



### Heather E. Schwartz

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## **Beyond Guesswork**

Have you ever been caught in a storm that you did not know was coming? Have you ever dressed in the morning only to have the weather change by lunch? Without a doubt, weather has a huge effect on our lives. We cannot change weather. We can only prepare for it. The more we know about weather before it happens, the better we can plan around it. But weather can be hard to predict and can change quickly.

When you see a weather **forecast**, it is more than just a guess. Modern **meteorologists** (mee-tee-uh-RAH-loh-jihsts) put science to work to predict what the future holds. They can help people plan their day. They can help people decide whether to pack an umbrella. But that's not all they do. They also track tornadoes, hurricanes, and other major storms. They help people plan for disasters—before they strike. Weather forecasts can actually save lives!

The first forecast that predicted a tornado was issued on March 25, 1948. The tornado was headed for Tinker Air Force Base in Oklahoma.

> tornado damage at Tinker Air Force Base

COMMAND



# What Is Weather?

120

100

6

When scientists talk about weather, they are describing the state of air at a certain place and time. Many things can affect weather. Air **temperature** is one. Wind speed and **humidity** (hvoo-MIH-dih-tee) can also change the weather.

Air temperature is the most common measurement. People read thermometers to find out the temperature. They help people know how hot or cold it is.

You may have felt humidity before. It can make it hard to breathe. This is due to the water vapor in the air. The more water vapor there is, the more humid it is. On a hot day, high humidity makes it feel even hotter. If it is too hot and too humid outside, it can be dangerous.



## **SCIENCE** Water Cycle

In the water cycle, water moves from Earth's surface to the sky and back again. When the sun heats oceans and lakes, some of that water **evaporates**. It becomes a gas, also called water vapor. Later in the cycle, the same water becomes **precipitation**. It falls back to the ground. This pattern has recycled Earth's water for billions of years.

Meteorologists track the weather.



### **Easy Breezy**

8

You know when it is windy. You can't see the wind, but you can see the effects of it. Leaves fly through the air and blow along the ground. Trees and branches sway in the breeze. But seeing what wind can do does not always give you enough information. Scientists use tools to learn a lot more about wind than they can see with their eyes.

Scientists use anemometers (a-neh-MAH-meh-tuhrz) to measure wind speed. An anemometer is made of a rod with cups attached to it. The cups spin when they catch the wind. Scientists count the number of times an anemometer spins to find the speed of the wind.

A barometer (bah-RAH-meh-tehr) measures the pressure of the **atmosphere**. That is the weight of the air as it is pulled down to Earth by gravity. Atmospheric pressure can help predict the weather. High pressure usually brings clear skies, while low pressure creates clouds and storms.

anemometer



### Get Your Head in the Clouds

When atmospheric pressure is low, air near the ground rises into the sky. As it moves higher, it cools and the water vapor forms clouds. But anyone who has looked at the sky knows that not all clouds are the same.

Meteorologists watch for different types of clouds to help forecast the weather. Clouds are classified by how high they form as well as by their shapes and colors.

For example, cotton-like clouds that float low to the ground are called cumulus (KYOO-myuh-luhs) clouds. They usually form on a nice sunny day. Cirrus (SIHR-uhs) clouds, on the other hand, look wispy and appear higher in the sky. They are a sign of a coming storm, such as a hurricane. Cumulonimbus (KYOO-myuh-loh-NIHM-bus) clouds are low like cumulus clouds. But they are large, **dense**, and sometimes dark. These are the clouds that cause storms.

cumulus clouds

cirrus clouds

### cumulonimbus clouds



### International Cloud Atlas Manual on the Observation of Clouds and Other Meteors

International Cloud Atlas

(WMO-No. 407)

Read Mo



### It's Raining, It's Pouring

Precipitation can come in many forms. Rain, sleet, hail, and snow all look different. They feel different, too, if you are outside when a storm hits. But they are all just different ways that water can fall to the ground.

Precipitation is when water vapor in clouds attaches to dust and forms droplets that fall to the ground. Rain is water falling in a liquid state. Hail falls from clouds fully frozen as hard stones made of ice. Like rain, hail can fall in many sizes. Large hailstones can be dangerous. Sleet is rain that freezes in the air before hitting the ground. Many times, sleet is mixed with rain and hail. Snow is made of ice crystals that form in clouds. As they fall, they stick together to create soft snowflakes.

When scientists have enough data about a place's weather, they can determine that place's climate. That is the average weather condition over time.

sleet on the ground



# Watching the Weather

Throughout history, people have used simple methods to see what kind of weather is coming. Many methods are based in science, but they are far from perfect for predicting weather.

An old rhyme states, "Red sky at night, sailor's delight; red sky in morning, sailors take warning." It sounds silly, however there is science behind this rhyme.

Weather systems often move from west (where the sun sets) to east (where the sun rises). That means that at night, the sky shows weather on its way. In the morning, it shows conditions that are on their way out.

So, a red sky at night usually indicates high air pressure. Nice weather will follow. When the sky looks red in the morning, however, it means that good weather has passed. There is more water vapor in the air, which means that a storm is likely.

# TECHNOLOGY

When Vikings sailed a thousand years ago, they used the sun to navigate. It might have been easy to get lost on cloudy days. Modern scientists believe Vikings used an old-fashioned form of technology to stay on course. On cloudy days, they looked at the sky through a crystal. The crystal helped them find the brightest light in the sky. This helped them know where the sun was.

This crystal was used by the Vikings.

For many years, people have watched animals to predict the weather. Legend has it that cows lie down when it is going to rain. Some people say cows sense the rise in humidity. Others say cows absorb water vapor with their legs. When they absorb too much, they can't stand up anymore.

The truth is, this forecasting method does not stand up to science. When it comes to weather prediction, scientists trust birds more than cows.



Birds have been seen preparing for storms days before they hit. In one study, scientists put small tracking devices on five birds. During **breeding** season, the birds suddenly left their nests, which they normally don't do. The five birds flew at least 1,500 kilometers (900 miles) away. Then, a tornado hit their home. It brought lightning, rain, wind, and hail. After the storm, the birds came back.

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The scientists who ran the study believed the birds could sense the storm was coming. Birds can hear infrasound, which is a sound that storms make. Humans can't hear infrasound.

# ENGINEERING

How can anyone know where a wild bird or animal goes when it is on its own? Scientists developed geologgers to solve this problem. These devices are put on animals and record the time and position of the sun. This data can be used to learn where the animals have been. This process is called solar geolocation.

## Weather Instruments at Work

It is possible to predict the weather without using any equipment. But meteorologists are more accurate when they use tools meant for the job. Some of these tools are simple. They have been around a long time. You have probably seen and used some of them.

Weather vanes are one example. They have directional markings for north, south, east, and west. An arrow on a rod turns to point in the direction the wind is coming from. One of the first weather vanes sat on top of a tower in Athens, Greece, around 50 BC. It was more than a tool. It was also a decoration. It had the shape of the Greek god Triton.

Even though weather vanes are simple, they are still useful. Keeping a record of wind direction can show patterns in the weather. A change in wind direction can warn that weather will soon change as well.

This weather vane in Prague, Czech Republic, is decorated as a rooster.

Modern airports still place wind socks on runways. These long tubes of striped orange and white fabric blow in the breeze to show wind speed and direction. Their colors are more than just decorative. The orange is bright so pilots can see them from a distance. In some designs, each stripe represents a measurement of wind strength.

### **Rising Waters**

A rain gauge is another tool meteorologists use. There are different types of rain gauges. Some are simpler than others. A standard rain gauge catches rain in a 20 cm (8 in.) tube. Markings on the tube show how much rain has fallen.

The tipping bucket rain gauge funnels rainfall into two small buckets. When the first bucket is full, it tips so rain goes into the second bucket. The device measures rain by counting the number of times the gauge switches buckets. A weighing rain gauge collects rain and weighs its **mass**. It can also measure solid precipitation, such as snow and hail.

An optical rain gauge collects rain and uses a light beam to measure how fast it is falling. The beam detects flashes of light in the rain.

This pole measures the height of flood waters.

Hurricane Harvey set a rain gauge record in 2017. Instruments measured between 127 and 152 cm (50 and 60 in.) of rain in Houston over a five to six day period.

### **Seriously Scientific**

Doppler radar is often mentioned in weather reports. This system sends **radio waves**. These waves detect rain, snow, hail, and sleet. The system shows the direction and speed of precipitation. With this data, scientists can tell when storms are on the way.

Scientists also use weather **satellites**. They take pictures and record videos and data about the atmosphere from space. Scientists study these images to track **severe** weather. Then, they warn people about major storms before they hit.

Advance warning about weather gives people time to prepare. They may need to stock up on water and food. They may need to board windows and protect their homes. Or they may need to **evacuate**. Early warning is important when it comes to severe weather. It can save lives.





### Data on Display

rain

Data from high-tech instruments and simple tools can be shown using symbols on a surface chart, or weather map. Reading weather maps takes practice. But meteorologists know what each curvy line and sign mean.

A front is an area of change between two **air masses**. A cold front happens when a cooler air mass replaces a warmer air mass. It is shown as blue triangles along a line. A warm front happens when a warmer air mass replaces a cooler air mass. It is shown as red half-circles along a line.

Precipitation is shown as shaded green areas. Inside the green, different symbols show the type of storm to expect. Snow is shown using star-like shapes. The symbol for sleet is a triangle with a dot inside.

Keep these marks in mind the next time you see a weather report. Now, you can read weather maps, too!

snow

sleet



# MATHEMATICS

The National Weather Service is a group that gathers data about weather. It collects data using radar, satellites, and other tools. But what makes the data useful is mathematics! Equations are used to help predict weather up to 16 days before it happens. This satellite monitors the environment, glaciers, and flooding.



# Weather Forecasting Today

Weather forecasting has come a long way since the Vikings sailed the seas. They looked up at the sky and only had simple tools.

Now, meteorologists predict weather with many tools. They have data from high-tech weather instruments. They are more accurate than ever.

Meteorologists can tell whether it is going to be sunny or rainy. They can also track severe weather systems. They are the first to know about major storms that can affect our lives.

Extreme weather is dangerous. It can be deadly. But scientists are on the case. They are learning better ways to forecast weather. They are working to develop new tools. In the future, they will spot storms even earlier. They will have even more time to warn people. And they will save even more lives.

> BREAKING NEWS LIVE NEWS ches expected in the north +10,000 sold



to improve weather forecasting.





### **Define the Problem**

Imagine your class is creating and installing a set of weather tools to be used at school. Your group has been challenged to design a tool that represents the school and measures wind strength and direction.



**Constraints:** Your tool must be made out of recycled materials.



**Criteria:** Your tool must have colors, artwork, and/or symbols that represent the school and clearly show wind speed and direction.



### **Research and Brainstorm**

How is wind strength measured? How does your tool work? Where will it be placed? What materials are used to make your tool? What colors, symbols, or themes represent your school?



### **Design and Build**

Sketch a design for your tool, including any artwork. Build your tool,



### Test and Improve

Use a multispeed fan to create different wind strengths. Does your tool clearly show the strength and direction of the wind? Ask teachers and students at your school about how well your artwork represents the school. Modify your design and try again.



### **Reflect and Share**

Does placement of your tool matter? How will your tool be useful to students at your school? Would your tool survive all weather conditions?

# Glossary

air masses—bodies of air that have nearly the same conditions of temperature and humidity throughout

atmosphere--the whole mass of air surrounding Earth

breeding—the process by which birds and animals produce their young

dense—containing parts that are close together

evacuate—to leave a dangerous place

evaporates—changes from liquid to gas

**forecast**—a prediction of something in the future

**geolocation**—someone's or something's location on a planet

**humidity**—the amount of moisture in the air

infrasound—sound
frequencies too low for
humans to hear

30

**mass**—the amount of matter in something

meteorologists—scientists who study the weather

**precipitation**—water that falls to the ground as rain, snow, and other forms

radio waves—energy that sends signals through the air without using wires

satellites—objects in space that orbit much larger objects

severe—very bad, serious, or likely to cause pain or suffering

temperature—a measurement that indicates how cold or warm something is

water vapor—water that is in the form of a gas

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# **Read and Respond**

- **1.** How can observing the sky help in forecasting weather?
- **2.** How can watching animal behavior help people predict the weather?
- **3.** What patterns can be found in weather systems?
- **4.** How would your life be different if weather was totally unpredictable?
- **5.** Why is knowing the weather so important to people?
- **6.** Create a journal of the weather for a month. Track changes in temperature, humidity, wind, and precipitation. When the month is over, look for patterns.





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