A Tornado Is Born

Name _____

Step 1: Use books, the Internet and other resources to define each of the words below. If possible, draw a picture of the word to help others understand its meaning.

anvil cloud:

atmosphere:

condense:

cumulus cloud:

cumulonimbus cloud:

downdraft:

front:

funnel cloud:

mesocyclone:

supercell:

thunderhead:

updraft:

vortex:

vertical wind shear:

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A Tornado Is Born

Step 2: Below is a description of the way tornadoes form. Some of the words are missing. Use the words from Step 1 to complete the description. Then, draw a storyboard on the back of the page showing the formation of a tornado.

High in the _____, cool air pushes against warm air. The place where the two kinds of air meet is called a _____. A front can stretch over 100 miles (161 kilometers).

On warm days, the air near the ground is much warmer than it is at higher elevations. Warm air rises by bubbling up from the ground, just like the bubbles in a pot of boiling water. If the air has enough moisture in it, the moisture _____ and forms _____.

Sometimes, the rising air is trapped by a layer of cooler air above it. As the day continues, the warm air builds up. If this pocket of warm air rises quickly, it can break through the cap of cooler air like water shooting up from a fountain and a _____, or _____ (kyu-mya-lo-NIM-buhs) cloud grows, topped by an _____. The thunderheads most likely to cause tornadoes are those that form along and ahead of fronts.

Strong, fast winds tend to blow along and above fronts. If slower surface winds blow opposite to the direction of the higher winds, a _____ forms. Vertical wind shear can cause the rising air in a thunderhead to begin to rotate.

A _____ is a thunderstorm with a constantly rotating _____. Supercells are responsible for a high percentage of severe weather events, especially _____.

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A Tornado Is Born

If the rising column of air in a thunderhead begins to rotate, it is called a _____ (mez-uh-SY-klon). In a mesocyclone the updrafts and _____ are in near balance, allowing the storm to continue for several hours.

As a mesocyclone rotates, it stretches toward warm air near the ground. The lower part of the mesocyclone narrows. The narrower it becomes, the faster it spins.

When this _____ dips down from the mesocyclone, it draws in warm, moist air. The air cools as it is pulled up into the column. Tiny droplets of water form and a whirling cloud appears. This cloud is called a _____.

Some funnel clouds hang straight down from the storm cloud. Others stretch sideways through the sky. A funnel cloud may dip down and retract into the mesocyclone, or it may touch the ground. If it touches the ground, the funnel cloud is called a _____.

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Hail Maker

Name _____

Directions: Gather the following materials and follow the steps below to illustrate how hail forms within thunderclouds.

What You Need—

- Scissors
- Wax paper
- Saucer
- Eyedropper
- Cold tap water
- Black construction paper
- Desk lamp
- Paper towel
- Magnifying lens
- Freezer

What You Do—

1. Cut a piece of wax paper to fit into the saucer. Place the paper into the saucer.
2. Use the eyedropper to place, separately, about 5 drops of water onto the wax paper.
3. Place the saucer in the freezer.
4. After 30 minutes, remove the saucer and place a drop of water on top of each frozen drop. Put the saucer back in the freezer.
5. Repeat Step 4 twice more. Wait an hour after you last add water. (**Note:** For a more dramatic effect, use different colors of water to form each layer.)
6. Place the black paper under the desk lamp. Remove one of the ice pellets and dry it with a paper towel. Place the pellet with its flat side facing up on the black paper.
7. Use the magnifying lens to observe the structure of the ice. View it from different angles. (As you make your observations, replace melted ice pellets with others.)

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Hail Maker

Describe the color and clarity of each of the different layers.

What You Discovered—
How do these ice pellets resemble hail? How are they different?

Challenge: Does the temperature of the water used to form each layer have an effect?

Test your hypothesis: Use both warmer and colder (ice-cooled) water as you form your ice pellets.

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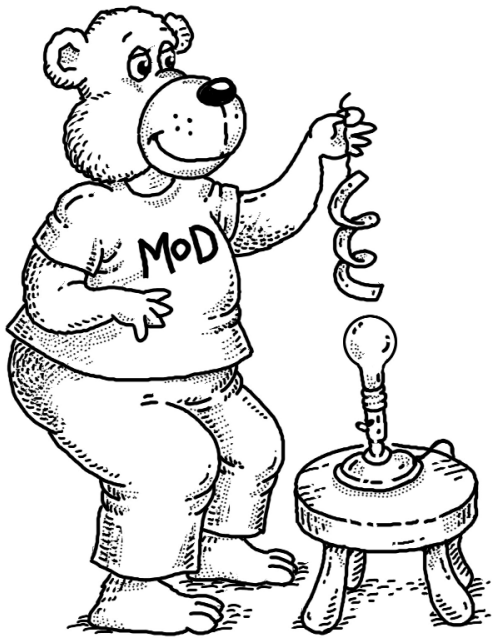
Wind Maker

Name _____

Directions: Gather the following materials and follow the steps below to illustrate how wind occurs.

What You Need—

- 3-in. (8-cm) paper circle cut into a spiral
- 10-in. (25-cm) piece of thread
- Heat source (light bulb)



What You Do—

1. Tie the thread to the center of one end of the paper spiral.

2. Hold the spiral by the thread and place it over the heat source. What happens?

3. Move the spiral away from the heat source. What happens?

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Wind Maker

What You Discovered—

- What happens when the air around the heat source is heated?

- What effect does that have on the air above?

- How does the activity explain the creation of winds? (Remember, when air is warmed, its molecules are excited and move farther apart.)

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Storm Cloud

Name _____

Directions: Gather the following materials and follow the steps below to illustrate how thunderstorm clouds form.

What You Need—

- Clear, plastic sweater box or similar container (8 in. x 8 in. x 12 in.)
- Water (room temperature)
- Heated milk (about 78° C or 140° F measured on a candy thermometer)
- Clean baby food jar
- Plastic wrap
- Rubber band
- Sharp object, such as the end of a paper clip

What You Do—

1. Fill the clear plastic box about 3/4 full of water
2. Fill the baby food jar to the top with heated milk and stretch a single layer of plastic wrap over it tightly
3. Carefully place the baby food jar into one end of the filled plastic container and allow it to sit for a minute until the water settles
4. Using a sharp object, puncture several holes in the top of the plastic wrap. Observe from the sides and top of the plastic container
5. Illustrate or describe what happens immediately

6. Illustrate or describe what happens next

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Storm Cloud

7. Illustrate or describe what happens when the milk begins to cool and sink.

What You Discovered—

How does this demonstration apply to thunderstorm cloud formation?

Challenge: Use the terms *anvil cloud*, *updraft*, *virga*, and *mammatus clouds* in your description.

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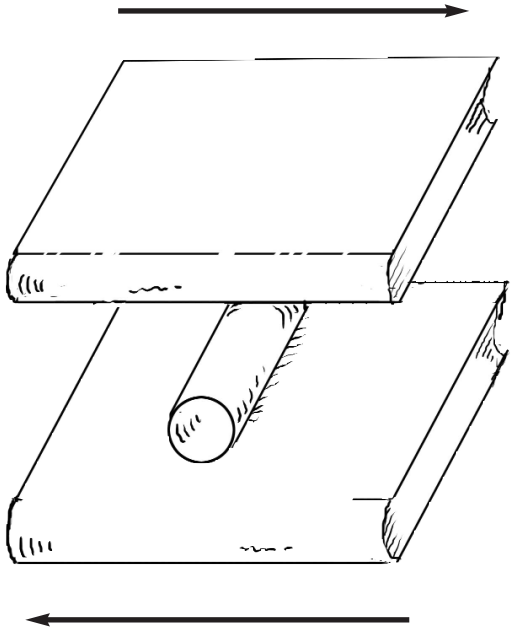
Wind Shear

Name _____

Directions: Gather the following materials and follow the steps below to illustrate wind shear and its role in creating tornadoes.



What You Need—

- Toilet tissue tube
- 2 hardbound books

What You Do—

1. Place the toilet tissue tube, horizontally, between the two books
2. Move the books in different directions as the tube rolls between them
3. Describe or illustrate what happens

What You Discovered—

If the top book represents the upper winds and the bottom book represents the lower winds, how does the movement represent wind shear?

If the tube in its initial position represents a horizontal wind tunnel, what does the tube represent when it hits the ground?

How does this illustrate real tornado formation?

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Tornado in a Bottle

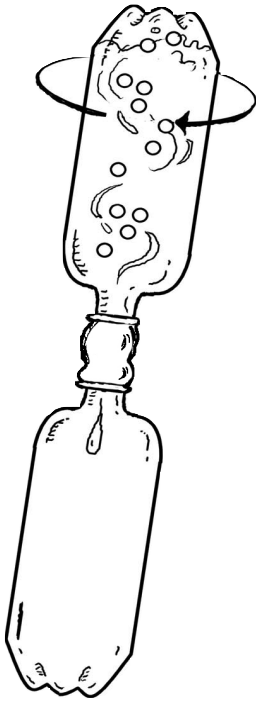
Name _____

Directions: Gather the following materials and follow the steps below to illustrate some of the concepts behind tornado formation.

What You Need—

- Two 2-liter soda bottles with caps
- Hammer and a 2-in. or 3-in. nail
- Scissors
- Balloon
- Food coloring
- About 2 liters (2 quarts) of water

What You Do—



1. Use the hammer and nail to punch a hole through each bottle cap. Widen the holes to about 1/4 inch.
2. Cut the top off the balloon, leaving just 1 inch or so of the tight bottom.
3. Fill one bottle 2/3 full with water. Put a few drops of food coloring the water and swirl it around so the color mixes in.
4. Leave the other bottle empty.
5. Screw the caps on each bottle.
6. Fit one end of the balloon over the neck of the bottle with water in it.
7. Flip the empty bottle over and place the caps of the bottles together.
8. Fit the other end of the balloon over the neck of the empty bottle.
9. Turn the bottles over and shake the full bottle in a circular motion.
10. Illustrate or describe what happens.

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Tornado in a Bottle

What You Discovered—
What part(s) of a tornado does this demonstrate?

How does it compare to real tornado formation?

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The Enhanced Fujita Scale of Tornado Intensity

Name _____

The winds of a tornado are often too difficult or even impossible to measure. The Enhanced Fujita Scale is a measurement of observed damage caused by tornadoes. The scale includes estimated wind speeds of 3-second gusts based on damage. You can read more about it at the National Oceanic and Atmospheric Administration's Storm Prediction Center Web site (*http://www.spc.noaa.gov/efscale/efscale.html*).

Challenge: Study the Enhanced Fujita Scale on the next page. Then, create scales to measure and compare the relative size or strength of other things: school or local teams, rivers, parks, buildings, pets, the success or failure of _____.

Make sure your descriptions will allow others to use the scale to measure and compare similar items.

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The Enhanced Fujita Scale of Tornado Intensity

	EF Scale Number	Wind Speed (3-second gusts)	Description of Damage
	**EF0 Light damage**	**65 to 85 mph (105–137 km/h)**	Causes some damage to siding, shingles and gutters; breaks branches from trees and overturns trees with shallow roots
	**EF1 Moderate damage**	**86 to 110 mph (138–177 km/h)**	Causes considerable roof damage; can uproot trees, bend flagpoles and large signs; may overturn single-wide mobile homes, tear off exterior doors and break windows and other glass
	**EF2 Considerable damage**	**111 to 135 mph (178–217 km/h)**	Destroys most single-wide mobile homes; tears roofs off well-constructed homes and shifts these homes from their foundations; uproots or breaks large trees in half; debarks softwood trees; tosses and overturns cars; collapses flag poles and large signs
	**EF3 Severe damage**	**136 to 165 mph (218–266 km/h)**	Tears the bark from hardwood trees; destroys all but small portions of houses; causes severe damage to office buildings or shopping malls; overturns trains and throws cars; blows away structures with weak foundations
	**EF4 Devastating damage**	**166 to 200 mph (267–322 km/h)**	Completely destroys well-built residences, large sections of school buildings and large office buildings; throws about cars and other large objects; tosses small objects like missiles
	**EF5 Incredible damage**	**More than 200 mph (more than 322 km/h)**	Causes significant structural deformation of mid- and high-rise buildings; throws automobile-sized missiles through the air 100 yards (91 meters) or more. To date, no EF5 tornadoes have been recorded.

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Map of the United States

Name _____

Directions: Complete the steps below using the data listed on *Tornado Strikes*.

1. Color the areas green that have an average of 0–10 tornadoes per year.

2. Color the areas blue that have an average of 11–20 tornadoes per year.

3. Color the areas yellow that have an average of 21–37 tornadoes per year.

4. Color the areas red that have an average of 38–125 tornadoes per year.

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Tornado Strikes

Name _____

Directions: The list below shows, by state, the average number of tornadoes from 1950 to 2005. Use this data, the completed *Map of the United States* and information about the meteorology of tornado formation to answer the questions on the *Tornado Worksheet*.

Alabama	27	New Hampshire	2
Alaska	Fewer than 1	New Jersey	3
Arizona	4	New Mexico	9
Arkansas	25	New York	7
California	5	North Carolina	19
Colorado	22	North Dakota	22
Connecticut	1	Ohio	15
Delaware	1	Oklahoma	57
Florida	55	Oregon	2
Georgia	22	Pennsylvania	12
Hawaii	1	Rhode Island	1
Idaho	3	South Carolina	14
Illinois	35	South Dakota	29
Indiana	22	Tennessee	15
Iowa	37	Texas	139
Kansas	55	Utah	2
Kentucky	12	Vermont	1
Louisiana	27	Virginia	10
Maine	2	Washington	2
Maryland	6	West Virginia	2
Massachusetts	3	Wyoming	11
Michigan	17		
Minnesota	25		
Mississippi	27	American Samoa	0
Missouri	30	District of Columbia	Fewer than 1
Montana	7	Guam	0
Nebraska	45	Puerto Rico	Fewer than 1
Nevada	1	Virgin Islands	0

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Tornado Worksheet

Name _____

Directions: Use *Map of the United States* and *Tornado Strikes* to answer the following questions.

1. How many states and U.S. territories have an average of 0–10 tornadoes per year?

   _____

2. How many states and U.S. territories have an average of 11–20 tornadoes per year?

   _____

3. How many states and U.S. territories have an average of 21–37 tornadoes per year?

   _____

4. How many states and U.S. territories have an average of 38–125 tornadoes per year?

   _____

5. The area of the United States that seems to be most prone to tornadoes is called Tornado Alley. Most tornadoes, especially severe tornadoes, have struck here. Use the data you have compiled to name the states that are included in Tornado Alley.

   _____

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Tornado Worksheet

6. Florida is a state that, historically, has a large number of tornado strikes. But it's not considered to be in Tornado Alley. Can you guess why?

7. Even though some areas have little or no record of tornado activity, can those areas still have tornadoes? _____

   Why?

   _____

   _____

   _____

   _____

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Climate Engines

Name _____

Directions: The five facts listed below describe "climate engines" that power the kind of weather we live with in the United States. Use the map of the United States on the next page to show the natural features that define Tornado Alley. Then, draw arrows and write short explanations to illustrate how these climate engines combine to create tornadoes in Tornado Alley.

Climate Engines

1. Daily heating and cooling of the earth is affected by the amount of solar energy reaching the earth's surface, the cloud cover and the type of surface. Earth spins on a tilted axis, so different areas warm up or cool down as it rotates around the sun. A water surface absorbs and releases heat energy more slowly than a land surface and tends to moderate temperatures and humidity.
2. The jet stream can be thought of as a river of moving air that encircles the globe, generally in the northern temperate zone. The jet stream, sometimes referred to as a storm track, is often associated with stormy weather.
3. The Gulf Stream is an oceanic river moving up the east coast of the United States, bringing warm tropical water from the equator. This warm water provides much of the humidity and energy that triggers cyclone development of all kinds, from hurricanes to tornadoes.
4. The cool Pacific currents, powered by the warm Kuroshio Current and cooled by the cold Oyashio Current, bring cool water from Alaska and western Canada past the West Coast of the United States.
5. The Great Plains exhibit a relatively flat terrain. This great area of former grasslands allows large masses of air to move quickly, unimpeded, down the center of the continent.

Challenge: Which of the five climate engines do you think would explain the fact that tornadoes usually happen in the spring and early summer?

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Climate Engines

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Tornado Weather Clues

Name _____

A good scientist observes change. To know when a tornado is possible, look for—

- **Dark, often greenish sky**. Sometimes one or more of the clouds turns greenish (a phenomenon caused by hail) indicating that a tornado may develop.
- **Wall cloud,** an isolated lowering of the base of a thunderstorm. The wall cloud is particularly suspect if it is rotating.
- **Large hail.** Tornadoes are spawned from powerful thunderstorms and the most powerful thunderstorms produce large hail. Tornadoes frequently emerge from near the hail-producing portion of the storm.
- **Cloud of debris.** An approaching cloud of debris can mark the location of a tornado even if a funnel cloud is not visible.
- **Funnel cloud.** A visible rotating extension of the cloud base is a sign that a tornado may develop. (A funnel cloud starts in the sky; once it touches down it becomes a tornado.)
- **Roaring noise.** The high winds of a tornado can cause a roar that is often compared to the sound of a freight train, a million angry bees, or a thousand jet engines.
- **Tornadoes** may occur near the trailing edge of a thunderstorm and be quite visible. It is not uncommon to see clear, sunlit skies behind a tornado. Tornadoes may also be embedded in rain and not visible at all.

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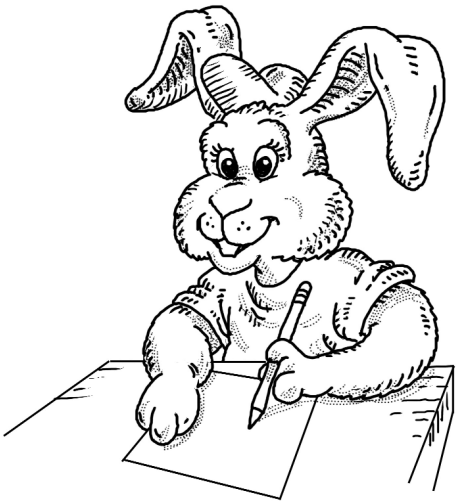
Tornado Weather Clues



Directions: Follow the directions below to turn one of the warning signs on page 1 into a descriptive poem.

1. Make a list of words and phrases that describe your tornado weather clue—how it looks, how it might make you feel, how it sounds or what it does to the world around you.

2. Use the following pattern to turn these terms into a tornado-shaped poem:

   1st line: four words or phrases that describe how it looks or sounds.
   2nd line: three words or phrases that describe how it makes you feel.
   3rd line: two words or phrases that describe how the atmosphere changes.
   4th line: one word or phrase that names your weather clue.

	4 words
	3 words
	2 words
	1 word

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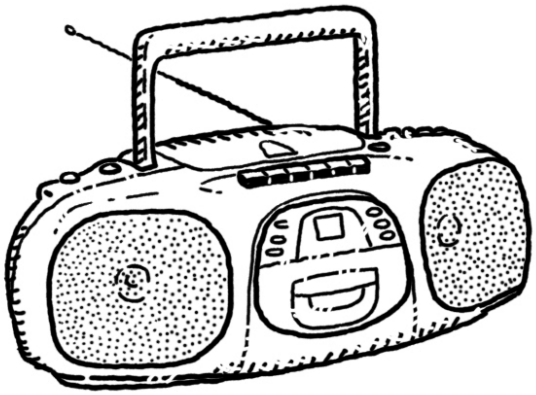
Tornado WATCH Versus WARNING

Name _____

What to Do During a Tornado WATCH
If a tornado WATCH is issued for your area, it means that a tornado is possible.

- Listen to National Oceanic and Atmospheric Administration (NOAA) Weather Radio or a local radio or television station for updated information. Tornadoes can change direction, intensity and speed very quickly.

- Be alert to changing weather conditions. Tornadoes accompany severe thunderstorms, and weather conditions can change rapidly. Large hail, blowing debris or the sound of an approaching tornado may alert you. Many people say an approaching tornado sounds like a freight train.



- Make sure your family disaster supplies kit is ready.

What to Do During a Tornado WARNING
If a tornado WARNING is issued, it means that a tornado has actually been spotted, or is strongly indicated on radar, and it is time to go to a safe place immediately. Remember, there is often no time to issue a tornado WARNING. If the signs are there and a WATCH is in effect, move to safety.

- Listen to NOAA Weather Radio or a local radio or television station for updated information. (NOAA Weather Radio, which is broadcast on seven VHF frequencies ranging from 162.400 MHz to 162.550 MHz, can be heard on handheld radio receivers that just pick up Weather Radio or desktop or console models that receive Weather Radio in addition to other broadcasts. These can be purchased at many retail outlets, including electronics, department, sporting goods and boat and marine accessory stores and their catalogs. They can also be purchased via the Internet from online retailers or directly from manufacturers.)

- If you are inside, go to your safe place to protect yourself from glass and other flying objects. The safest place to take shelter during a tornado is in a basement. If your

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Tornado WATCH versus WARNING

home does not have a basement, go to the lowest floor and take shelter in a hallway, closet or small room toward the inside of the building, away from windows.

- Get under a piece of sturdy furniture, such as a workbench or heavy table, and hold on to it. Sturdy furniture will help protect you from falling debris. If a tornado wind enters the room and the object moves, holding on with one hand will help you move with it, keeping you protected. Use your other arm and hand to protect your head and neck from falling or flying objects.

- Stay away from windows. Opening windows allows damaging winds to enter the structure. Leave the windows alone.

- If you are outside in a car or in a mobile home or transportable classroom, go immediately to the basement of a nearby sturdy building. Tornado winds can blow large objects, including cars and mobile homes, hundreds of feet.

- If there is no nearby building, lie flat in a low spot. Use your arms and hands to protect your head. Do not go under highway bridges and overpasses because dangerous flying debris can be blown under them, or weakened overpasses and bridges can be destroyed. Tornadoes come from severe thunderstorms, which can produce a lot of rain. If you see quickly rising water or floodwater coming toward you, move to another spot.

- Avoid places with wide-span roofs, such as auditoriums, cafeterias, gymnasiums, large hallways, or shopping malls. Wide-span roofs are frequently damaged or destroyed in tornado winds. Wide-span roofs provide less protection than roofs over smaller rooms and increase the risk of injury.

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Myths and Facts About Tornadoes

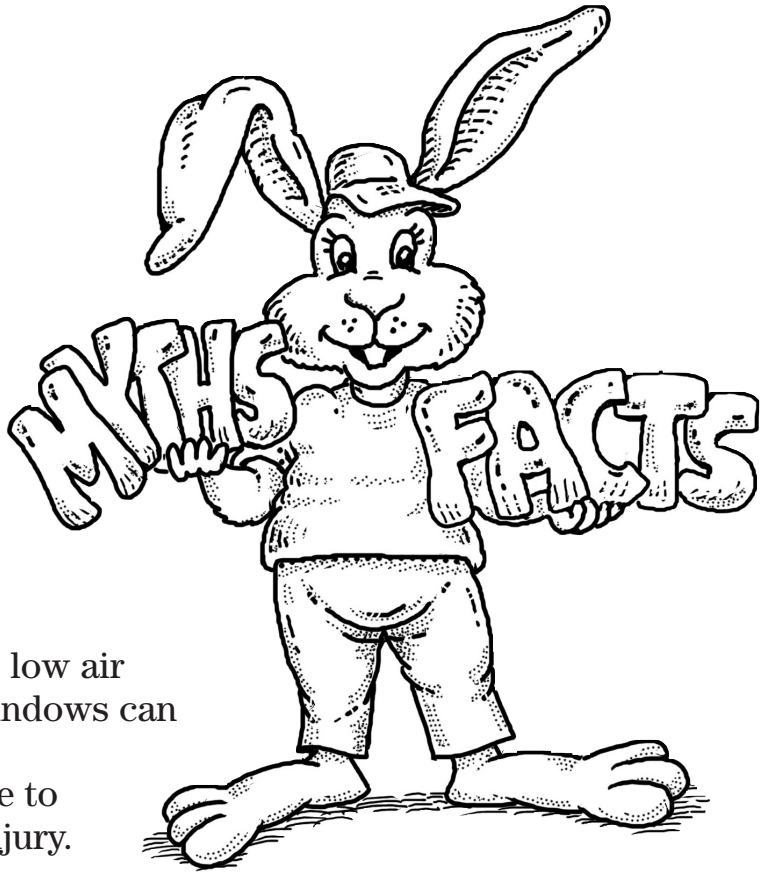
Name _____

Myth

Tornadoes can happen only in "Tornado Alley."

Fact

Tornadoes can happen in every state.



Myth

You should open the windows if a tornado is coming so the building will not explode.

Fact

Research has shown that buildings do not explode from the low air pressure of a tornado. Opening windows can increase the chance of high winds entering and causing more damage to your home and exposing you to injury. Leave the windows alone.

Myth

You should try to "outdrive" a tornado.

Fact

It is not safe to try to outdrive a tornado because tornadoes shift direction so quickly. A tornado can pick up cars and toss them about like toys. If you are in a car during a tornado, you should get out and find a safe place.

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Myths and Facts About Tornadoes

Myth

Highway overpasses are a safe place to hide during a tornado.

Fact

People who take shelter under a highway overpass can be killed because the overpass acts like a wind tunnel and brings stronger winds and a lot of debris.

Myth

Tornadoes happen only in the springtime.

Fact

Most tornadoes do happen from March through August; however, they can occur in any month.

Myth

Tornadoes never strike big cities.

Fact

Tornadoes do strike big cities. For example, St. Louis has had 22 tornadoes in the past 40 years; Oklahoma City and Salt Lake City have been struck by tornadoes.

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