

Tornadoes Answer Sheet

LEVEL 1

None

LEVEL 2

Definitions for *A Tornado Is Born*

anvil cloud: the upper portion of a cumulonimbus cloud that flattens spreads out, sometimes for hundreds of miles

atmosphere: the mass of air surrounding the earth

condense: to cause a gas or vapor to change into a liquid

cumulonimbus cloud: a cloud that towers above ordinary cumulus clouds with stronger or severe storms. The cloud often has a more sharply outlined, defined appearance with relatively rapid rising motions that are visible.

cumulus cloud: a column of rising air that has condensed into a dense cloud with distinct outlines. The cumulus cloud is the first stage of a developing thunderstorm, although most cumulus clouds do not form thunderstorms.

downdraft: rapidly descending column of cooling air that causes heavy rains and violent wind gusts

front: the boundary between two air masses with differing characteristics, such as temperature or humidity

funnel cloud: a rotating, cone-shape column of air extending downward from the base of a thunderstorm. When a funnel cloud reaches the ground, it is called a tornado.

mesocyclone: a rotating shaft of rapidly rising air within a storm. Under certain conditions, a mesocyclone can generate a tornado.

supercell: a violent thunderstorm that has a persistent, rotating updraft and is capable of spawning tornadoes

thunderhead: the upper portion of a swelling cumulus cloud, or the entire cumulonimbus cloud

updraft: a column of warm, moist air that is rising in a thundercloud or supercell

vertical wind shear: the change in the wind's direction and speed with height

vortex: a whirling mass of air in the form of a column or spiral

Answers to *A Tornado Is Born*, Pages 2 and 3

High in the **atmosphere**, cool air pushes against warm air. The place where the two kinds of air meet is called a **front**. 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 **condenses** and forms **cumulus clouds**.

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 **thunderhead** or **cumulonimbus** (kyu-mya-lo-NIM-buhs) cloud, grows, topped by an **anvil cloud**. 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 **vertical wind shear** forms. Vertical wind shear can cause the rising air in a thunderhead to begin to rotate.

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A **supercell** is a thunderstorm with a constantly rotating **updraft**. Supercells are responsible for a high percentage of severe weather events, especially **tornadoes**. If the rising column of air in a thunderhead begins to rotate, it is called a **mesocyclone** (mez-uh-SY-klon). In a mesocyclone, the updrafts and **down drafts** 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 **vortex** 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 **funnel cloud**.

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

Answers to *Hail Maker*, page 2

Observation of Layers

You can see the different layers within the frozen droplet. The layers farthest from the center are the clearest; the inner layer is white.

What You Discovered

The ice pellets resemble hail because of the layers of ice within each. They are different from hail because they are not round and the number of layers is not dependent on the winds and temperature changes within a cloud.

Challenge: Temperature differences may have an effect, because the addition of warm water might partially melt the previous layer of the ice pellet before it is refrozen, blurring the layers. Using ice-cooled water might change the clarity of the layers. The actual demonstration may differ depending on the temperature of the water used.

Answer to *Wind Maker*

When you hold the spiral by the thread over the heat source, the spiral begins to swirl. When you move it away from the heat source, the spiral stops swirling.

What You Discovered

When the air around the heat source is heated, the warmer air rises (updraft) and the cooler air drops down (downdraft) causing air movement. This movement of air causes wind.

Answer to *Storm Cloud*

The warmer milk immediately rises toward the top of the container. It spreads into an anvil-shaped cloud as it hits the cooler water of the container and the water's surface. As the milk cools, it sinks in pouches and then in tiny streams back into the water.

What You Discovered

A cumulonimbus cloud develops vertically (updrafts of moist air) and is often capped by an anvil-shaped cloud. This is a thunderstorm cloud, frequently accompanied by heavy rains, lightning, thunder and, sometimes, hail, tornadoes or strong winds.

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Answer to *Wind Shear*

When you move the books in opposite directions, the horizontal tube rolls between the books and then shears off vertically.

What You Discovered

Wind shear is the effect of winds moving in opposite directions. When the tube hits the ground, it represents a tornado. The power of the winds aloft and the slower winds closer to the ground can make the rising air in a thunderhead start spinning, forming a column of spinning air (mesocyclone) that can be the basis of a tornado.

Answer to *Tornado in a Bottle*

What You Discovered

The swirling motion builds energy and, as the water drops through the opening of the bottle, it forms a vortex (a spinning funnel shape). The energy of a real tornado comes from winds and wind shear that produce “rotation,” which results in the tornado vortex. As this energy is forced into the smaller opening, it becomes more violent because the molecules move closer to the center.

Answers to *Tornado Worksheet*

1. 32
2. 11
3. 7
4. 5
5. Texas, Oklahoma, Kansas, Nebraska and Missouri
6. Florida has many tornadoes simply because it experiences thunderstorms almost daily. In addition, tropical cyclones also affect the Florida peninsula. When these cyclones move ashore, the embedded thunderstorms often will produce tornadoes. However, despite the violent nature of a tropical cyclone, most of the tornadoes they spawn (some being water spouts) are normally relatively weak.
7. Yes. Tornadoes can strike anywhere if conditions are right. Some areas are more susceptible to tornado activity than others.

LEVEL 3

Answers to *A Cartographer’s Guide to Tornadoes*

1. Weather in the United States is influenced by four air masses. What are they?
 - Tropical:** These air masses form over the tropic latitudes. They are warm, humid and have low air pressure.
 - Polar:** These air masses form north of the 50° line of latitude. They are cold and have high pressure.
 - Maritime:** These air masses form over the oceans, so they are humid.
 - Continental:** These air masses form over land, so they tend to be drier than maritime air masses.
2. What forces move these air masses around? What direction will they take as they move toward and into the United States?
 - The jet stream is a prevailing, upper-level, westerly wind. It moves from west to east in a sinuous line that changes with the strength of the cold fronts moving south.

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- A cyclone is an area of low pressure around which the winds flow counterclockwise in the Northern Hemisphere. A developing cyclone is typically formed by a warm front pushing northward and a cold front pulling southward.
 - Air masses move south from the arctic land mass, southwest from the northern Pacific, southeast from the northern Atlantic, north and then northeast from the Tropics.
3. How might the landforms of the United States affect the air masses moving through the area?
- When air is confronted by a mountain, it is lifted up and over the mountain; as it rises, it cools. If it reaches its dew point it will condense and form a cloud and probably precipitation. Usually, the wind releases its moisture on the west side of the mountains, and as it flows down onto the plains, the drier air begins to warm.
 - There is no barrier to the movement of air masses between the Gulf of Mexico and the states of the Great Plains.
4. What is a cold front and what is a warm front? What happens when the two air masses collide?
- A cold front is an air mass characterized by cold, dense air. Cold fronts have winds that move in a clockwise direction. They are sometimes called “anticyclones.”
 - A warm front is an air mass of light, warm air. Warm fronts have winds that move counterclockwise and are called cyclones.
 - When a cold front collides with a warm front, it slides under the warm front and pushes the lighter, warmer air upward. The warm air cools down, condenses and forms cumulus clouds. If there is enough warm air, as in the summer, it may form cumulonimbus clouds and even tornadoes.
5. Based on information about the formation of cumulonimbus clouds, why does an occluded front create excellent conditions for the formation of severe thunderstorms and eventually tornadoes?
- An occluded front occurs when a warm air mass is trapped between two cold air masses. The warm air is pushed upward when the two cold air masses meet in a kind of squeeze action. The warm air mass is completely cut off from the ground by the colder air below. The warm air has nowhere to go but up, resulting in the creation of high, strong cumulus clouds. As it cools, it will fall and then be pushed up again, adding energy to the updraft.
6. Collisions between cold, dry air masses and warm, moist air masses take place in the Great Plains. This part of the United States is sometimes called Tornado Alley. Compare an alley in your town to Tornado Alley. How are they similar?
- Possible answer: An alley is a narrow street with walls on both sides. Tornado Alley is a geographic corridor in the United States, which stretches north from Texas to Nebraska and Iowa. In the case of Tornado Alley, the walls on either side of the alley are the two mountain ranges, the Rocky Mountains and the Appalachian Mountains.
7. Tornado season tends to move north with the sun. That is, tornado season starts earlier in the southern part of Tornado Alley than in its northern regions. Why is spring the most active time for tornadoes? Use the same reasoning to explain why the southeastern states sometimes have a “mini-tornado season” in the fall.
- Spring and summer comprise the prime thunderstorm season; so it is also prime tornado season in the Great Plains. The reason is that because, during these seasons, the air temperature decreases dramatically as the air rises (called the temperature gradient). Moreover, as the earth rotates around the sun, the surface warms, releasing energy (heat) and water vapor.
 - Severe thunderstorms need large infusions of energy to build into supercells and tornadoes. The warmer the surface, the more energy is available. Energy and water

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vapor are released from the warm surface and rise in buoyant plumes which, when combined and organized, form a thunderstorm cell. Therefore, spring and summer have the greatest possibility for the development of thunderstorms.

Answers to *Real-life Tornadoes*

(1) EF3; (2) EF5; (3) EF1.

Answers to *The Truth About Tornadoes*

- 1. True.** There are three possible explanations for the greenish sky.
 - As light from above travels through the storm, it is reflected and refracted by the water droplets and hailstones. The hail allows more of the green to get through and color the clouds.
 - When the sun is low in the sky, such as before sunset when most severe storms occur, the reddening light of the sun when shining through the earth's atmosphere makes the bluish cloud tint turn green.
 - Storm clouds may act as a kind of canvas upon which low sunlight, scattered by particles in the air, paints a greenish color. Hail can fall from severe thunderstorms. The rotation of a thunderstorm's updraft strengthens the upward wind motion, helping to hold larger ice particles aloft for a longer time. The longer a hailstone can remain suspended in a growth region of the thunderstorm, the bigger the hailstone will grow.
- 2. False.** Tornadoes can happen in every state if there is warm, moist, unstable air along and ahead of cold fronts.
- 3. False.** Waterspouts are weak tornadoes that form over warm water. The water drops in the waterspout are the result of condensation, not the body of water over which the spout has formed. They are most common along the Gulf Coast and southeastern states. Occasionally, waterspouts move inland becoming tornadoes that cause damage and injury.
- 4. False.** 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.
- 5. True.** As the tornado moves over the ground, it stirs up dust and soil and other debris dragged in by the low pressure.
- 6. True.** Never try to "outdrive" a tornado. Vehicles can be deadly in a tornado; the more surface they present to the wind, the more easily they are blown from the road. A tornado can pick up a car and toss it about like a toy. If you are in a car during a tornado, get out and find a safe place.
- 7. True.** The whirling appearing near the cloud base is actually evidence of the mesocyclone that is responsible for the tornado's formation. Although the classic funnel shape is common, it can look like a jar or have more than one funnel. In fact, large tornadoes may have several narrow, twisting funnels circling around.
- 8. True.** All that is needed for a tornado to form is warm, moist, unstable air along and ahead of cold fronts.
- 9. False.** People who take shelter under a highway overpass can be killed because the overpass acts like a wind tunnel. The reality of a tornadic circulation in the atmosphere is that the wind has a very strong horizontal element. In most cases, the strongest horizontal and vertical components of the wind can be found not far above the surface. In addition, in almost ALL

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tornadoes, the very strong wind extends outside the diameter of the visible funnel—and in many cases, **a considerable distance** from the visible funnel.

10. **True.** The high winds of a tornado can cause a roar that is often compared to the sound of a freight train. However, what you hear depends on what the tornado is hitting, its size, intensity and distance from you. The most common tornado sound is a continuous rumble, like a nearby train. Sometimes a tornado produces a loud “whooshing” sound, like that of a waterfall or of open car windows while driving very fast. Tornadoes that are tearing through densely populated areas may be producing all kinds of loud noises at once which, collectively, may make a **tremendous roar**.
11. **True.** Tornadoes generally occur near the trailing edge of a thunderstorm. It is not uncommon to see clear, sunlit skies behind a tornado. The tornado circulation develops at midlevels—about 20,000 feet (6,100 kilometers)—in the storm where the storm’s updraft and mesocyclone are strongest. The circulation gradually builds down (and up) within the storm. At about the same time, a downdraft develops at midlevels near the back edge of the storm. This downdraft, called a “rear flank downdraft” (RFD), descends to the ground along with the tornado circulation.
12. **False.** Tornadoes do happen in 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.