum
(Optional) Food coloring, your choice of color

Rain Gauge Materials

- Straight-sided glass or plastic container, with a diameter of about two inches or less (such as an olive jar)
- Coat hanger or wire bent to make a holding rack (see Figure 4)
- Measuring spoons: One teaspoon and 1/4 teaspoon
- Hammer and nails to secure the rack
- Felt tip marker

We all know that weather can change quickly, sometimes in only a few minutes. Climate also varies, but over longer periods of time. You may have heard someone say, "Expert weather forecasters can't accurately predict what the weather will be next week; how can anyone possibly know what the climate will be years from now?"

The answer is that forecasting climate is not the same as forecasting weather. Local weather predictions are based on natural processes that are more random and by their nature are difficult to precisely predict. Earth's climate systems, though, obey the basic physical laws that operate throughout the Universe. For example, when a planet's atmosphere traps heat, the planet's surface tends to become warmer. This means that the behavior of the climate system can be understood and predicted by careful scientific studies. Environmental observations are the foundation for these studies. Instruments carried on satellites, ships, buoys, weather stations, and other platforms can gather information about many pieces of the present climate system. Information about past climates can be found in natural records such as tree rings, ice cores, and layers of sediment, as well as in historical documents and local knowledge.

Image courtesy NOAA

This information can be combined with theories about climate to construct computer models that make predictions about what the climate will be when the ocean and atmosphere have certain characteristics. Comparing these predictions with knowledge about actual climate when these characteristics exist allows scientists to improve the computer models and make additional observations and experiments to make better predictions about future climate conditions.

A lot of research has been done about Earth's climate system, and climate prediction models continue to improve. Today's climate models are able to reproduce the average global temperature changes that occurred in the 20th century when they include all of the known natural and human-caused factors that affect climate. This gives us additional confidence that predictions about future climate conditions provide accurate information that will help societies decide how to prepare for the impacts of climate change.

* Scientists use many different instruments to make measurements that help predict weather and climate; but only a few instruments are needed to set up a Home Weather Station that can help you make your own weather predictions. You need to be able to measure temperature, wind speed, wind direction, and atmospheric pressure. You already know how to make an instrument for measuring temperature from Activity 4. Table 1 lists some clues that will help you estimate wind speed. To complete your Home Weather Station, you need a wind vane to measure wind direction, and a barometer to measure atmospheric pressure.

How It Works

Weather Vane: Winds are named according to the direction from which the wind is blowing, so a "north wind" is blowing from the north. The head of the Weather Vane will point to the direction from which the wind is blowing.

Beaufort Scale

Table 1

In 1805, Sir Francis Beaufort invented a scale from 0 – 12 for estimating wind speed based on features that can easily be observed. Sailors still use the Beaufort scale, but professional weather forecasters usually report wind speed in miles per hour or kilometers per hour.

(source: *http://www.srh.noaa.gov/jetstream/ocean/beaufort_max.htm#beaufort*)

Beaufort Scale No.	Wind Speed (km/hr)	Wind Speed (mi/hr)	Forecast Term	Observations	
				Sea	Land
0	0-1	0-1	Calm	Sea surface smooth	Smoke rises vertically
1	1-5	1-3	Light	Sea surface rippled	Smoke drift indicates wind direction, wind vanes do not move
2	6-11	4-7	Light	Small wavelets, crests have glassy appearance but do not break	Wind felt on face, leaves rustle, wind vanes begin to move
3	12-19	8-12	Gentle	Large wavelets, crests begin to break	Leaves constantly moving, light flags extended
4	20-28	13-18	Moderate	Small waves, numerous whitecaps	Leaves, and loose paper lifted, small tree branches move
5	29-38	19-24	Fresh	Moderate waves, many whitecaps	Small trees in leaf begin to sway
6	39-49	25-31	Strong	Larger waves, whitecaps common, some spray	Larger branches moving, whistling in wires, umbrella use difficult
7	50-61	32-38	Strong	Sea heaps up, white foam streaks off breakers	Whole trees moving, resistance felt walking against wind
8	62-74	39-46	Gale	Moderately high (18-25 ft) waves, foam blown in streaks	Twigs breaking off trees, walking difficult
9	75-88	47-54	Gale	High waves (23-32 ft), dense streaks of foam	Slight structural damage may occur, slate blows off roofs
10	89-102	55-63	Whole Gale	Very high waves (29-41 ft) with overhanging crests, sea white with foam	Trees broken or uprooted, considerable structural damage
11	103-117	64-72	Whole Gale	Exceptionally high (37-52 ft) waves, foam covers sea	Extensive damage
12	118-132	72-82	Hurricane	Air filled with foam, waves over 45 ft, sea completely white	Countryside devastated

Barometer: The water level in the barometer tube will rise and fall as atmospheric pressure changes. When atmospheric pressure increases, air presses on the surface of the water in the container causing the height of the water in the tube to rise. When atmospheric pressure decreases, there is less pressure on the surface of the water in the container so the height of the water in the tube falls. Decreasing atmospheric pressure usually indicates that a low-pressure area is approaching, and this often brings clouds and rain. Increasing atmospheric pressure often indicates fair weather.

How to Do It

Make the Wind Vane

Be careful of the sharp edges on the pieces of cut aluminum!
Use gloves to protect your hands until the edges are taped.

1. Use the saw or serrated knife to cut a notch about 1/2-inch deep into each end of the wood stick. The notches should be parallel (Figure 1).

2. Rotate the stick so that the two slots are vertical. Use the ruler or tape measure to find the exact center of the wood stick. Mark this spot on the upper surface of the stick, and drive a nail through the marked spot. Be careful: if the nail is too big, the stick will probably split. To avoid this, drill a hole slightly larger than the nail through the marked spot. You may need your adult partner to help with the drilling.

3. Cut the head and tail pieces of the Weather Vane from the aluminum baking dish using Figure 2 as a guide. **Be Careful—The Edges Are Sharp!** Use duct tape to cover the sharp edges.

Figure 1. Wind Vane Assembly

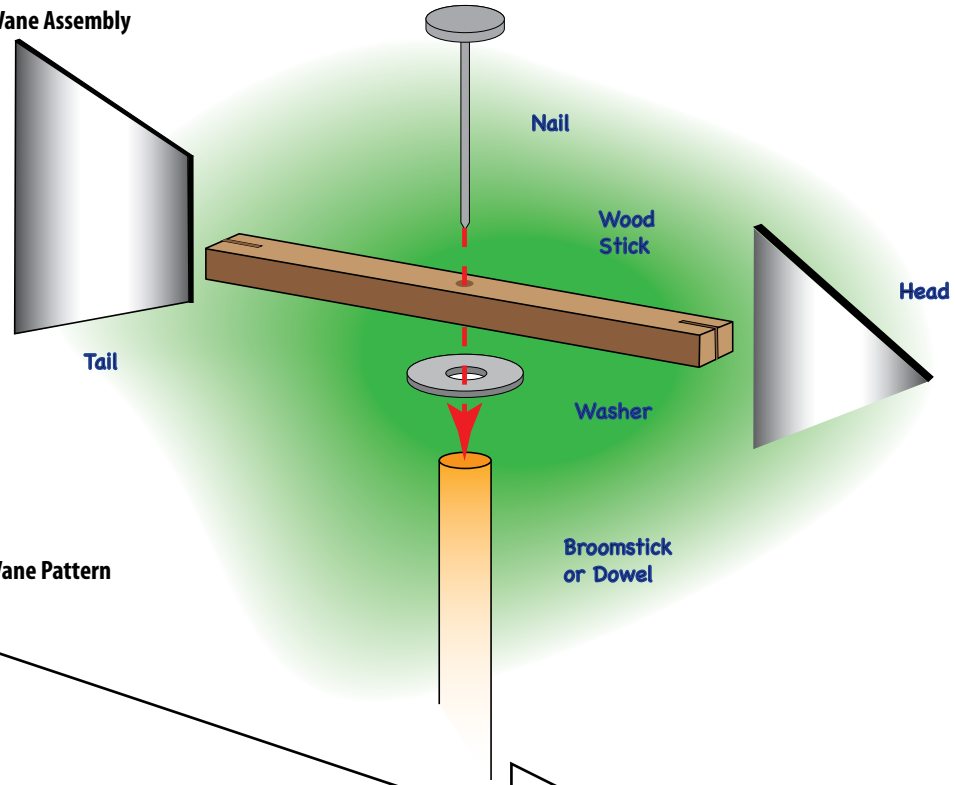
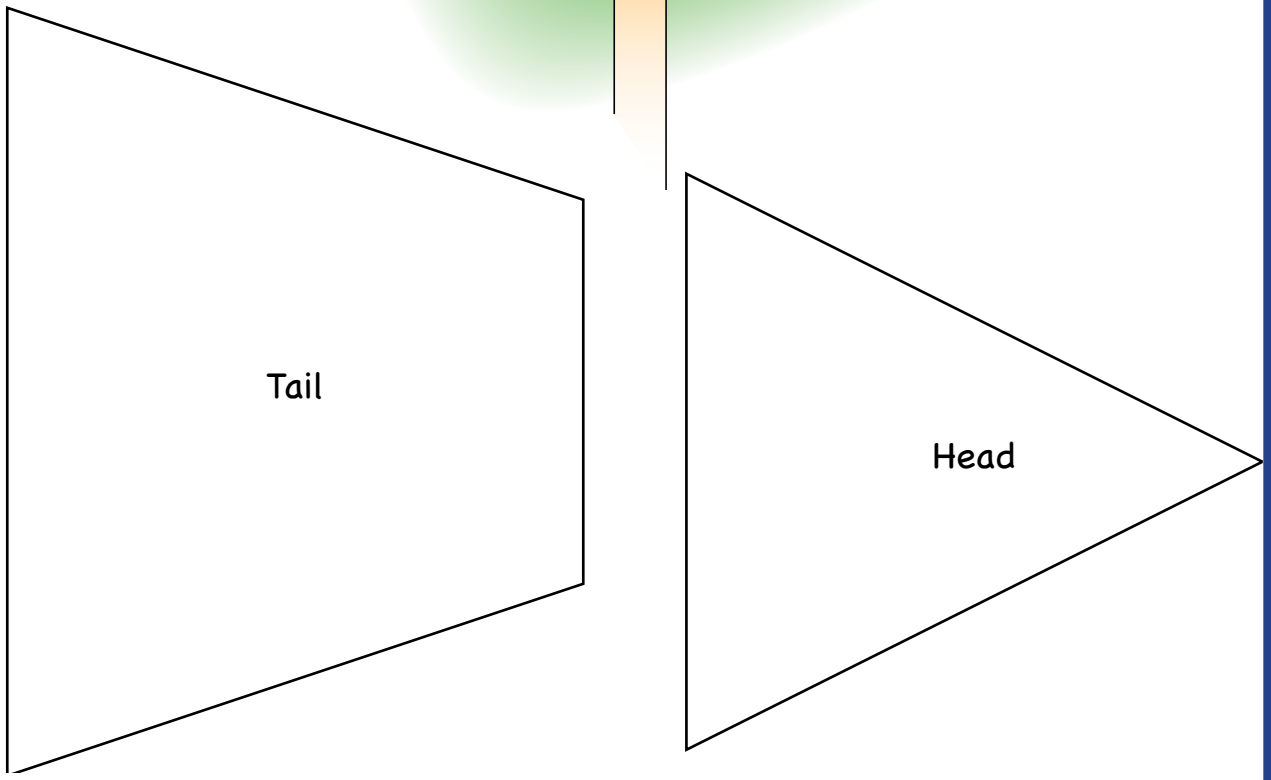


Figure 2. Wind Vane Pattern



4. Fit the head piece into one of the slots in the wood stick and fit the tail piece into the other slot. Glue the head and tail pieces into place and allow the glue to dry.

5. Attach the Weather Vane to the broomstick or dowel, by placing the washer on one end of the dowel and hammering the nail through the wooden stick into the dowel. Be sure the stick still moves freely around the nail.

6. Mount your Weather Vane outside where there are no nearby obstructions to block the wind. Try to get the dowel as high as you can while still keeping it steady and secure.

Make the Barometer

1. Tape the plastic straw or plastic tubing to the ruler so that one end is lined up with the "1 cm" ("1/2-inch") mark on the ruler.

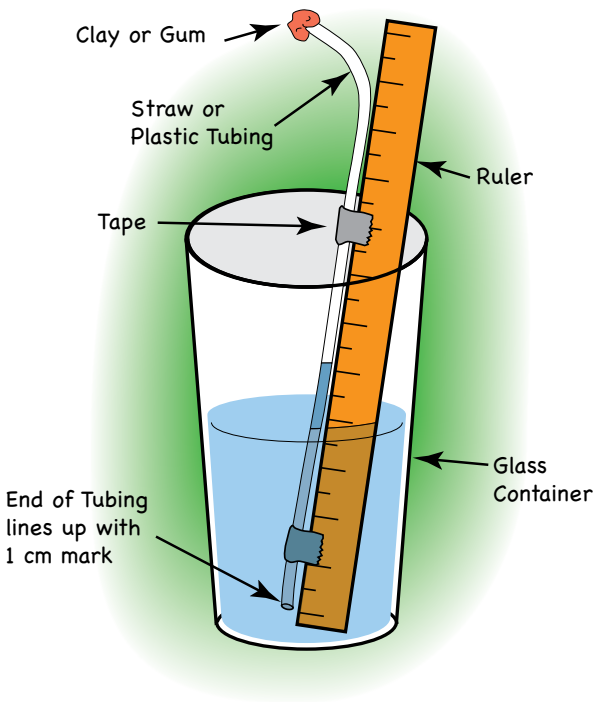
2. Stand the ruler-tubing assembly upright in the glass (or other container), and tape the assembly to the top of the container.

3. Fill the container about 3/4-full of water. If you want colored water, first mix food coloring with the water in another container.

4. Use the modeling clay or chewing gum (you'll have to chew it until it is soft enough) to plug the end of the straw or plastic tubing near the top of the ruler.

5. Carefully pour out some of the water so the container is about half full. Be sure the lower end of the straw or tubing stays beneath the water surface while you do this! When you are finished, the water in the straw or tube should be higher than the water in the container. Your barometer is now finished. Since barometers are sensitive to minor changes in weather conditions, keep your barometer indoors for greatest accuracy. (See Figure 3 for finished barometer.) The water level in the tube will rise and fall as atmospheric pressure changes. When atmospheric pressure increases, air presses on the surface of the water in the container causing the height of the water in the tube to rise. When atmospheric pressure decreases, there is less pressure on the surface of the water in the container, so he height of the water in the tube falls. Decreasing atmospheric pressure usually indicates that a low pressure area is approaching, and this often brings clouds and rain. Increasing atmospheric pressure often indicates fair weather.

Figure 3. Barometer



Sample Weather Journal Data Form

Date	Time	Temperature	Barometric Pressure		Wind		Precipitation		Other Events
			Instrument	NWS	Speed	Direction	Type	Amount	

Keep a daily record of outside temperature, barometric pressure, wind speed, wind direction, and recent precipitation or other significant weather events. When you record barometric pressure, record the height of the water in the barometer tube (using the scale on the ruler), as well as barometric pressure reported by a local office of the National Weather Service. That way, you will know how readings from your Home Weather Station barometer compare to measurements from barometers used by professional weather forecasters.

Make the Rain Gauge

1. Rain gauges measure the amount of rainfall in cubic inches. So your first task is to make a scale for your container that shows how many cubic inches of water are in the container. One cubic inch of water is about 3 1/4 teaspoons, so you can draw the scale on your container by measuring 3 1/4 teaspoons of water to your container, then drawing a short line at the level of the water. If you look closely, the top of the water will seem to be slightly curved and thickened. Draw your line so that it matches the bottom of the curved surface (which is called a meniscus). This line corresponds to a rainfall of one inch.

2. Add another 3 1/4 teaspoons of water to the container and draw another line. The second line corresponds to a rainfall of two inches.

3. Repeat Step 2 until you have at least five marks on the container. This will be enough for most rain events; but you may want to add another line or two, just in case!

4. Find a location for your rain gauge where there is nothing overhead (such as trees or a building roof) that could direct water into or away from your gauge. The edge of a fence away from buildings is often a good spot. Another possibility is to attach your rain gauge to a broomstick driven into the ground in an open area. Be sure to record rainfall soon after a rain event to avoid false readings caused by evaporation.

Empty your gauge after each reading, and you are ready for the next event!

This activity is adapted from "Build Your Own Weather Station" by the Educational Technology Programs Team at the Franklin Institute, Philadelphia, PA (*http://www.fi.edu/weather/todo/todo.html*).

Figure 4. Rain Gauge