The NASA "Why?" Files
The Case of the
Phenomenal Weather

Segment 2

After learning about the various types of clouds and that weather is very unpredictable, the tree house detectives decide that they had better learn more about hurricanes. They visit Dr. Steve Lyons at the Weather Channel in Atlanta, Georgia, who explains how hurricanes grow and strengthen as they gain water vapor. Once the tree house detectives "survive" a hurricane at the Museum of Science Institute (MOSI) in Tampa, Florida, they are convinced they need to find out how much water vapor the hurricane is receiving. They visit Ed Browell at NASA Langley Research Center, who explains how NASA collects data by using LIDAR to determine water vapor in a hurricane. At the end of this segment, the tree house detectives visit the Hurricane Hunters in Biloxi, Mississippi as they try to chase down more information about hurricanes!

Objectives

The students will

- learn how to plot coordinates on a map.
- understand that energy is a property of many substances, is associated with heat, and is transferred in many ways.
- learn how high- and low-pressure systems are formed on Earth.
- understand how hurricanes are formed.
- understand the Coriolis effect.
- learn how scientists collect data to determine water vapor.
- learn that light interacts with matter by absorption and scattering.
- learn the categories of hurricanes.

Vocabulary

Coriolis effect - the effect of Earth's rotation on the movement of air masses

counterclockwise - in a direction opposite to that in which the hands of a clock rotate

eye wall - the ring of thunderstorms that surrounds a storm's eye. The heaviest rain, strongest winds, and greatest turbulence are normally in the eye wall.

hurricane - large, swirling, low-pressure system with winds of at least 74 mph that forms over tropical oceans. Depending on the location of the storm, it is also called cyclone, typhoon, and willy willie.

hurricane season - The portion of the year having a relatively high incidence of hurricanes. The hurricane season in the Atlantic, Caribbean, and Gulf of Mexico runs from June 1 to November 30. The hurricane season in the Eastern Pacific basin runs from May 15 to November 30. The hurricane season in the Central Pacific basin runs from June 1 to November 30.

latitude - distance measured by degrees north or south from the equator

LIDAR - acronym for Light Detection and Ranging. An instrument that uses pulses of laser light to detect particles or gases in the atmosphere.

longitude - distance measured by degrees or time east or west from the prime meridian

meteorologist - scientist who studies the atmosphere and atmospheric phenomena

prevailing westerlies - winds between 30° and 60° north and south of the equator that blow opposite to the trade winds and cause much of our weather

reconnaissance - a survey of an area to gain information

scattering - bouncing of light in another direction when it hits a molecule in the atmosphere

trade winds - steady winds about 15 degrees north and south of the equator; caused by cool, descending air

tropical storm - a storm with winds between 39 and 74 mph

water vapor - water in a gaseous form, especially when below boiling temperature and spread through the atmosphere

Video Component

Implementation Strategy

The NASA "Why?" Files is designed to enhance and enrich the existing curriculum. Two to three days of class time is suggested for each segment to fully use video, resources, activities, and web site.

Before Viewing

1. Prior to viewing Segment 2 of *The Case of the Phenomenal Weather*, discuss the previous segment to review the problem and what the tree house detectives have learned thus far. Download a copy of the Problem Board from the NASA "Why?" Files web site and have students use it to sort the information learned so far.

2. Review the list of questions and issues that the students created prior to viewing Segment 1 and determine which if any were answered in the video or in the students' own research.
3. Revise and correct any misconceptions that may have been dispelled during Segment 1. Use tools located on the Web, as was previously mentioned in Segment 1.
4. Focus Questions - Print the questions from the web site ahead of time for students to copy into their science journal. Encourage students to take notes during the program to answer the questions. An icon will appear when the answer is near.
5. What's Up? Questions - Questions at the end of the segment help students predict what actions the tree house detectives should take next in the investigation process and how the information learned will affect the case. These can be printed from the web site ahead of time for students to copy into their science journals.

View Segment 2 of the Video

For optimal educational benefit, view *The Case of the Phenomenal Weather* in 15-minute segments and not in its entirety. If you are viewing a taped copy of the program, you may want to stop the video when the Focus Question icon appears to allow students time to answer the question.

Careers

meteorologist
flight meteorologist
oceanographers
storm chasers
hurricane forecaster

After Viewing

1. Have students reflect on the "What's Up? Questions" asked at the end of the segment.
2. Discuss the Focus Questions.
3. Have students work in small groups or as a class to discuss and list what new information they have learned about weather and tropical storms. Organize the information and determine if any of the students' questions from Segment 1 were answered.
4. Decide what additional information is needed for the tree house detectives to predict if the weather will keep them from going to the physics fair and/or Florida. Have students conduct independent research or provide students with information as needed. Visit the NASA "Why?" Files web site for an additional list of resources for both students and educators.
5. Choose activities from the educator guide and web site to reinforce concepts discussed in the segment. Pinpoint areas in your curriculum that may need to be reinforced and use activities to aid student understanding in those areas.
6. If time did not permit you to begin the web activity at the conclusion of Segment 1, refer to number 6 under "After Viewing" on page (p. 13) and begin the Problem-Based Learning activity on the NASA "Why?" Files web site. If the web activity had begun, monitor students as they research within their selected roles, review criteria as needed, and encourage the use of the following portions of the online, Problem-Based Learning activity:

   Research Rack - books, internet sites, and research tools

   Problem-Solving Tools - tools and strategies to help guide the problem-solving process

   Dr. D's Lab - interactive activities and simulations

   Media Zone - interviews with experts from this segment

   Expert's Corner - listing of Ask-An-Expert sites and biographies of experts featured in the broadcast
7. Have students write in their journals what they have learned from this segment and from their own experimentation and research. If needed, give students specific questions to reflect upon as suggested on the PBL Facilitator Prompting Questions instructional tool found in the educator's area of the web site.
8. Continue to assess the students' learning, as appropriate, by using their journal writings, problem logs, scientific investigation logs, and other tools that can be found on the web site. Visit the Research Rack in the tree house, the online PBL investigation main menu section "Problem Solving Tools," and the "Tools" section of the educator's area for more assessment ideas and tools.

Resources

Books

Allaby, Michael: *Reader's Digest: How the Weather Works*. Dorling Kindersley Ltd., 1995, ISBN: 089577612X.

Challoner, Jack: *Eyewitness: Hurricane and Tornado*. DK Publishing, 2000, ISBN: 0789452421.

Cole, Joanna: *The Magic School Bus Inside a Hurricane* (Magic School Bus Series). Scholastic Trade, 1996, ISBN: 0590446878.

Simon, Seymour: *Storms.* Mulberry Books, 1992, ISBN: 0688117082.

Williams, Jack: *USA Today: The Weather Book*. Vintage Books, 1997, ISBN: 0679776656.

Web Sites

National Hurricane Center
Visit this site for the latest in satellite images, hurricane tracking charts, hurricane preparedness information, and much more.
http://www.nhc.noaa.gov/

The Hurricane Hunters
Come and read about the men and women who fly into the center of hurricanes! There are photos, movies, history, fact files, and much more. You can even e-mail your question to a hurricane hunter.
http://www.hurricanehunters.com/

LIDAR
At this web site learn more about the wonderful world of LIDAR.
http://asd-www.larc.nasa.gov/lidar/lidar.html

Activities and Worksheets

Plotting to Rescue

Purpose

To use lines of latitude and longitude to locate a position on a coordinate graph

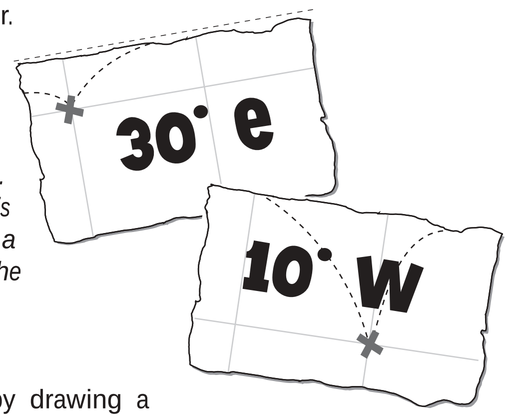
Materials

game card sheet (p. 30)
game board (p. 31)
15 plastic chips or beans
2 envelopes
scissors
highlighter (optional)
pencil

Procedure

1. Label one envelope "longitude" and one envelope "latitude."
2. Using scissors, cut along dotted lines to separate the game cards.
3. Place the longitude cards (N and S) in the longitude envelope and the latitude cards (E and W) in the latitude envelope.
4. Lay the game board on a flat surface and place a chip (survivor) on an island. Repeat until all survivors have been distributed.
5. Read the following scenario to your partner.

   A fishing boat caught in a tropical storm sank after battling the storm for several hours. Fortunately, all of the crewmembers were able to swim to nearby deserted islands. Each survivor has a device that transmits his or her longitude and latitude coordinates. As a member of the Marine Rescue Team, use the coordinates to locate and rescue as many survivors as you can!



6. The youngest player starts the game by drawing a latitude and a longitude card from each envelope.
7. Using the coordinates, find where the longitude and latitude lines meet. If the lines meet on an island where there is a survivor, rescue the survivor.
8. Return the cards to their envelopes.
9. Play will continue with the next person on the left and so on until all the survivors have been rescued. The player with the most survivors wins the game.

Plotting to Rescue - Game Card Sheet

Longitude Cards

30° E

25° E

20° E

15° E

10° E

5° E

0°

5° W

10° W

15° W

20° W

25° W

30° W

Latitude Cards

30° N

25° N

20° N

15° N

10° N

5° N

0°

5° S

10° S

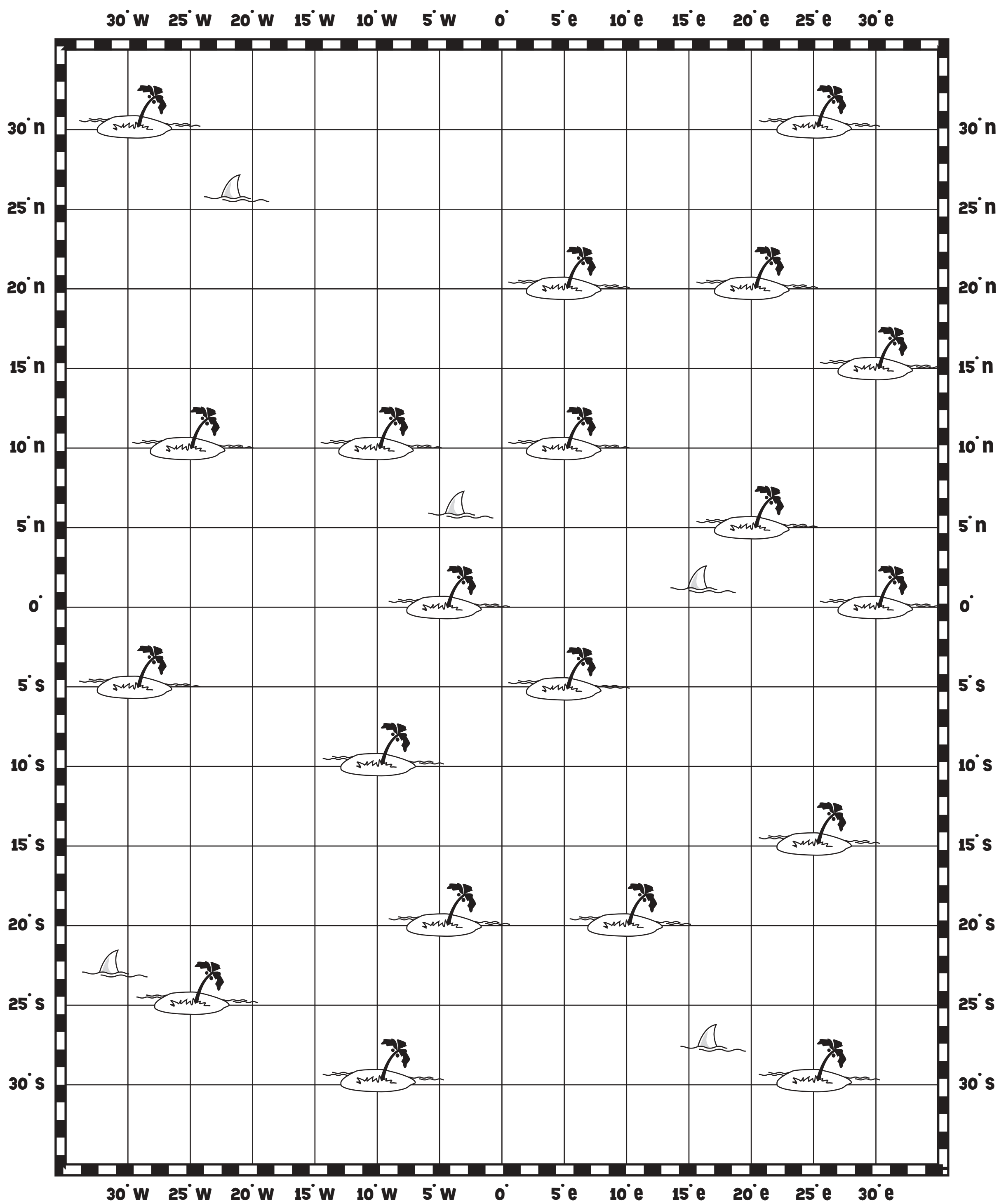
15° S

20° S

25° S

30° S

Plotting to Rescue - Game Board

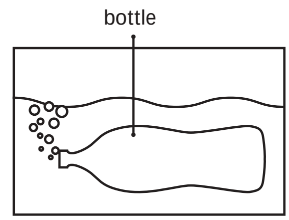


What About Air?

Although you cannot see it, air is all around you. Try a few of these simple experiments to learn some characteristics of air. The more you know about air, the easier it is to learn about weather.

Where's the Air?

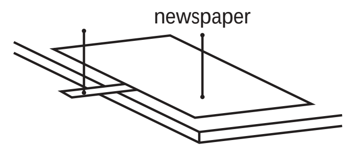
Fill a large tub or sink with water and push an empty plastic bottle into the water. Let the bottle fill with water and watch what happens to the water. Was the bottle really empty?



Where's the Air?

Some Pushy Air

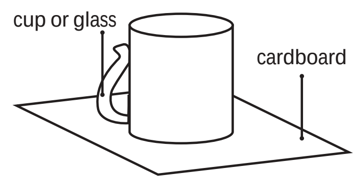
Tear a sheet of newspaper in half and smooth it out on a flat surface such as a table. Put a ruler under the paper so it sticks out over the edge of the table. Stand to one side and press down on the ruler to see if you can snap it off the table. Was there an unseen force holding the paper and ruler to the table?



Some Pushy Air

Magic Air

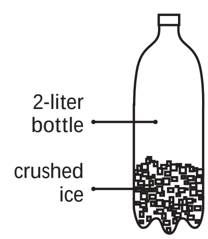
Fill a plastic glass or cup with water to the brim. Put a piece of cardboard on top of the cup and turn the cup upside down, holding the cardboard in place. Make sure there are no gaps between the cup and the cardboard. Let go of the cardboard and see what happens. What was the magic in this trick?



Magic Air

Shrinking Air

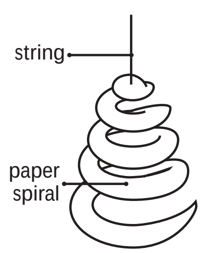
Fill a 2-liter soda bottle about one-third full of crushed ice. Replace the cap on the bottle and shake it for about a minute. Observe the bottle as the ice cools the air inside. What happened to the air inside the bottle?



Shrinking Air

Rising Air

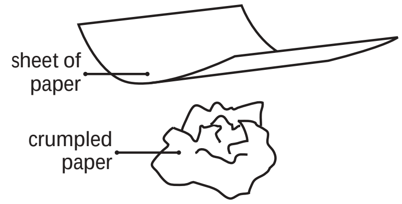
On a piece of construction paper, trace the outline of a plate to form a large circle. Cut out the circle. Starting at one edge of the circle, begin to draw around and around inside the circle to make a spiral. Color the spiral and cut it out. Place a string on the top end of the spiral and let it hang. Place the spiral over a lamp and observe. What causes the spiral to move?



Rising on Air

Flying on Air

Take two identical sheets of paper and crumple one of the sheets into a ball. Hold both sheets at the same height and drop them at the same time. Which one landed first and why?



Flying on Air

Things Are Heating Up!

High- and low-pressure systems all start with the Sun. Heat causes air to expand and become less dense. The air then rises, leaving an area of low pressure. Because the cooler air higher in the atmosphere is denser, it sinks and replaces the air that has risen, creating an area of high pressure. When this new air sinks toward Earth, it is warmed and the cycle continues. The replacement of the warmed (less dense) air by cooler (more dense) air is called a convection current.

Materials

small latex balloon
rubber bands
large salad dressing bottle
hot water
large rectangular pan,
about 33 x 23 cm
science journal

Purpose

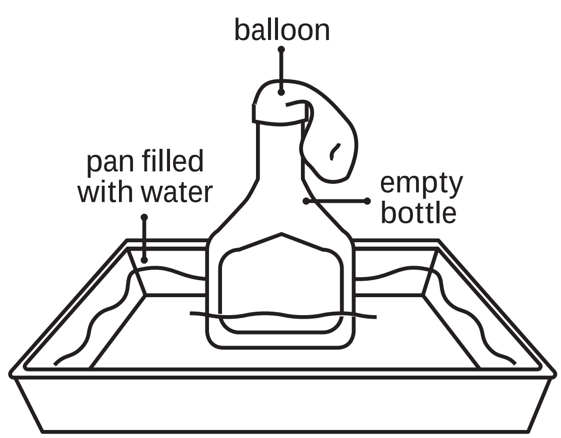
To understand that heat makes air expand and rise
To learn how pressure systems are formed

Procedure

1. Attach the mouth of the balloon to the top of the bottle.
2. Place rubber bands over the balloon onto the neck of the bottle to ensure a tight fit.
3. Pour the hot water into the pan to about 2.5 cm from the top.
4. CAREFULLY place the bottle in the hot water. It may be necessary to hold the bottle down.
5. Observe and record your observations.
6. Carefully place the bottle and balloon in a refrigerator or a tub of ice for 10-15 minutes.
7. Observe and record your observations.

Conclusion

1. What happens to the air in the bottle?
2. Explain how you know that is what happened.
3. How did what happened demonstrate convection?
4. How are low-pressure systems formed?
5. Explain the formation of a high-pressure system.



Vaporizing Vapor

Materials

large pan
water
sponge
science journal

Problem

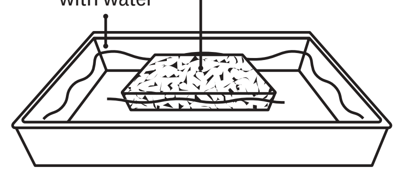
To understand water vapor in the atmosphere

Procedure

1. Fill the large pan with water.
2. Put the sponge into the pan.
3. Observe the sponge and record.
4. Lift the sponge out of the pan. Observe and record.

Conclusion

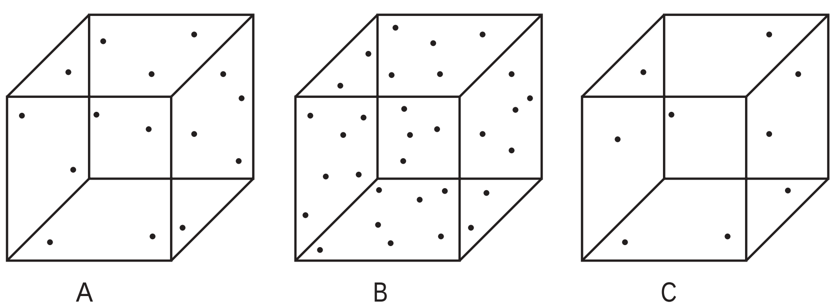
1. What happened to the sponge when you put it in the pan?
2. When you lifted the sponge, why did it leak?



Background

The sponge soaks up the water, but not all of it. The sponge soaks up as much water as it can hold. Eventually, the sponge is "full" and cannot soak up any more. We say that the sponge is saturated. Air is like a sponge. It can also hold water and water in air is in the form of gas. Water in gas form is called water vapor. The amount of water vapor in the air does not stay the same. Sometimes air has a small amount of water vapor and sometimes it has a lot. When the air becomes saturated like the sponge, there is precipitation. The amount of water vapor air can hold depends on the temperature. Warm air holds more water vapor than cold air. Relative humidity tells us how "full" the air is with water vapor. It compares the amount of water vapor in the air to how much the air can hold.

Look at the cubes of air below and answer the following questions:
The temperature in each cube is 24º C; the balls stand for water vapor.



3. Which air has the least water vapor? _________
4. Which air has the most water vapor? _________
5. Which air is the dampest? _________
6. Which air is the driest? _________
7. Which air has the highest relative humidity? _________
8. Which air has the lowest relative humidity? _________
9. Which air might have rain soon? _________

Humble Humidity

Purpose

To find the relative humidity with a psychrometer

Materials

2 metal thermometers
small piece of cloth
string
water
humidity chart
science journal
clock with second hand or egg timer

Procedure

1. Use a string to attach a small piece of cloth to the bulb of one of the thermometers. See diagram 1.
2. Cut two pieces of string approximately 30 cm long.
3. Attach the string through the hole and tie in a knot. Repeat for the second thermometer. If the thermometers do not have holes, the teacher can make a hole with a nail and a hammer or you can use tape to attach the strings securely to the back of the thermometer. See diagram 2.
4. Wet the cloth on the bulb. This one will be the wet bulb thermometer and the other will be the dry bulb.
5. You and your partner each take a thermometer and hold the string carefully looped around your hand. Slowly twirl the two thermometers for two minutes. Be sure to stand several meters apart from each other so that the thermometers do not collide as you are swinging them.
6. Stop twirling and read and record the temperature of both thermometers.
7. Subtract the wet bulb temperature reading from the dry bulb temperature.
8. To find the humidity in the room, use the relative humidity chart on p. 36 and follow these steps:
   a. Locate the dry bulb temperature along the left edge of the chart.
   b. Locate the difference between the dry bulb and wet bulb temperature along the top edge of the chart.
   c. Use your fingers to follow each to the place they intersect.
9. This intersection shows the relative humidity. It is usually expressed as a percent. Record in your journal.
10. Repeat in various other rooms and outside.

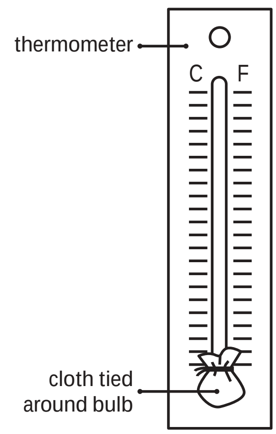


Diagram 1

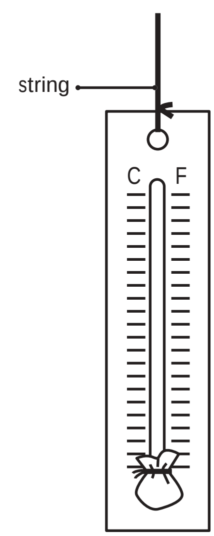


Diagram 2

Conclusion

1. Explain relative humidity.
2. Eventually, what will happen if an area continues to receive large amounts of water vapor?
3. In a hurricane, where does the storm get its water vapor?

Bonus: Why is warm water necessary for hurricanes to form?

Humble Humidity

Relative Humidity Chart

Dry Bulb Temp	Dry Bulb Temperature Minus Wet Bulb Temperature (C°)									
	1	2	3	4	5	6	7	8	9	10
10° C	88	77	66	55	44	34	24	15	6	
11° C	89	78	67	56	46	36	27	18	9	
12° C	89	78	68	58	48	39	29	21	12	
13° C	89	79	69	59	50	41	32	22	15	7
14° C	90	79	70	60	51	42	34	26	18	10
15° C	90	80	71	61	53	44	36	27	20	13
16° C	90	81	71	63	54	46	38	30	23	15
17° C	90	81	72	64	55	47	40	32	25	18
18° C	91	82	73	65	57	49	41	34	27	20
19° C	91	82	74	65	58	50	43	36	29	22
20° C	91	83	74	67	59	53	46	39	32	26
21° C	91	83	75	67	60	53	46	39	32	26
22° C	92	83	76	68	61	54	47	40	34	28
23° C	92	84	76	69	62	55	48	42	36	30
24° C	92	84	77	69	62	56	49	43	37	31
25° C	92	84	77	70	63	57	50	44	39	33
26° C	92	85	78	71	64	58	51	46	40	34
27° C	92	85	78	71	65	58	52	47	41	36
28° C	93	85	78	72	65	59	53	48	42	37
29° C	93	86	79	72	66	60	54	49	43	38
30° C	93	86	79	73	67	61	55	50	44	39

Answer Key

What About Air?

Where's the Air? The bottle was not empty, it was full of air. When you pushed the bottle under the water to fill it up, the air escaped in the form of bubbles. Most things that look empty are really full of air!

Some Pushy Air The air all around you was pushing down on the newspaper and keeping it in place. The newspaper has a large surface area and that is a lot of weight pressing down!

Magic Air There was no magic, just air. The air pressing around us, pushed up on the cardboard to keep it in place, making the water stay in the cup unless the seal is broken!

Shrinking Air Due to the ice in the bottle, the air inside the bottle cooled. As it cooled, the molecules slowed down and came nearer to each other, making the air denser than before. Since dense air does not take up as much space, the air pressing on the outside of the bottle pressed inward, causing the bottle's sides to go inward.

Rising Air The lightbulb heats the air surrounding it. Because air molecules spread out when heated, a certain volume of hot air is lighter (less dense) than the same volume of cold air, making the hot air rise and float above the cold air. As the air rises, it causes the spiral to move.

Flying on Air The paper that was crumbled into a ball hit the floor first. Air pushes up on the paper pieces as they drop. The flat piece of paper is larger so more air can push against it, thus making it fall more slowly than the smaller ball. When things move through the air, they have to overcome the air pressure rushing against them. This slowing-down effect of the air is called air resistance. Some shapes have more air resistance than others.

Things are Heating Up!

1. The air in the bottle expanded as it was heated by the hot water. As the molecules got hot, they moved farther away from each other.
2. You know because the balloon began to inflate and became larger.
3. In convection, the air is heated at the surface of the Earth, which causes the molecules to move away from each other, creating less dense air. Now that the air is less dense, it will begin to rise. As the air rises, it begins to cool. As it cools, the molecules move closer together and the air becomes denser. The air will begin to fall again back toward the Earth. The cycle of convection was demonstrated when the balloon increased in size as the air warmed and then became smaller as the air cooled.
4. Low-pressure systems are created when the air near the surface of the Earth is heated. When air warms, the air molecules spread out so there are fewer air molecules in the same space. Warm air weighs less than cool air, which means that warm air presses down on Earth less than cool air does. A mass of warming air is an area of low pressure.
5. When air cools, the air molecules come closer together, so there are more air molecules in the same space. The air mass becomes heavier and sinks toward the Earth, creating an area of high pressure.

Vaporizing Vapor

1. The sponge absorbed the water.
2. The sponge was full of water and could not hold any more.

3. C 4. B 5. B 6. C 7. B 8. C 9. B

Humble Humidity

1. Relative humidity is the amount of water vapor that air can hold at a certain temperature.
2. Eventually, the air will become saturated, and it will have some form of precipitation (rain, sleet, snow, or hail).
3. The hurricane gets its water vapor from the warm ocean water.

   Bonus: Warm water is necessary for a hurricane to form because the warm water heats the air above its surface, and the warm air rises, creating clouds. As the warm ocean water continues to feed water vapor into the air, the clouds become larger and more saturated. Finally, the clouds will become a storm, and as it continues to receive water vapor, the storm will grow stronger and stronger.