Thunderstorms

1. What are thunderstorms? Describe how knowledge of thunderstorms has grown historically, and how it is studied today.

2. How do thunderstorms form? Illustrate the lifecycle of a thunderstorm in a creative way.

3. Compare and contrast the four types of thunderstorms, ranking them from weakest to strongest. Which is most common in your area?

4. What type of clouds are associated with thunderstorms? How do they form?

5. Answer the following about thunder and lightning:
    a. What causes lighting?
    b. How fast does lightning travel on average?
    c. What is the average electrical charge produced by a lightning discharge?
    d. How often does lightning strike around the world?
    e. What is the likelihood of someone being struck by lightning?
    f. Describe the following steps of a lightning strike:
        i. Stepped leader
        ii. Upward moving particles/streamers
        iii. Return stroke
        iv. Dart leader
    g. What is the cause of thunder?
    h. What method is used to approximate the distance to the site of a lightning flash?

6. Answer the following about tornados:
    a. What type of thunderstorms cause tornados?
    b. How are tornados formed?
    c. How fast are tornado windspeeds?
    d. How fast and how far can tornados travel?
    e. How are tornados classified?
    f. What is the difference between a tornado and a waterspout?
    g. In what ways can you protect yourself in the event of a tornado?

7. Thunderstorms can occasionally cause severe hazards to humans and the environment. Explain how each of the following can harm humans, and how to be safe from them:
    a. Air-to-ground lightning strikes
    b. Hail
    c. Floods
    d. Wildfires

8. Describe the function of a lightning rod or another lightning protection device.

9. The Bible makes many references to storms, thunder, and lightning. Choose seven passages that mention thunder, lighting, or storms, and discuss why you think they are important.
10. Research and present on one of the following:

   a. A scientist or individual who made advances in the study of thunderstorms
   b. A building or structure with a special construction that prevents damage from lightning strikes
   c. A thunderstorm which had a significant impact on humans and/or the environment

11. Do one of the following:
   a. Create a model of a thunderstorm, demonstrating how electrical charges in the cloud create lighting and thunder.
   b. Model or creatively demonstrate how a tornado can form from a thunderstorm.
   c. Participate in a thunderstorm awareness event to encourage safety from thunderstorm hazards.
   d. Conduct a survey of your town to discover the methods of thunderstorm protection that have been used. Report your findings to your instructor.

Thunderstorms

Upper Columbia Conference Honor Pilot

Nothing beats a good old-fashioned thunderstorm! One of the most awe-inspiring forces of nature, the flashes of lightning and the crashes of thunder speak of the incredible power that God shows us through His creation. We've all experienced storms that are loud enough to rattle the windows, and everyone has been taught that lightning is dangerous, but what does it all really mean? What causes thunderstorms and what makes them so powerful? How can we stay safe and still enjoy the incredible display of nature? Let's find out!

Thunderstorms are both incredibly fascinating and dangerous.[1]

(1) https://static.wikia.nocookie.net/darkpictures/images/7/7f/91dfd7a501091d708c84f34c4bbc5ec4.jpg/revision/latest?cb=20200206090717
(2) https://assetsnffrgf-a.akamaihd.net/assets/m/1102016033/univ/art/1102016033_univ_cnt_2_xl.jpg

Early Study of Thunderstorms

The ancient Greeks believed that lightning was their mythical god Zeus throwing dart-like bolts at his enemies.[1]

Our understanding of how and why thunderstorms form has grown over the centuries, many early civilizations believing it to be a work of their gods. Thunder was typically seen as a positive thing (possibly because it was accompanied by rain), representing a revered deity going to war against dangerous enemies. Different civilizations had rituals used in an effort to either drive the thunderstorms away, or to attract them to water their crops. Some of these superstitions are still used today!

God's people also recognized it as a sign or work of God in Bible times, often accompanying His words when He spoke to people, showing His power and glory, and also His displeasure when angry.

Thunder accompanied God's voice when He spoke directly to the Children of Israel and gave them the 10 Commandments on Mount Sinai.[2]

(1) https://static.wikia.nocookie.net/darkpictures/images/7/7f/91dfd7a501091d708c84f34c4bbc5ec4.jpg/revision/latest?cb=20200206090717
(2) https://assetsnffrgf-a.akamaihd.net/assets/m/1102016033/univ/art/1102016033_univ_cnt_2_xl.jpg

Benjamin Franklin Flies a Kite

Benjamin Franklin, (1705 – 1790)[1]

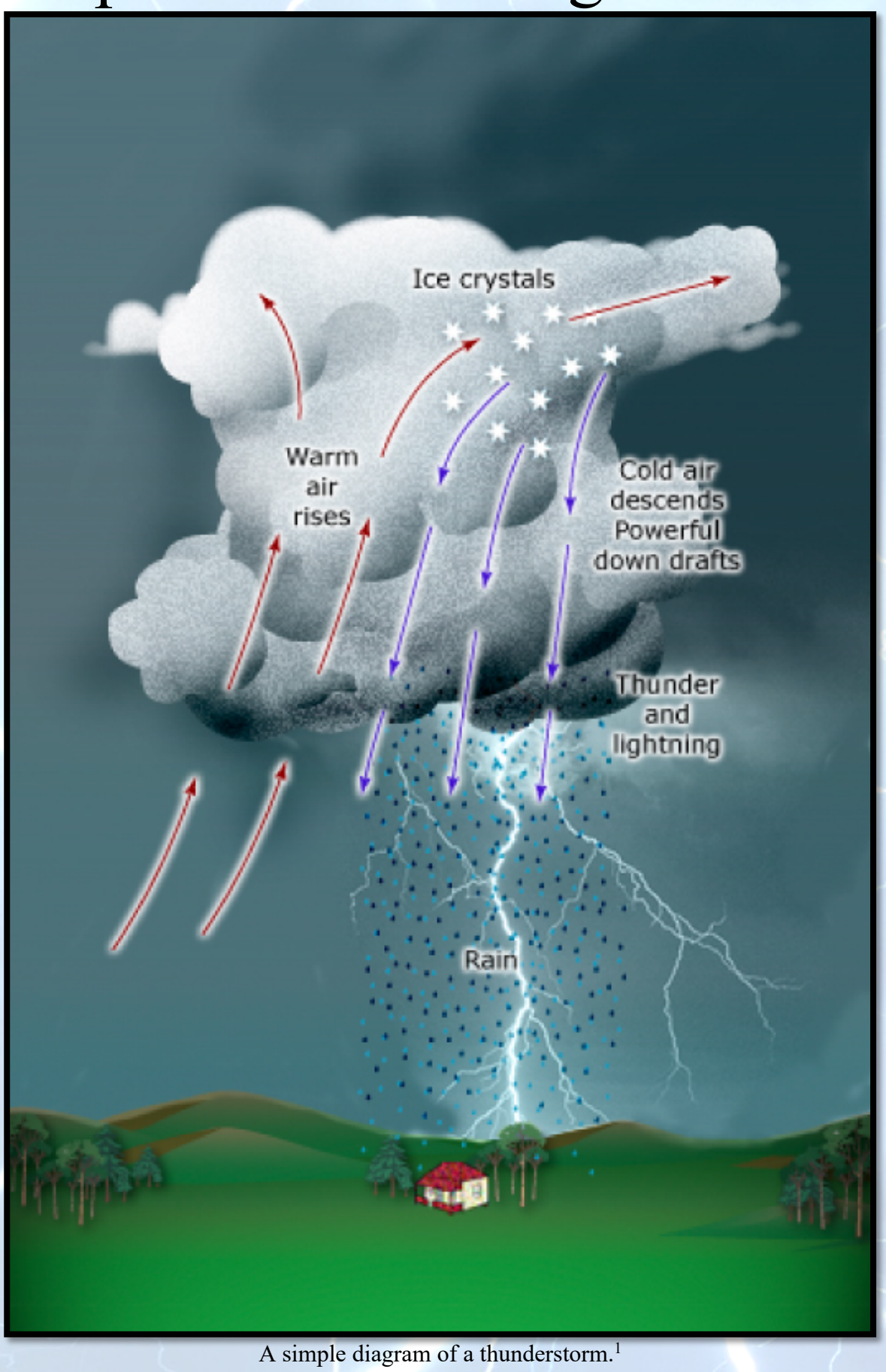
As scientific curiosity increased, so did people's interest in thunderstorms. Benjamin Franklin, an American scientist, pioneered the study of thunderstorms and their connection to electricity. During a thunderstorm, he flew a kite with a ketal key attached to the base of it. The electricity from the storm made its way down the string and electrically charged the metal key, giving Franklin a minor shock when he touched it. From this, he learned that thunderstorms contained electricity. Inventions such as his lightning rod helped protect tall objects, buildings, and even tall-masted ships from lightning strikes.

Contrary to popular belief, lightning did not strike Franklin's kite. He would have fried! He discovered thunderstorms contained electricity from the static that traveled down the kite string.[2]

(1) https://mtv-main-assets.mountvernon.org/files/resources/franklin.jpg
(2) https://media.sciencephoto.com/h4/06/02/56/h4060256-800px-wm.jpg

What is a Thunderstorm?

A thunderstorm, also known as an electrical storm or lightning storm, is a storm that involves lightning and typically includes wind and precipitation such as rain or hail. They are cased when a warm mass of moist air rises over or through a mass of cooler air. As the warm air rises, it begins to cool, its moisture forming water droplets. If the rising mass of air is large enough, they can develop static electricity, with a positive electrical charge on the top of the cloud and a negative charge underneath. These static electricity charges are where lightning comes from and what changes a rainstorm into a thunderstorm!

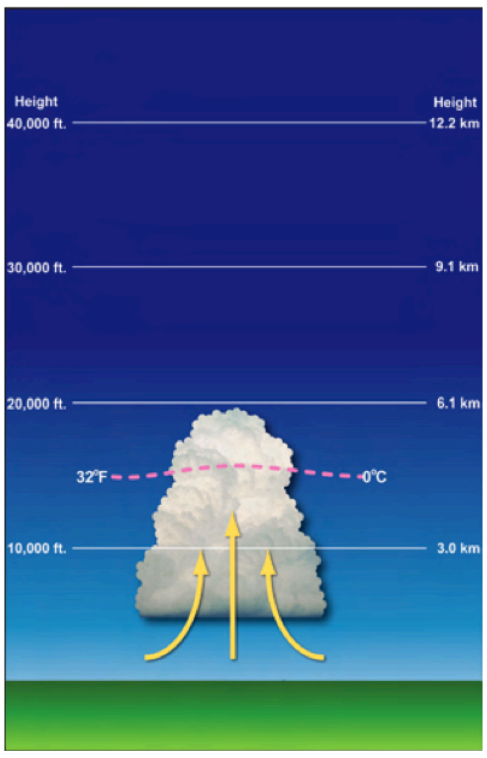


A simple diagram of a thunderstorm.[1]

(1) https://aos.gsfc.nasa.gov/images/thunderstorm.png

Life Cycle of a Thunderstorm

The Developing Stage



Developing Stage

- Towering cumulus cloud indicates rising air
- Usually little if any rain during this stage
- Lasts about 10 minutes
- Occasional lightning

Characteristics of the developing stage of a thunderstorm.[1]

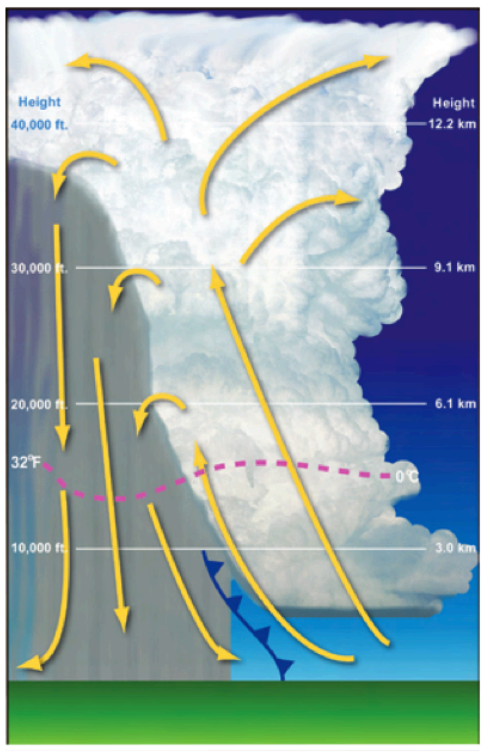
Thunderstorms typically have 3 phases they go through in their "lifecycle." The first phase is known as the Developing Stage, during which cumulonimbus clouds, the large clouds characteristic of thunderstorms, form. Warm air rises and creates an "updraft," cooling and creating water droplets suspended in the air. These droplets appear to us as clouds and form the foundation of a thunderstorm.

Large clouds indicating an updraft, the first stage of a thunderstorm's lifecycle.[2]

(1) https://ialert.com/blog/wp-content/uploads/2014/09/Screen-Shot-2014-09-09-at-5.24.25-PM.png
(2) https://www.weather.gov/images/spotterguide/tstrms_singlecell1a.jpg

Life Cycle of a Thunderstorm

The Mature Stage



Mature Stage

- Most likely time for hail, heavy rain, frequent lightning, strong winds, and tornadoes
- Storm occasionally has a black or dark green appearance
- Lasts an average of 10 to 20 minutes but some storms may last much longer

Characteristics of the mature stage of a thunderstorm.

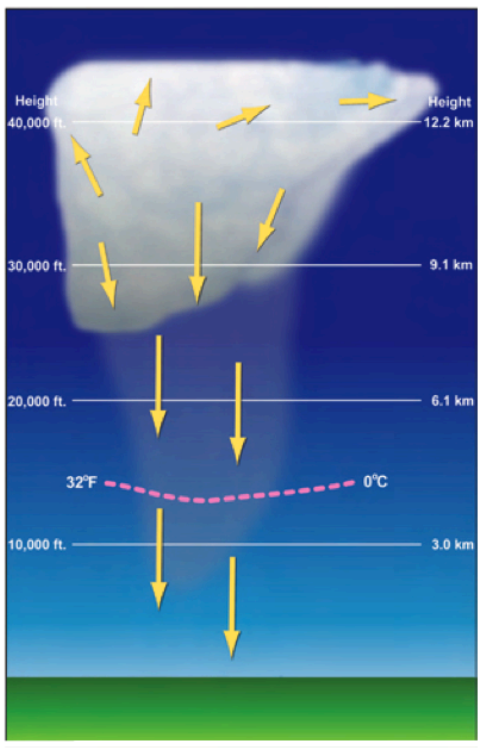
The second stage, known as the Mature Stage, is the stage in which most of the thunderstorm action takes place. If a thundercloud reaches the top of the troposphere, the lowest layer of the atmosphere, it can rise no further and is compressed together. Precipitation begins to fall within the cloud, creating a "downdraft." This causes friction with the updraft creating static electricity. This stage usually involves heavy wind and rain, and typically lasts until enough precipitation has fallen that it is no longer building up static electricity.

The mature stage of a thunderstorm typically involves heavy rain, and is the stage when the lightning and thunder is most intense.[2]

(1) https://ialert.com/blog/wp-content/uploads/2014/09/Screen-Shot-2014-09-09-at-5.24.25-PM.png
(2) https://www.weather.gov/images/unr/historical/weather/2020-07-10/Stradling.gif

Life Cycle of a Thunderstorm

The Dissipating Stage



Dissipating Stage

- Downdrafts, downward flowing air, dominate the storm
- Rainfall decreases in intensity
- Can still produce a burst of strong winds
- Lightning remains a danger

Characteristics of the dissipating stage of a thunderstorm.[1]

The third and final stage is called the Dissipating Stage. By this time, there isn't much updraft anymore, so the downdraft is free to make its way to the ground, spreading out when it hits the ground. This cuts off any remaining updraft, preventing the thunderstorm from growing any further. The downdraft "drains" the thundercloud of the last of its energy, and the cloud may even disappear shortly afterward!

The thick cumulonimbus clouds associated with thunderstorms gradually become thin wispy stratocumulus clouds.[2]

(1) https://ialert.com/blog/wp-content/uploads/2014/09/Screen-Shot-2014-09-09-at-5.24.25-PM.png
(2) https://australiasevereweather.com/photography/photos/1996/1229mb08.jpg

Thunderstorm Categories

Thunderstorms fall into four major categories, each one referring to the number and arrangement of the storm's "cells," a storm-causing updraft.

Isolated single-cell thunderstorm.[1]

A single-cell thunderstorm has only one major updraft. The thunderstorm is relatively minor, lasting only 20-30 minutes with minimal precipitation, thunder, or lightning.

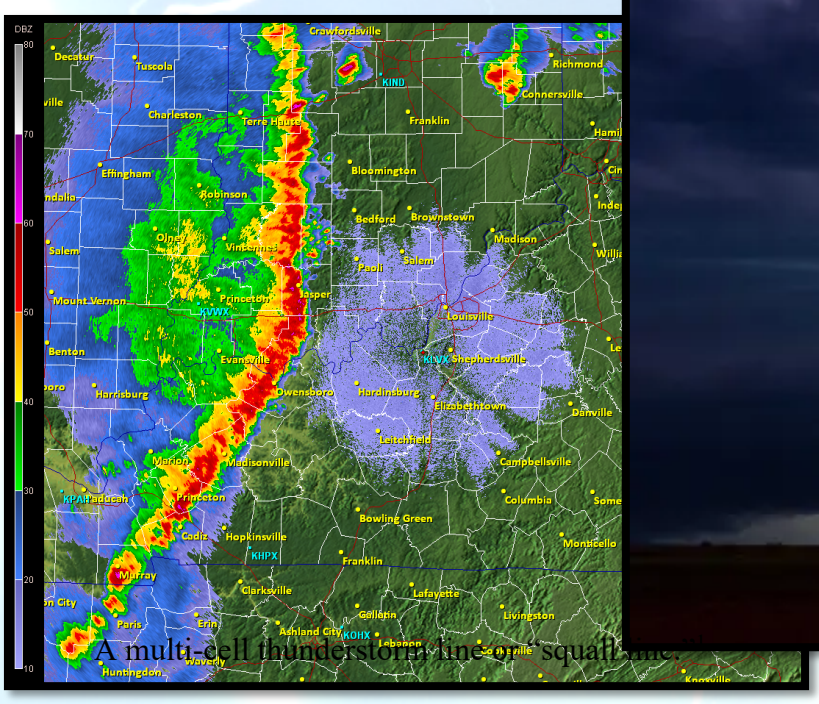
A multi-cell cluster thunderstorm.[2]

Multi-cell thunderstorms occur in two different types. Multi-cell clusters are the most common type of thunderstorm and form around a group of storm cells. The stronger the cell, the closer to the center it is, moving toward the outside as it weakens. These can last for hours, though each cell may last only an hour or less.

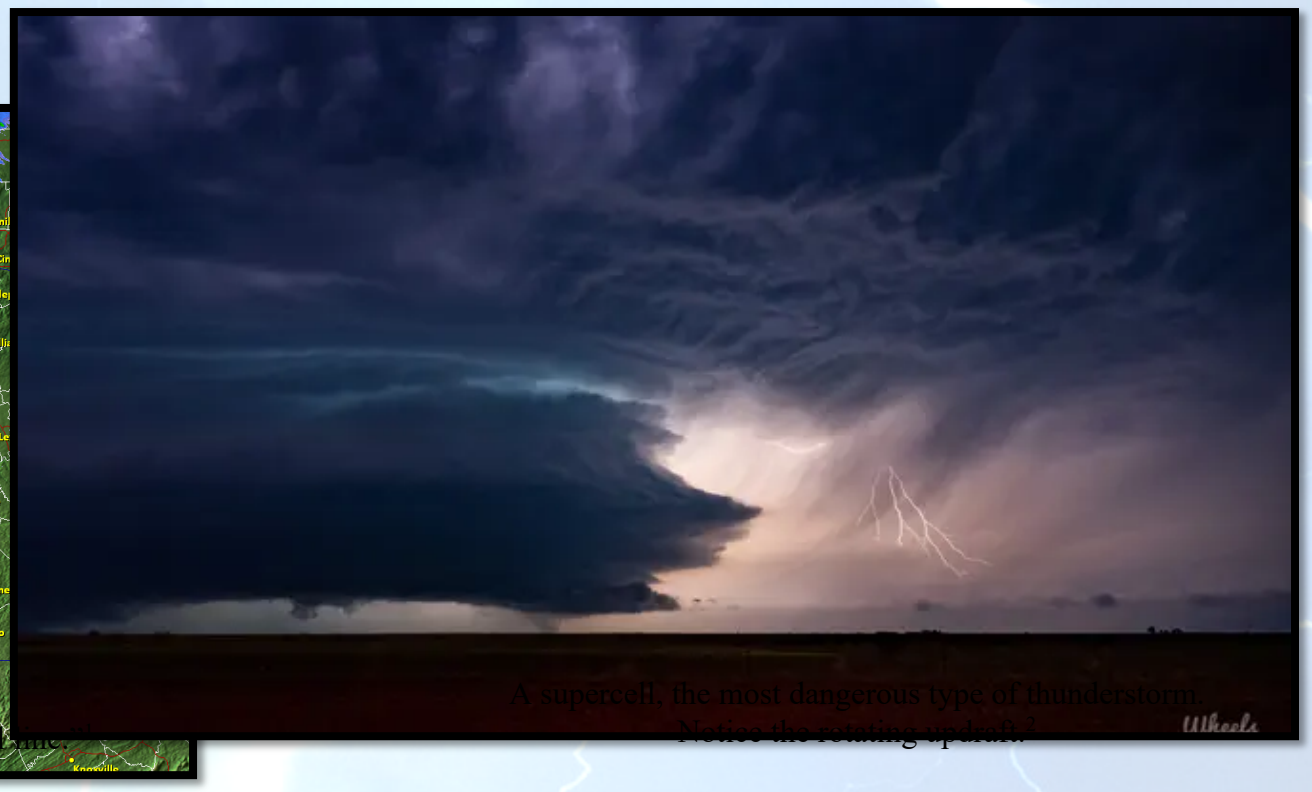
(1) https://www.nssl.noaa.gov/education/svrwx101/thunderstorms/types/img/squallline.png
(2) https://images.foxweather.com/static.foxweather.com/www.foxweather.com/content/uploads/2023/05/668/376/sean_tstorm.jpeg?ve=1&tl=1

Thunderstorm Categories

Like a multi-cell cluster, a multi-cell line or "squall line" is a series of storm cells that form at the edge of a boundary between a large mass of cold air and a large mass of warm air. As these air masses push against each other, they form a string of thunder cells that can stretch for hundreds of miles all along the weather "front." These storms form under high pressure and can be very severe.



A multi-cell thunderstorm line "squall line."[1]



A supercell, the most dangerous type of thunderstorm. Notice the rotating updraft.[2]

The most severe type of thunderstorm is the supercell. They often form with rotating updrafts and can be so strong they can break into higher layers of the atmosphere. Supercells can be up to 15 miles wide with wind speeds of over 80 miles per hour. They can create hail up to 4 inches in diameter (the size of an apple!), can last for hours, and may even create tornados.

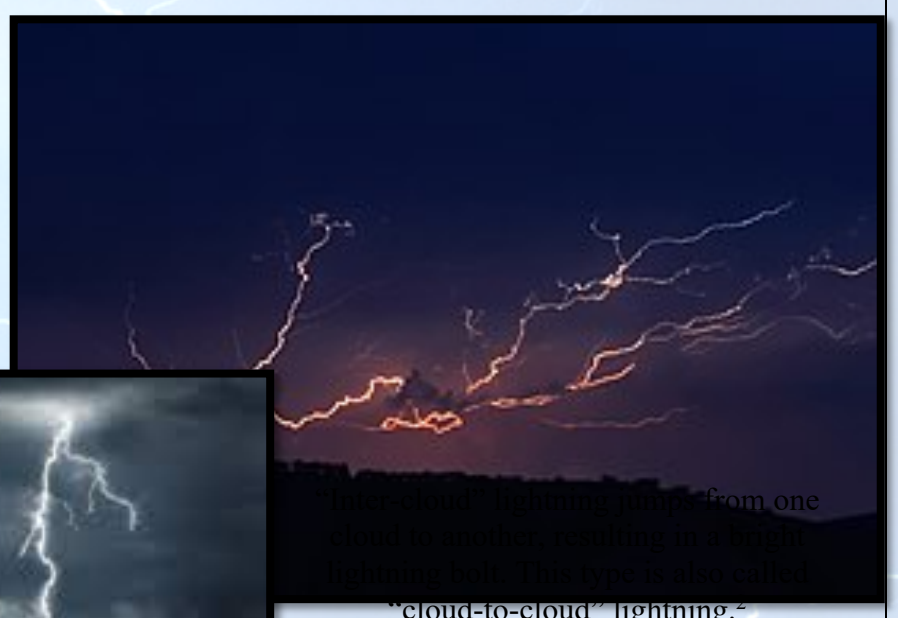
(1) https://www.nssl.noaa.gov/education/svrwx101/thunderstorms/types/img/squallline.png
(2) https://images.foxweather.com/static.foxweather.com/www.foxweather.com/content/uploads/2023/05/668/376/sean_tstorm.jpeg?ve=1&tl=1

Lightning

Lightning is static electricity that has built up in a cloud and is looking to equalize or "discharge" its built-up electricity. The top of a cloud holds a positive charge, while to bottom holds a negative charge. When the charges are strong enough to overpower the thick pad of air that separates them, ZAP!

Electricity follows the path of least resistance, and will always travel the shortest and easiest distance it can. Most of the time this means that it will jump from one part of the cloud to another, or from one cloud to another cloud, but occasionally it will reach the ground.

"Intracloud lightning" jumps from one part of the cloud to another and looks like a simple flash or



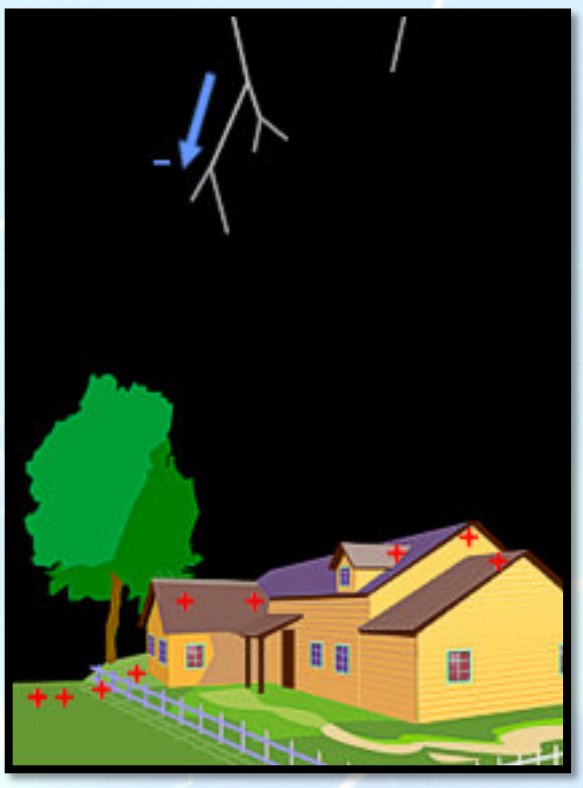
"Inter-cloud" lightning jumps from one cloud to another, resulting in a bright lightning bolt. This type is also called "cloud-to-cloud" lightning.[2]

"Cloud-to-ground" lightning is also called a lightning strike and can be very dangerous for humans and animals.[3]

(1) https://pbs.twimg.com/media/DL-k0SJWAAAaUzP.jpg:large
(2) https://upload.wikimedia.org/wikipedia/commons/thumb/1/1e/Cloud_to_cloud_lightning_strike.jpg/270px-Cloud_to_cloud_lightning_strike.jpg
(3) https://www.rmets.org/sites/default/files/lightning.jpg

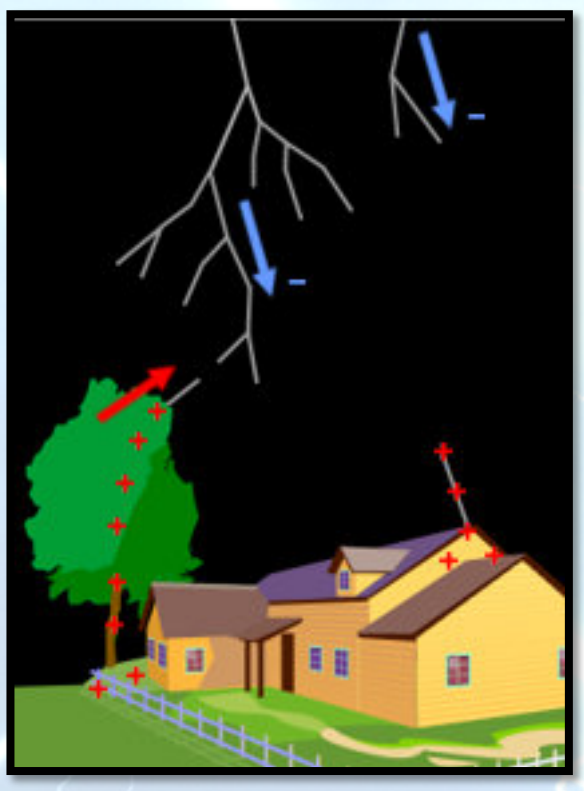
How Lightning Strikes

Phases 1 and 2



In the first phase, a negatively-charged "leader" searches for an object to strike.[1]

A lightning strike happens in several steps. First, a thin, finger-like "leader" begins to descend from the bottom of the storm cloud. This negatively-charged channel travels almost 200 feet, pauses while looking for an object to strike, then moves on, forming a "stepped leader" as it branches out in many directions to find a path to the ground. The stepped leader can reach its full length in 1/20th of a second, with over 10,000 different "steps" taking place!



The negative charge begins to attract positively-charged "streamers."[1]

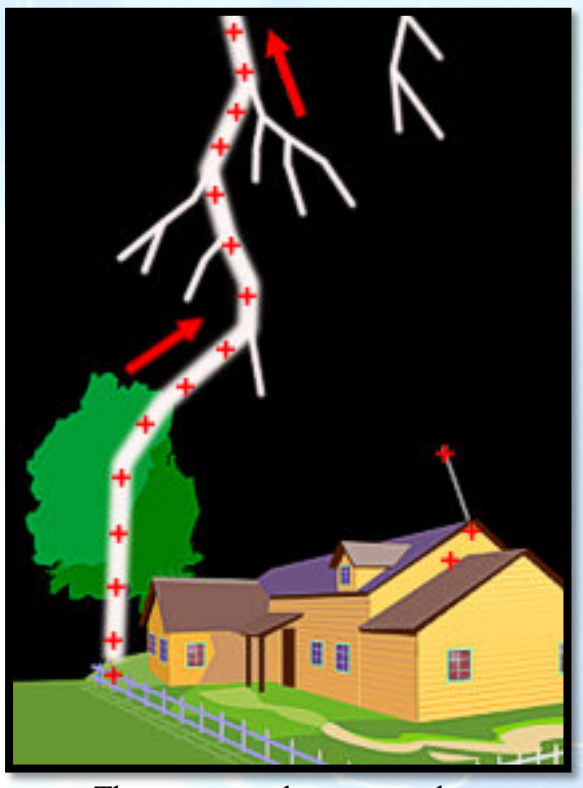
During the second phase, the powerful negative charge from the stepped leader reaches close enough to the ground that it repels any negative charges near it. This leaves only the positive charges, and they begin to reach toward the stepped leader in streams called "streamers"

(1) https://www.noaa.gov/jetstream/lightning/how-lightning-is-created/jetstream-max-lightning-process-keeping-in-step#:~:text=Under%20the%20influences%20of%20the,(0.000001%20seconds)%20in%20duration.

How Lightning Strikes

Phases 3 and 4

During the third step, the stepped leader makes contact with the stream of positive charge from the ground. Now that it has an established pathway, it follows it all the way down, creating a path between the bottom of the cloud and Earth.



The return stroke occurs when positively-charged electricity jumps from the ground to the cloud.[1]

A positive charge known as a "return stroke" shoots up the created path at a rate of around 270,000 miles per hour! While it looks like lightning jumps from the cloud to the ground, it actually jumps from the ground to the cloud following a route created by static electricity from the ground! This flash moves many times the speed of sound, breaking the sound barrier and causing the crashing sound we know as thunder.

If there is still more positive charge to be found after the lightning strike is over, another leader, called a "dart leader," can jump down the path already created by the stepped leader, creating another flash. This back-and-forth jump of the electricity is what causes the lightning to look like it's flickering or flashing.

(1) https://www.noaa.gov/jetstream/lightning/how-lightning-is-created/jetstream-max-lightning-process-keeping-in-step#:~:text=Under%20the%20influences%20of%20the,(0.000001%20seconds)%20in%20duration.

Did You Know?

Fun Facts About Lightning

On average, lightning strikes the earth 3 million times per day! That's about 44 times per second!

A lightning bolt can carry up to 3 million volts of electricity! That's enough to power over 850,000 homes for a full day!

1 in every 15,300 people will be struck by lightning in their lifetime. That's about 2,000 people per year worldwide!

Brothers Michael and Sean McQuilken just before they were struck by lightning in 1975. Hair standing up on end and tingling skin is a sign of the positive charge reaching upward toward a stepped leader. They survived.[1]

The odds of surviving a lightning strike are fairly high. In fact, 90% of people who are struck by lightning live to tell about it!

If you count the number of seconds between when you saw a lightning strike and when you here the thunder, then divide the number of seconds by 5, you can estimate how far away the lightning struck!

(1) https://media-cldnry.s-nbcnews.com/image/upload/t_social_share_1024x768_scale,f_auto,q_auto:best/streams/2013/July/130729/6C8448108-Lightning_Mike_and_Sean_V6-S.jpg

Thunderstorm Safety

Thunderstorms are fascinating, but they can also be dangerous. If you find yourself in a thunderstorm, protect yourself by getting away from tall objects that might be struck by lightning. Typically getting inside a building or vehicle can protect you from lighting strikes. Avoid using electronics or appliances that are connected to the wall with a power cord, as these can (rarely) hurt you if the powerlines are struck by lightning. Water is a good conductor of electricity, so avoid water and stay dry if possible. Remember, the lower you are outside, the less likely the lightning will find you an easy target!

In the 1800s, church bells would be rung loudly during storms, hoping to scare away the thunderstorm “demons” that kept attacking church steeples. What they didn’t know was that lightning was simply following the path of least resistance and distance, which was the top of the steeple![2]

The safest place to be in a thunderstorm is indoors, away from windows, water, and electricity.[1]

(1) https://assets3.cbsnewsstatic.com/hub/i/r/2023/07/11/5c438ac0-104e-4e9b-a780-425f8d5d279e/thumbnail/1200x630/cd61095182f2b31e3eea122cc17d0fa5/gettyimages-1345042779.jpg?v=6616762727d81e1cb010134e0c556e29

(2) https://www.montgomeryadvertiser.com/gcdn/presto/2018/08/13/PMOY/e433fcb9-4054-4680-8ba4-ffd1b0104124-GettyImages-472904092.jpg?crop=5183,2902,x0,y0&width=3200&height=1792&format=pjpg&auto=webp

Thunderstorm Hazards

Thunderstorms can cause a variety of problems to people. Besides being hazardous for people, lightning can also cause damage to infrastructure such as powerlines and buildings. A lightning strike to the power grid could knock it out for hours or even days, and powerful waves of electricity can force their way into homes and damage electronics. In addition, lightning causes about 10% of wildfires (unfortunately most of the other wildfires are caused by people!), and the high winds and rain associated with thunderstorms can cause tornados and flooding.

Thunderstorms can cause serious flooding.[1]

10% of wildfires are started by lightning.[3]

Tornados are a serious hazard caused by thunderstorms.[2]

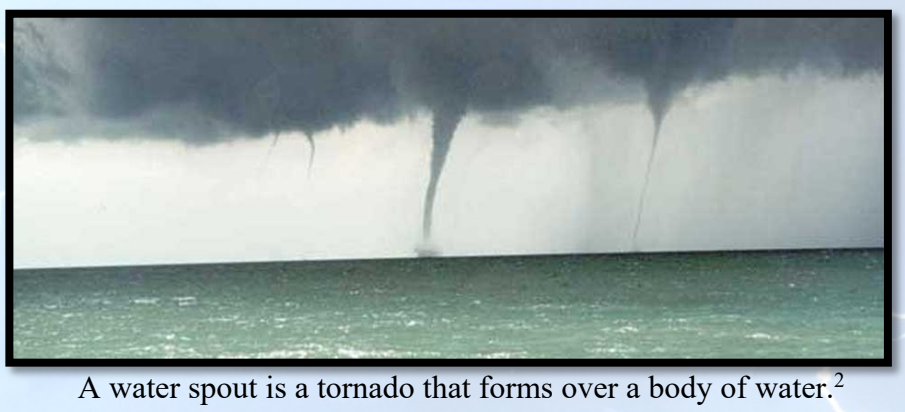
(1) https://a57.foxnews.com/static.foxnews.com/foxnews.com/content/uploads/2020/07/896/500/nyc-storm-1-Gary-Hershorn.jpg?ve=1&tl=1
(2) https://www.iii.org/sites/default/files/p_tornado_storm_135190816.jpg
(3) https://images.zapnito.com/uploads/6b7TtfaDRPu1jZqWwZ8X_pexels-frank-cone-2308671(1).jpg

Tornados

Tornados can be a dangerous result of thunderstorms. They are a funnel of high-speed formed from the swirling updraft of a supercell, spinning from 110 to over 300 miles per hour, their powerful spinning vortex sucking up and destroying everything in its path. They can travel over ten miles at speeds as slowly as 10 miles per hour or faster than 60 miles per hour! Extreme tornados have been measured at more than 2½ miles wide, and some tornados have traveled hundreds of miles!

Tornados cause severe damage every year in the Midwestern United States.[1]

The Fujita Scale rates the strength of a tornado after it has ended by measuring the amount of damage it caused. The TORRO Scale measures tornados by wind intensity. A low score in either scale represents a weaker tornado.



A water spout is a tornado that forms over a body of water.[2]

In the case of a tornado, look for shelter such as an inner room without windows or someplace underground. If you are caught outside, get in a ditch or as low to the ground as possible and cover your head.

(1) https://scx2.b-cdn.net/gfx/news/2019/sizeofthunde.jpg
(2) https://oceanservice.noaa.gov/facts/waterspout.jpg

Lightning Protection Devises

Lightning Rods

A lightning rod, installed to protect a home.[1]

Several important devices have been created to protect buildings and equipment from thunderstorms and the lightning that can be associated with it. Lightning rods, invented by Benjamin Franklin, can be mounted onto tall buildings and equipment. When they are struck by lightning, cables connected to the ground funnel the lightning down to the ground and away from the building, preventing the building from damage. These lightning rods are helpful to other lower buildings around them because the tall buildings attract the lightning strikes, saving the lower ones from damage as well.

Lightning rods can protect tall buildings from damage by funneling the lightning safely into the ground.[2]

(1) https://cloudfront-us-east-1.images.arcpublishing.com/gray/PMHGNAY73ROPNJYZMFNRSOE2K4.jpg
(2) https://today.tamu.edu/wp-content/uploads/2012/02/GettyImages-502937461.jpg

Lightning Protection Devises

Surge Protectors

A surge protector often looks like a power strip but includes a grounding line to funnel extra electricity away from the things that are plugged into it.[1]

A surge protector is a device that can be installed in a home to protect the home's electronics from getting overloaded and the delicate inner workings fried in the case of a power surge. When a lightning strike hits a powerline, the powerline is overloaded with too much electricity and it looks for a place to escape. Sometimes this means into the homes that are connected to the powerline. A surge protector is a device that the electronics can be plugged into, allowing them to remain plugged in but also protecting them from a surge. If a surge does happen, the surge protector funnels the extra electricity into the ground just like a lightning rod.

A power outlet that has been damaged from a power surge.[2]

(1) https://waynepleonardelectric.com/wp-content/uploads/2018/10/bigstock-180767077-1024x684-1024x585.jpg
(2) https://assets.tripplite.com/large-image/tlp608-front-l.jpg

Studying Thunderstorms Today

In the past, thunderstorms were not well understood because of how dangerous it was to get up close to study them. Nowadays, satellites can photograph storms and use certain sensors to collect data. Other tools include weather balloons released into the thunderstorm with sensors to send back data to the scientists on the ground. Drones and aircraft can also be used for this purpose.

A meteorologist prepares a weather balloon for launch.[1]

A storm chaser is someone who follows storms. Professional storm chasers are highly trained in meteorology and usually work with weather stations and science labs to collect data on how the storms form, build, and react. Other storm chasers are untrained and chase storms to take photos or even just for fun. This is very dangerous and should be left to the professionals!

A professional storm chaser adjusts his sensors and instruments.[2]

(1) https://imageio.forbes.com/blogs-images/marshallshepherd/files/2018/05/img_launching_sonde_hilo_3.jpg?format=jpg&width=1200
(2) https://media.istockphoto.com/id/1010669420/photo/storm-chaser-adjusts-the-rooftop-weather-station-on-his-chase-vehicle-as-a-severe-storm.jpg?s=612x612&w=0&k=20&c=N1s6Xs39Sd3CF1iqzD1HIDI2Ulz3qAJkbWpEbXpZyxc=

Thunderstorms and the Bible

The Bible uses thunder many times, each one to represent something special. It almost always accompanied God's voice when He spoke directly to humans, and some people even mistook God's voice for thunder! (John 12:39). It also demonstrated His displeasure on many occasions, used as a weapon against God's enemies (1 Samuel 7:10-11) or even showing His anger against the sins of His people Israel (Isaiah 29:6). It also represented judgement on many occasions, both toward the Israelites and their enemies (Revelation 10:4).

Whether the Israelites were obedient to God or not, God used thunder and lightning to demonstrate His great power and majesty. Just like today as we watch a thunderstorm from a place of safety, when the people were obedient to His words, they could safely stand in awe of His glory without the fear!

What other lessons can you learn from thunderstorms?

(1) https://assetsnffrgf-a.akamaihd.net/assets/m/1102016033/univ/art/1102016033_univ_cnt_2_xl.jpg

Name(s): _____ Date: _____

Thunderstorms

1. Match the following terms with their definitions

_____ Updraft

_____ Cumulonimbus

_____ Power Surge

_____ Storm Chaser

_____ Fujita Scale

a. Occurs when lightning strikes a powerline, overwhelming its power-carrying capabilities.

b. A rising column of air within a thundercloud.

c. Large billowing clouds associated with thunderstorms.

d. A measurement used to rate a tornado's strength.

e. Someone who seeks out storms for study or fun.

2. Number the steps of a lightning strike.

_____ The negatively-charged stepped leader and positively-charged streamers meet.

_____ The negatively-charged leader makes its way from the base of the cloud in a "stepped" ladder-like path.

_____ Positive charges on the ground form "streamers," reaching up toward the stepped leader.

_____ A dart leader follows the path created by the stepped leader, repeating the process several times.

_____ The positively-charged return stroke shoots up the path created by the stepped leader.

_____ The negatively charge d stepped leader follows the path of the streamers to the ground.

_____ The negatively charged leader nears the ground, driving away negative electrical charges.

3. Match the following types of thunderstorms with their description:

_____ Multi-Cell Cluster

_____ Single-Cell

_____ Supercell

_____ Multi-Cell Line

a. The largest type of thunderstorm, often involving swirling updrafts.

b. A thunderstorm featuring several updrafts. Stronger updrafts group toward the middle, and weaker updrafts move toward the edge.

c. A string of thunderstorms along a weather "front."

d. A small thunderstorm featuring one major updraft.

4. **Create your own Biblical parallel or object lesson from what you know about thunderstorms:**