TULSA PUBLIC SCHOOLS

HS Science

(Earth Science/Physics)

Distance Learning Activities

Dear families,

These learning packets are filled with grade level activities to keep students engaged in learning at home. We are following the learning routines with language of instruction that students would be engaged in within the classroom setting. We have an amazing diverse language community with over 65 different languages represented across our students and families.

If you need assistance in understanding the learning activities or instructions, we recommend using these phone and computer apps listed below.

Google Translate

- Free language translation app for Android and iPhone
- Supports text translations in 103 languages and speech translation (or conversation translations) in 32 languages
- Capable of doing camera translation in 38 languages and photo/image translations in 50 languages
- Performs translations across apps

Microsoft Translator

- Free language translation app for iPhone and Android
- Supports text translations in 64 languages and speech translation in 21 languages
- Supports camera and image translation
- Allows translation sharing between apps

3027 SOUTH NEW HAVEN AVENUE | TULSA, OKLAHOMA 74114
918.746.6800 | www.tulsaschools.org

Queridas familias:

Estos paquetes de aprendizaje tienen actividades a nivel de grado para mantener a los estudiantes comprometidos con la educación en casa. Estamos siguiendo las rutinas de aprendizaje con las palabras que se utilizan en el salón de clases. Tenemos una increíble y diversa comunidad de idiomas con más de 65 idiomas diferentes representados en nuestros estudiantes y familias.

Si necesita ayuda para entender las actividades o instrucciones de aprendizaje, le recomendamos que utilice estas aplicaciones de teléfono y computadora que se enlistan a continuación:

Google Translate

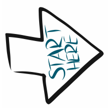
- Aplicación de traducción de idiomas para Android y iPhone (gratis)
- Traducciones de texto en 103 idiomas y traducción de voz (o traducciones de conversación) en 32 idiomas
- Traducción a través de cámara en 38 idiomas y traducciones de fotos / imágenes en 50 idiomas
- Realiza traducciones entre aplicaciones

Microsoft Translator

- Aplicación de traducción para iPhone y Android (gratis)
- Traducciones de texto en 64 idiomas y traducción de voz en 21 idiomas
- Traducción a través de la cámara y traducción de imágenes
- Permite compartir la traducción entre aplicaciones

Earth Science - Unit: Weather

Packet 1 - Earth Science - Remote Learning



- This packet of work continues the weather unit portion of Earth Science.
  - Each school in TPS with an Earth Science class may be at different places within their curriculum. That is okay.
- The packet is intended to be completed independently of the internet but there are additional resources that complement the work should a student have access to the internet and these would be optional.
- **The material can be completed by middle school and high school alike so please feel free to use it with other students that are not enrolled in an Earth Science course.**

Table of Contents

Suggested time table:

- ➢ Day 1
  - OPTIONAL: View the documentary titled Decoding the Weather Machine either on Netflix or the internet if you have access
- ➢ Day 2
  - Complete items 2 and 3 from the table of contents.
- ➢ Day 3
  - Complete item 4 from the table of contents before continuing on with other content material.
  - Complete items 5 and 6 from the table of contents.
- ➢ Day 4
  - Complete item 7 from the table of contents before continuing on with other content material.
- ➢ Day 5
  - OPTIONAL: Complete item 8 from the table of contents if you're able.
- ➢ Day 6
  - Complete items 9 and 10 from the table of contents.
- ➢ Day 7
  - Complete item 11 from the table of contents
- ➢ Day 8
  - Continue working on item 11 from the table of contents
- ➢ Day 9
  - Complete item 12 and 13 from the table of contents.
- ➢ Day 10
  - Complete item 14 from the table of contents.
    - Be prepared to utilize this document in discussions with your teacher for feedback.

The next packet of work will contain learning materials for astronomy and climate change. Please reach out to your teacher with questions.

Unit: Weather and Climate

Instructions: Read the following text as an introduction/continuation of the weather unit. Define the vocabulary terms on a separate sheet of paper and answer the questions at the end of the reading on a separate sheet of paper.

Lesson Objectives

- Discuss the difference between weather and climate.
- Describe the relationship between air temperature and humidity, including the concept of dew point.
- List the basics of the different cloud types and what they indicate about current and future weather.
- Explain how the different types of precipitation form.

Vocabulary

- cloud
- dew point
- relative humidity

Introduction

If someone across the country asks you what the weather is like today, you need to consider several factors. Air temperature, humidity, wind speed, the amount and types of clouds, and precipitation are all part of a thorough weather report. In this chapter, you will learn about many of these features in more detail.

What are Weather and Climate?

Weather is what is going on in the atmosphere at a particular place at a particular time. Weather can change rapidly. A location's weather depends on:

- air temperature
- air pressure
- fog
- humidity
- cloud cover
- precipitation
- wind speed and direction

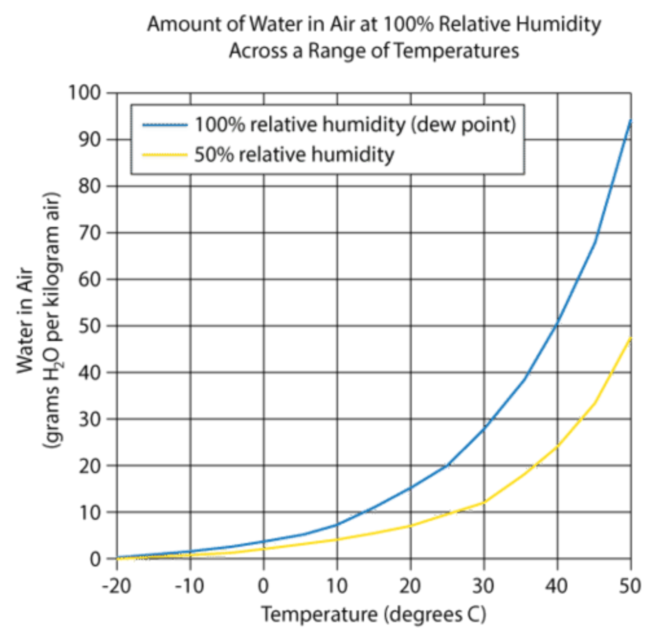
All of these are directly related to the amount of energy that is in the system and where that energy is. The ultimate source of this energy is the sun.

Climate is the average of a region's weather over time. The climate for a particular place is steady, and changes only very slowly. Climate is determined by many factors, including the angle of the Sun, the likelihood of cloud cover, and the air pressure. All of these factors are related to the amount of energy that is found in that location over time.

Humidity

Humidity is the amount of water vapor in the air in a particular spot. We usually use the term to mean **relative humidity**, the percentage of water vapor a certain volume of air is holding relative to the maximum amount it can contain. If the humidity today is 80%, it means that the air contains 80% of the total amount of water it can hold at that temperature. What will happen if the humidity increases to more than 100%? The excess water condenses and forms precipitation.

Since warm air can hold more water vapor than cool air, raising or lowering the temperature can change the air's relative humidity (**Figure** below). The temperature at which air becomes saturated with water is called the air's **dew point**. This term makes sense, because the water condenses from the air as the dew, if the air cools down overnight and reaches 100% humidity.



This diagram shows the amount of water air can hold at different temperatures. The temperatures are given in degrees Celsius. [Figure1]

Clouds

Clouds have a big influence on weather:

- by preventing solar radiation from reaching the ground.
- by absorbing warmth that is re-emitted from the ground.
- as the source of precipitation.

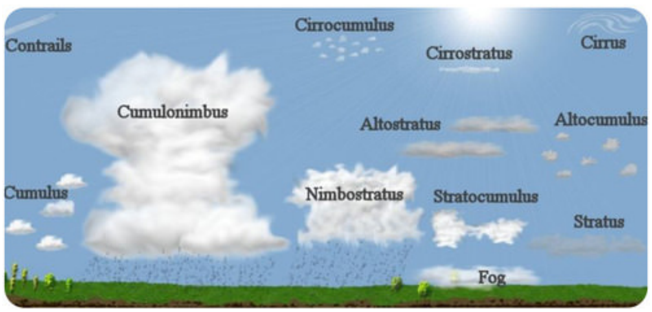
When there are no clouds, there is less insulation. As a result, cloudless days can be extremely hot, and cloudless nights can be very cold. For this reason, cloudy days tend to have a lower range of temperatures than clear days.

Clouds form when air reaches its dew point. This can happen in two ways: (1) Air temperature stays the same but humidity increases. This is common in locations that are warm and humid. (2) Humidity can remain the same, but temperature decreases. When the air cools enough to reach 100% humidity, water droplets form. Air cools when it comes into contact with a cold surface or when it rises.

Rising air creates clouds when it has been warmed at or near the ground level and then is pushed up over a mountain or mountain range or is thrust over a mass of cold, dense air.

Water vapor is not visible unless it condenses to become a cloud. Water vapor condenses around a nucleus, such as dust, smoke, or a salt crystal. This forms a tiny liquid droplet. Billions of these water droplets together make a cloud.

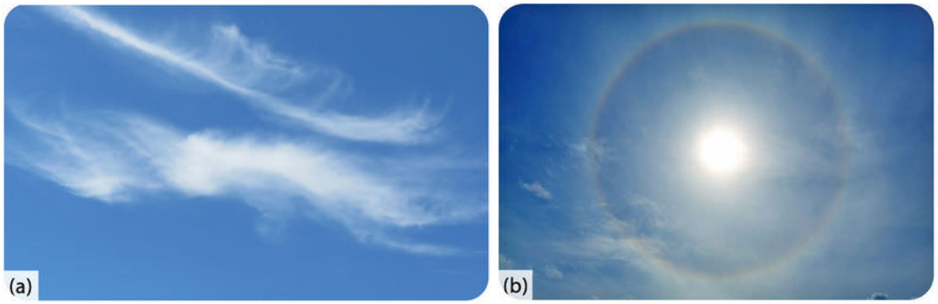
Clouds are classified in several ways. The most common classification used today divides clouds into four separate cloud groups, which are determined by their altitude (**Figure** below).



The four cloud types and where they are found in the atmosphere. [Figure2]

High Clouds

High clouds (**Figure** below) form from ice crystals where the air is extremely cold and can hold little water vapor. Cirrus, cirrostratus, and cirrocumulus are all names of high clouds.



(a) Cirrus clouds are thin wisps of ice crystals found at high altitudes. (b) Cirrostratus clouds are thin white sheets of ice crystals that are sometimes invisible unless backlit by the Sun or Moon. [Figure3]

Cirrocumulus clouds are small, white puffs that ripple across the sky, often in rows. Cirrus clouds may indicate that a storm is coming.

Middle Clouds

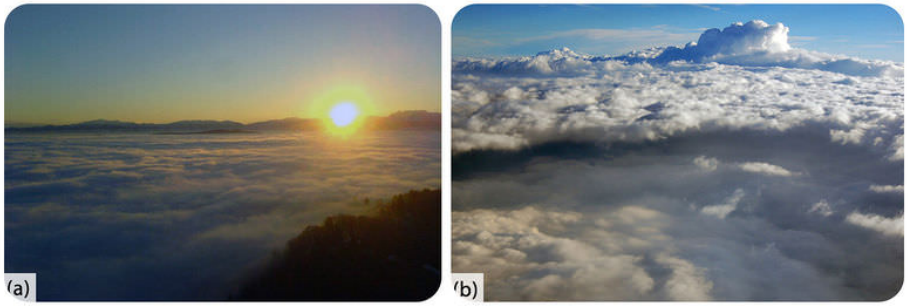
Middle clouds, including altocumulus and altostratus clouds, may be made of water droplets, ice crystals or both, depending on the air temperatures (**Figure** below).

Altocumulus clouds are white to puffy stripes rolling across the sky. They may precede a thunderstorm. [Figure4]

Thick and broad altostratus clouds are gray or blue-gray. They often cover the entire sky and usually mean a large storm, bearing a lot of precipitation, is coming.

Low Clouds

Low clouds (**Figure** below) are nearly all water droplets. Stratus, stratocumulus and nimbostratus clouds are common low clouds.



(a) Stratus clouds are gray sheets that cover the entire sky and may produce a steady drizzle. Stratus clouds with the Alps in the distance. (b) Stratocumulus clouds are rows of large, low puffs that may be white or gray. These clouds rarely bring precipitation. [Figure5]

Nimbostratus clouds are thick and dark. They bring steady rain or snow.

Vertical Clouds

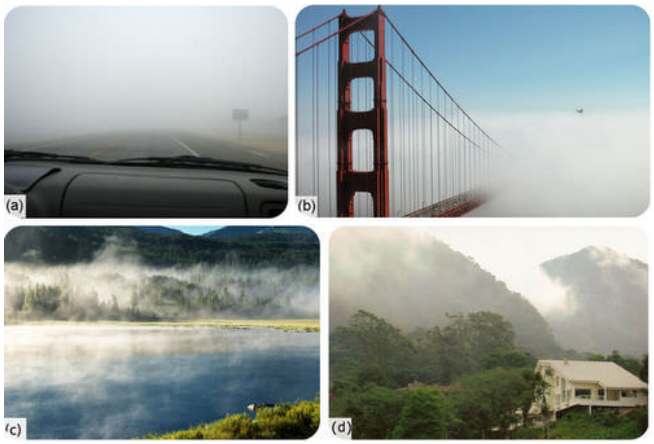
Clouds with the prefix 'cumulo-' (**Figure** below) grow vertically instead of horizontally and have their bases at low altitude and their tops at high or middle altitude. Clouds grow vertically when strong air currents are rising upward.

(a) Cumulus clouds resemble white or light gray cotton and have towering tops and may produce light showers. (b) A cumulonimbus cloud grows when vertical air currents are strong as in a thunderstorm. This one is lit up by lightning. [Figure6]

Fog

Fog (**Figure** below) is a cloud located at or near the ground . When humid air near the ground cools below its dew point, fog is formed. The several types of fog that each form in a different way.

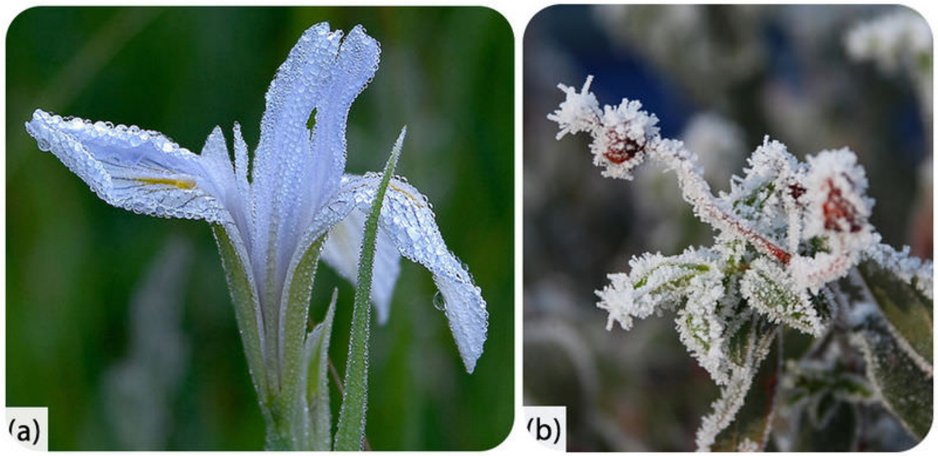
- Radiation fog forms at night when skies are clear and the relative humidity is high. As the ground cools, the bottom layer of air cools below its dew point. Tule fog is an extreme form of radiation fog found in some regions.
- San Francisco, California, is famous for its summertime advection fog. Warm, moist Pacific Ocean air blows over the cold California current and cools below its dew point. Sea breezes bring the fog onshore.
- Steam fog appears in autumn when cool air moves over a warm lake. Water evaporates from the lake surface and condenses as it cools, appearing like steam.
- Warm humid air travels up a hillside and cools below its dew point to create upslope fog



(a) Tule fog in the Central Valley of California. (b) Advection fog in San Francisco. (c) Steam fog over a lake. (d) Upslope fog in Teresópolis city, Rio de Janeiro State, Brazil. [Figure7]

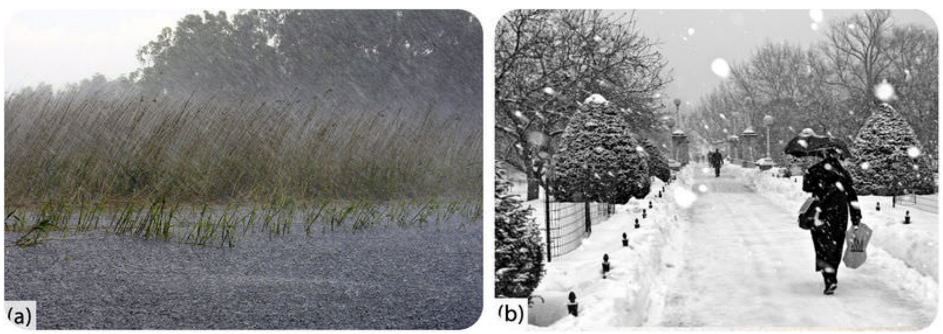
Precipitation

Precipitation (**Figure** below) is an extremely important part of weather. Some precipitation forms in place .



(a) Dew forms when moist air cools below its dew point on a cold surface, such as a flower. (b) Frost is dew that forms when the air temperature is below freezing; hoar frost. [Figure8]

The most common precipitation comes from clouds. Rain or snow droplets grow as they ride air currents in a cloud and collect other droplets (**Figure** below). They fall when they become heavy enough to escape from the rising air currents that hold them up in the cloud. One million cloud droplets will combine to make only one raindrop ! If temperatures are cold, the droplet will hit the ground as a snowflake.



(a) Rain falls from clouds when the temperature is fairly warm. (b) Snow storm in Boston, Massachusetts. [Figure9]

Other less common types of precipitation are sleet (**Figure** below).

Lesson Summary

- Different air temperatures create convection cells.
- Air rising in a convection cell may cool enough to reach its dew point and form clouds or precipitation if the humidity is high enough.
- Clouds or fog may form if warmer air meets a colder ground surface. Air temperature and humidity also determine what sorts of clouds and precipitation form.
- Different factors play a role in creating pleasant or uncomfortable weather, such as when it might be warm and dry or hot and humid.

Review Questions: Use these questions to analyze the text and to further investigate the content.

1. What factors need to be included in a thorough weather report?

2. If Phoenix, Arizona, experiences a cool, wet day in June (when the weather is usually hot and dry), does that mean the region's climate is changing?

3. What happens when a batch of air reaches its dew point? What is the temperature?

4. What effect do clouds have on the weather?

5. You are standing in a location that is clear in the morning, but in the afternoon there are thunderstorms. There is no wind during the day, so the thunderstorms build directly above you. Describe how this happens.

6. What are the four different cloud groups and how are they classified?

7. How does sleet form? How does glaze form?

8. What circumstances must be present for enormous balls of hail to grow and then fall to the ground?

Lesson 16.1: True or False

Name____________________ Class______________ Date________

Write true if the statement is true or false if the statement is false.

_____ 1. When air temperature falls, the air can hold more water vapor.

_____ 2. Cloudy days tend to have a greater range of temperatures than clear days.

_____ 3. Water vapor condenses when air temperature reaches the dew point.

_____ 4. A cloud consists of billions of individual water droplets.

_____ 5. Dust or other particles are needed for clouds to form.

_____ 6. Only high clouds consist of ice crystals.

_____ 7. Stratocumulus clouds rarely bring precipitation.

_____ 8. Advection fog forms when warm humid air travels up a hillside and cools.

_____ 9. All precipitation falls from clouds.

_____ 10. Hail forms in cumulonimbus clouds with strong updrafts.

Lesson 16.1: Critical Reading

Name____________________ Class______________ Date________

Read this passage based on the text and answer the questions that follow.

Clouds

Clouds have a big influence on weather. They are a necessary precursor of precipitation, although not all of them produce precipitation. Clouds also prevent some solar radiation from reaching the ground and absorb some of the heat that is re-radiated from the surface. As a result, cloudy days are likely to be cooler and cloudy nights warmer than clear days and nights.

Water vapor condenses out of the air when the temperature reaches the dew point. Air may reach its dew point when humidity increases or air temperature decreases. The latter commonly happens when warm, moist air rises. For clouds to form, water vapor must condense around tiny particles called nuclei (singular, nucleus). A nucleus might be a speck of dust or smoke, or it might be a salt crystal. The condensation of many water molecules around a nucleus forms a tiny droplet of liquid water. If billions of these water droplets come together, they make a cloud.

Clouds are classified in several ways. The most common classification used today divides clouds into groups based on altitude.

- High clouds form at high altitudes and consist of ice crystals. Examples of high clouds include cirrus, cirrostratus, and cirrocumulus clouds.
- Middle clouds form at middle altitudes and consist of ice crystals, water droplets, or both. Examples of middle clouds include altocumulus and altostratus clouds.
- Low clouds form at low altitudes and consist entirely or mainly of water droplets. Examples of low clouds include stratus, stratocumulus, and nimbostratus clouds.
- Vertical clouds grow upward and have their bases at low altitude and their tops at middle or high altitude. They form when strong air currents carry warm air upward. Examples of vertical clouds include cumulus and nimbocumulus clouds.

Questions

1. How do clouds influence weather?
2. Explain how clouds form.
3. Outline how clouds are classified by altitude.

Lesson 16.1: Multiple Choice

Name____________________ Class_______________ Date________

Circle the letter of the correct choice.

1. Weather factors include
   a. average air temperature.
   b. annual precipitation.
   c. humidity.
   d. two of the above
2. The dew point is the temperature at which
   a. dew forms on surfaces.
   b. water vapor starts to condense.

c. relative humidity is 100 percent.

d. all of the above

3. Relative humidity may decrease if

a. water vapor condenses out of the air.

b. water evaporates into the air.

c. air temperature decreases.

d. two of the above

4. Which type of cloud forms at high altitudes?

a. cirrocumulus

b. altocumulus

c. stratocumulus

d. nimbostratus

5. Which type of cloud forms when strong air currents carry warm air upward?

a. cirrus

b. stratus

c. cumulus

d. cirrostratus

6. The type of fog that forms when cool air moves over a warm lake is called

a. radiation fog.

b. advection fog.

c. steam fog.

d. upslope fog.

7. Rain that passes through a layer of freezing air near the ground becomes

a. glaze.

b. hail.

c. sleet.

d. snow.

Lesson 16.1: Matching

Name___________________ Class______________ Date________

Match each definition with the correct term.

Definitions

_____ 1. amount of water vapor in the air in a particular place

_____ 2. percentage of water vapor in a given volume of air relative to the maximum amount the air can hold

_____ 3. type of middle-altitude cloud

_____ 4. temperature at which air becomes saturated with water vapor

_____ 5. type of low-altitude cloud

_____ 6. type of cloud that grows vertically

_____ 7. type of high-altitude cloud

Terms

a. dew point

b. humidity

c. cirrostratus cloud

d. relative humidity

e. altostratus cloud

f. stratus cloud

g. cumulus cloud

Lesson 16.1: Fill in the Blank

Name___________________ Class______________ Date________

Fill in the blank with the appropriate term.

1. __________ is the condition of the atmosphere at a particular place and time.
2. Weather depends on the amount and location of __________ in the atmosphere.
3. The average weather of a region over a long period of time is the region's __________.
4. Basic cloud types are defined on the basis of their __________.
5. A cloud located at ground level is called __________.
6. __________ is a type of precipitation that forms when moist air cools on contact with a cold surface.
7. __________ is dew that forms when the air temperature is below freezing.

Lesson 16.1: Critical Writing

Name__________________ Class_____________ Date________

Thoroughly answer the question below. Use appropriate academic vocabulary and clear and complete sentences.

Explain why relative humidity depends on air temperature.

Weather or Climate?

By Cindy Grigg

1 What is the difference between climate and weather? The simple answer is "time."

2 Weather is what is happening in the atmosphere, the mixture of gases around the Earth, at a certain time and place. Weather changes constantly. Air masses move. Fronts form when two air masses of different temperatures with different moisture contents meet. Then the weather will change. Often a front brings thunderstorms. Warm air rises. Cooler air sinks. It rains. It's sunny. Weather changes from day to day or from hour to hour.

3 Climate is the **average** weather in a place over a long time. Weather data is recorded for a number of years. Climate is the average weather that has been recorded. Earth has many different climate zones. Tropical climate zones lie on either side of the equator. Polar zones are found near the North and the South Poles. Temperate climates are not too hot or too cold. Desert climates don't receive much rainfall. *Climate change* is a trend of change in climate averages of the past.

4 Many things affect the climate of a place. One thing is latitude. *Latitude* is a measure of the distance from the equator. Higher latitudes are closer to the North or South Pole. There, the sun's rays are less direct than at the equator. The sun's energy is spread out over a larger area. There the land and ocean don't get as much of the sun's heat, so they have lower temperatures. At the equator, the sun's rays are nearly at a right angle to Earth's surface. The sun's energy is concentrated. Land and ocean waters receive more heat than those near the poles.

5 *Wind* patterns affect the climate. If the wind starts out over water, it carries more water. If winds begin over land, the air mass is dryer. If the winds begin at high latitudes, the air masses are colder. Winds that start out in the tropics carry warmer air.

6 *Mountains* affect the climate of a place. Along the mountains of the western coast of the U.S., for one example, it is common to have lush green forests on the windward side. Moist air over the Pacific holds lots of water. The wind blows the moist air toward the mountains. The mountain is a barrier that pushes the air upward, and this causes it to cool. Cool air holds less moisture, so it rains on the side of the mountain facing the coast. The air that passes over the other side is dry. This is called the rain shadow effect. Because of this effect, deserts often are found on the leeward side (the side away from the wind) of mountains.

7 *Ocean currents* also shape the climate of a place. A current is a steady flow of water moving in one direction, like a river in the ocean. Warm ocean currents like the Jet Stream move heat from near the equator to the colder north. This makes the climate warmer along the coast of Great Britain, for instance. Currents in the ocean help distribute the uneven heat of the sun. Warmer water moves from the equator toward the poles. Cold water around the poles moves toward the equator.

8 Weather changes from day to day. Climate is the average weather over a number of years in a particular area. Different patterns of temperature and rainfall are found in different climates. Many different factors affect the climate of a certain place.

Name ______________________________ Date ____________________

Weather or Climate?

1. ______ is what is happening in the air or atmosphere at one time in one place. (A) Climate (B) Weather	2. Weather stays the same all the time. (A) False (B) True
3. What happens when two different air masses meet? (A) Fronts form (B) The weather will change (C) Thunderstorms often happen (D) All of the above	4. What does the rain shadow effect explain? (A) It explains why the climate is changing. (B) It explains why it often rains in the rainforest. (C) It explains why deserts are often found on the leeward side of mountains. (D) It explains why clouds make shadows on the ground.
5. What is climate? (A) The average weather in a place over a long time (B) The same as weather (C) The reason for deserts near some mountains (D) All of the above	6. Which one of these does **not** affect the climate of a place? (A) Ocean currents (B) Ground cover (C) Latitude (D) Mountains
7. The author's main purpose for writing this story was to ______. (A) Persuade readers that climate and weather are the same (B) Entertain readers with weather stories (C) Inform readers with facts about climate and weather (D) Express the writer's feelings about warm climates	8. How do ocean currents affect climate? ______________________________ ______________________________

Unit: Weather and Climate - Changing Weather

Instructions: Read the following text as an introduction/continuation of the weather unit. Define the vocabulary terms on a separate sheet of paper and answer the questions at the end of the reading on a separate sheet of paper.

Lesson Objectives

- Describe the characteristics of air masses and how they get those characteristics.
- Discuss what happens when air masses meet.
- List the differences between stationary, cold, warm, and occluded fronts.

Vocabulary

- air mass
- cold front
- front
- occluded front
- squall line
- stationary front
- warm front

Introduction

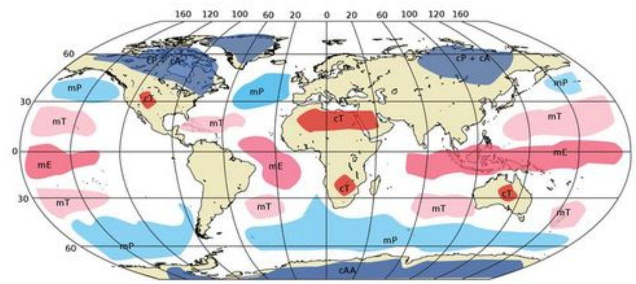
The weather in a location often depends on what type of air mass is over it. Another key factor is whether the spot is beneath a front, the meeting place of two air masses. The characteristics of the air masses and their interactions determine whether the weather over an area is constant, or whether there are rapid changes.

Air Masses

An **air mass** is a batch of air that has nearly the same temperature and humidity (**Figure** below). An air mass acquires these characteristics above an area of land or water known as its source region. When the air mass sits over a region for several days or longer, it picks up the distinct temperature and humidity characteristics of that region.

Air Mass Formation

Air masses form over a large area; they can be 1,600 km (1,000 miles) across and several kilometers thick. Air masses form primarily in high-pressure zones, most commonly in polar and tropical regions. Temperate zones are ordinarily too unstable for air masses to form. Instead, air masses move across temperate zones so the middle latitudes are prone to having interesting weather.



The source regions of air masses found around the world. Symbols: (1) origin over a continent (c) or an ocean (m, for maritime); (2) arctic (A), polar (P,) tropical (T), and equatorial (E); (3) properties relative to the ground it moves over: k, for colder, w for warmer.
[Figure1]

What does an air mass with the symbol cPk mean? The symbol cPk is an air mass with a continental polar source region that is colder than the region it is now moving over.

Air Mass Movement

Air masses are slowly pushed along by high-level winds. When an air mass moves over a new region, it shares its temperature and humidity with that region. So the temperature and humidity of a particular location depend partly on the characteristics of the air mass that sits over it.

Storms arise if the air mass and the region it moves over have different characteristics. For example, when a colder air mass moves over the warmer ground, the bottom layer of air is heated. That air rises, forming clouds, rain, and sometimes thunderstorms. How would a moving air mass form an inversion? When a warmer air mass travels over colder ground, the bottom layer of air cools and, because of its high density, is trapped near the ground.

In general, cold air masses tend to flow toward the equator and warm air masses tend to flow toward the poles. This brings heat to cold areas and cools down areas that are warm. It is one of the many processes that act towards balancing out the planet's temperatures.

Fronts

Two air masses meet at a **front**. At a front, the two air masses have different densities and do not easily mix. One air mass is lifted above the other, creating a low-pressure zone. If the lifted air is moist, there will be condensation and precipitation. Winds are common at a front. The greater the temperature difference between the two air masses, the stronger the winds will be. Fronts are the main cause of stormy weather.

The rest of this section will be devoted to four types of fronts. Three of these fronts move and one is stationary. With cold fronts and warm fronts, the air mass at the leading edge of the front gives the front its name. In other words, a cold front is right at the leading edge of moving cold air and a warm front marks the leading edge of moving warm air.

Stationary Front

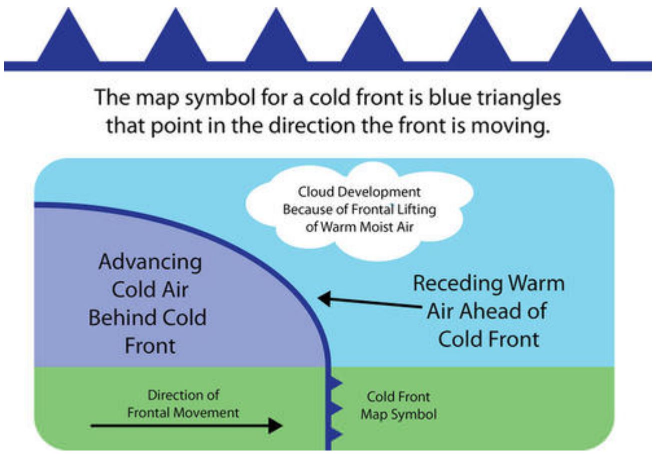
At a **stationary front,** the air masses do not move (**Figure** below). A front may become stationary if an air mass is stopped by a barrier, such as a mountain range.

A stationary front may bring days of rain, drizzle, and fog. Winds usually blow parallel to the front, but in opposite directions. After several days, the front will likely break apart.

The map symbol for a stationary front has red domes for the warm air mass and blue triangles for the cold air mass. [Figure2]

Cold Fronts

When a cold air mass takes the place of a warm air mass, there is a **cold front** (**Figure** below).



The cold air mass is dense so it slides beneath the warm air mass and pushes it up. [Figure3]

Imagine that you are standing in one spot as a cold front approaches. Along the cold front, the denser, cold air pushes up the warm air, causing the air pressure to decrease (**Figure** above). If the humidity is high enough, some types of cumulus clouds will grow. High in the atmosphere, winds blow ice crystals from the tops of these clouds to create cirrostratus and cirrus clouds. At the front, there will be a line of rain showers, snow showers, or thunderstorms with blustery winds (**Figure**below). A **squall line** is a line of severe thunderstorms that forms along a cold front. Behind the front is the cold air mass. This mass is drier so precipitation stops. The weather may be cold and clear or only partly cloudy. Winds may continue to blow into the low-pressure zone at the front.

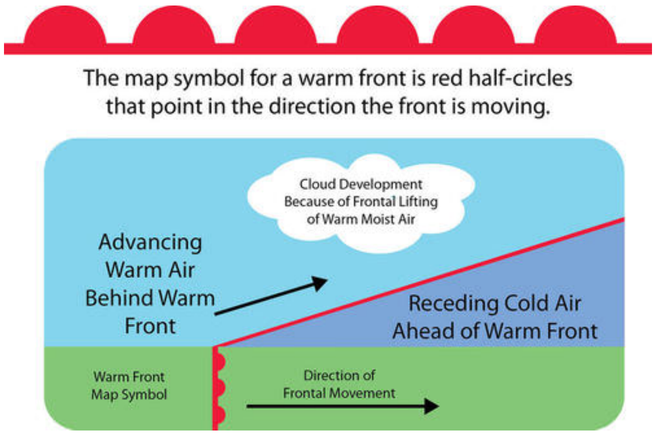
A squall line. [Figure4]

The weather at a cold front varies with the season.

- spring and summer: The air is unstable so thunderstorms or tornadoes may form.
- spring: If the temperature gradient is high, strong winds blow.
- autumn: Strong rains fall over a large area.
- winter: The cold air mass is likely to have formed in the frigid arctic so there are frigid temperatures and heavy snows.

Warm Fronts

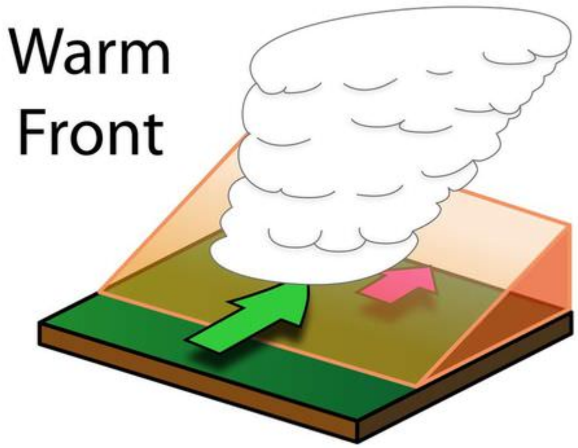
At a **warm front**, a warm air mass slides over a cold air mass (**Figure** below). When warm, less dense air moves over the colder, denser air, the atmosphere is relatively stable.



Warm air moves forward to take over the position of colder air. [Figure5]

Imagine that you are on the ground in the wintertime under a cold winter air mass with a warm front approaching. The transition from cold air to warm air takes place over a long distance so the first signs of changing weather appear long before the front is actually over you. Initially, the air is cold: the cold air mass is above you and the warm air mass is above it. High cirrus clouds mark the transition from one air mass to the other.

Over time, cirrus clouds become thicker and cirrostratus clouds form. As the front approaches, altocumulus and altostratus clouds appear and the sky turns gray. Since it is winter, snowflakes fall. The clouds thicken and nimbostratus clouds form. Snowfall increases. Winds grow stronger as the low-pressure approaches. As the front gets closer, the cold air mass is just above you but the warm air mass is not too far above that. The weather worsens. As the warm air mass approaches, temperatures rise and snow turns to sleet and freezing rain. Warm and cold air mix at the front, leading to the formation of stratus clouds and fog (**Figure** below).



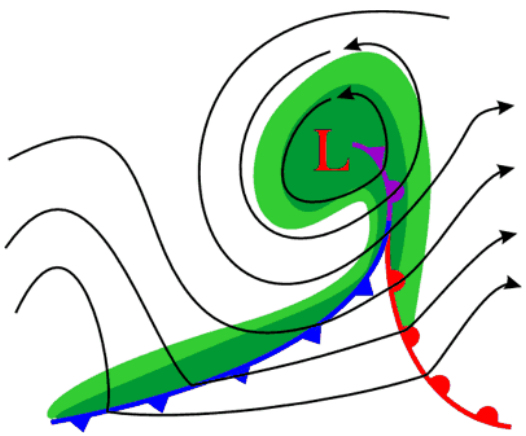
Cumulus clouds build at a warm front. [Figure6]

Occluded Front

An **occluded front** usually forms around a low-pressure system (**Figure** below). The occlusion starts when a cold front catches up to a warm front. The air masses, in order from front to back, are cold, warm, and then cold again.

The map symbol for an occluded front is mixed cold front triangles and warm front domes. [Figure7]

Coriolis Effect curves the boundary where the two fronts meet towards the pole. If the air mass that arrives third is colder than either of the first two air masses, that air mass slip beneath them both. This is called a cold occlusion. If the air mass that arrives third is warm, that air mass rides over the other air mass. This is called a warm occlusion (**Figure** below).



An occluded front with the air masses from front to rear in order as cold, warm, cold. [Figure8]

The weather at an occluded front is especially fierce right at the occlusion. Precipitation and shifting winds are typical. The Pacific Coast has frequent occluded fronts.

Weather is explored in this video at National Geographic Video, Natural disaster, Landslides, and more: Weather 101

Lesson Summary

- An air mass takes on the temperature and humidity characteristics of the location where it originates. Air masses meet at a front.
- Stationary fronts become trapped in place; the weather they bring lasts for many days.
- At a cold front, a cold air mass forces a warm air mass upwards.
- At a warm front, the warm air mass slips above the cold air mass.
- In an occluded front, a warm front overtakes a cold front, which creates variable weather.

Review Questions

1. What type of air mass is created if a batch of air sits over the equatorial Pacific Ocean for a few days? What is the symbol for this type of air mass?

2. What conditions must be present for air to sit over a location long enough to acquire the characteristics of the land or water beneath it?

3. How does latitude affect the creation of air masses in tropical, temperate, and polar zones?

4. Why are the directions fronts move in the Southern Hemisphere a mirror image of the directions they move in the Northern Hemisphere?

5. How is a stationary front different from a cold or warm front?

6. What sorts of weather will you experience as a cold front passes over you?

7. What sorts of weather will you experience as a warm front passes over you?

8. How does an occlusion form?

9. What situation creates a cold occlusion and what creates a warm occlusion?

Lesson 16.2: True or False

Name____________________ Class_______________ Date_________

Write true if the statement is true or false if the statement is false.

_____ 1. An air mass acquires the temperature and humidity of its source region.

_____ 2. Temperate zones are ordinarily too stable for air masses to form.

_____ 3. Storms may arise if an air mass and the region it moves over have different characteristics.

_____ 4. A temperature inversion forms when a cold air mass travels over warmer ground.

_____ 5. You would expect an air mass that forms near the north pole to flow south.

_____ 6. Fronts between air masses are the main cause of stormy weather.

_____ 7. At a stationary front, winds usually blow parallel to the front.

_____ 8. A squall line forms along an occluded front.

_____ 9. The weather along a front varies with the season.

_____ 10. The stormiest weather usually occurs along a warm front.

Lesson 16.2: Critical Reading

Name____________________ Class_______________ Date_________

Read this passage based on the text and answer the questions that follow.

Air Masses

An air mass is a very large batch of air that has nearly the same temperature and humidity throughout. An air mass acquires its characteristics from the region over which it forms, called its source region. When the air mass sits over the source region for several days, it picks up the temperature and humidity of that region. Air masses form in high pressure zones. They may form over continents, in which case they are dry, or over oceans, in which case they are moist. They most commonly form over polar or tropical regions. Polar air masses have cold temperatures, and tropical air masses have warm temperatures. Temperate zones are typically too unstable for air masses to form.

After air masses form, they are slowly pushed along by high-level winds. Cold air masses tend to flow toward the equator, and warm air masses tend to flow toward the poles. This movement of air masses brings heat to cold areas and cools down warm areas. Movement of air masses is one several processes that help balance out the planet’s temperatures.

When an air mass moves over a region, it shares its temperature and humidity with that region. Storms may arise if an air mass moves over a region with different characteristics. For example, when a cold air mass moves over warmer ground, the bottom layer of air is heated. The heated air rises, forming clouds, rain, and sometimes thunderstorms. When a warm air mass travels over colder ground, the bottom layer of air cools. The cool air is dense, so it stays near the ground below the warm air above it. This forms a temperature inversion.

Questions

1. What is an air mass?
2. What gives an air mass its characteristics? Where might a warm, moist air mass form?
3. Why do air masses move? How do they influence weather in the regions over which they move?

Lesson 16.2: Multiple Choice

Name____________________ Class_______________ Date_________

Circle the letter of the correct choice.

1. An air mass gets its characteristics from the
   a. regions over which it passes.
   b. atmospheric layers above it.
   c. other air masses it meets.
   d. area where it forms.
2. An air mass that forms over a polar land mass is likely to have
   a. low temperature and high humidity.
   b. low temperature and low humidity.
   c. moderate temperature and high humidity.
   d. moderate temperature and low humidity.
3. Air masses are slowly pushed along by

a. Earth's rotation.

b. the Coriolis effect.

c. high-level winds.

d. Earth's gravity.

4. What generally happens at any front?

a. An air mass rises.

b. The temperature falls.

c. A high-pressure zone forms.

d. two of the above

5. After a cold front passes, the weather is likely to be

a. drier.

b. cooler.

c. warmer.

d. two of the above

6. One air mass is lifted above two others at a(n)

a. stationary front.

b. occluded front.

c. warm front.

d. cold front.

7. The source region of an air mass labeled mP might be

a. the northern Atlantic Ocean.

b. northern Canada.

c. the Caribbean Sea.

d. northern Africa.

Lesson 16.2: Matching

Name____________________ Class_______________ Date________

Match each definition with the correct term.

Definitions

_____ 1. line where two air masses meet

_____ 2. front in which air masses do not move for several days

_____ 3. line of thunderstorms along a front

_____ 4. front that involves three air masses

_____ 5. large batch of air that all has about the same temperature and humidity

_____ 6. front in which a cold air mass overtakes a warm air mass

_____ 7. front in which a warm air mass slides over a cold air mass

Terms

a. air mass

b. front

c. cold front

d. stationary front

e. warm front

f. squall line

g. occluded front

Lesson 16.2: Fill in the Blank

Name___________________ Class______________ Date________

Fill in the blank with the appropriate term.

1. Air masses typically form in __________ pressure zones.
2. Cold air masses tend to flow toward the __________.
3. Warm air masses tend to flow toward the __________.
4. Air masses do not mix at a front because they have different __________.

5. At a front, one air mass rises above another, causing a __________ pressure zone.
6. A cold air mass has greater __________ than a warm air mass.
7. An air mass that forms over the ocean will have __________ humidity.

Lesson 16.2: Critical Writing

Name___________________ Class______________ Date________

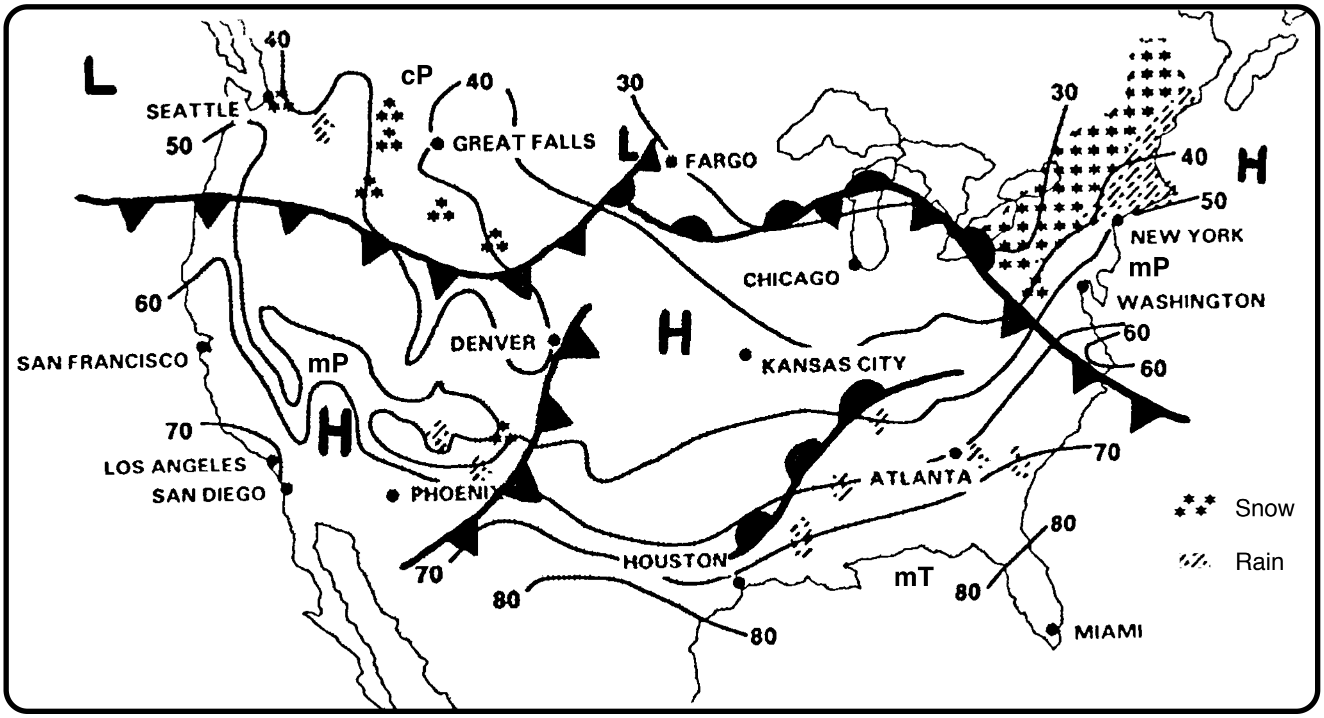
Thoroughly answer the question below. Use appropriate academic vocabulary and clear and complete sentences.

Compare and contrast warm and cold fronts.

Name - ____________________

Per - ________ Table - ________

Fronts and Air Masses Worksheet



Use the map above to answer the following questions.

1. List the different fronts shown .
2. What kinds of clouds would people in Kansas City probably have today?
3. Which kind of air mass would Atlanta be in?
4. In what direction is the front near Phoenix moving?
5. What is the definition for an *air mass*?
6. What kind of front is near Denver? What kinds of clouds would Denver probably have?
7. What kind of front is north of Chicago?
8. What kind of air mass would there be over Great Falls?
9. Would Los Angeles have clear or cloudy skies? Explain your answer.
10. Draw the profile (side view) of the front near Houston.

BLUE SKY EXPERIMENT

MATERIALS:

- flashlight
- 2-liter pop bottle
- milk
- water

PROCESS:

Fill the 2-liter bottle three-fourths full of water and prop up the flashlight, so it will shine through the bottle from the side.

Add a teaspoon of milk to the water.

Put the cap on the bottle and shake to mix up the water and milk.

What do you see? Keep adding milk until you start to see a blue light that is scattered to your eyes from the mixture.

Once you see the blue light, add more milk to the mixture until you see more of an orange or red light.

EXPLANATION:

Just like in the atmosphere, the mixture scatters more of the blue wavelength than any other color. ' why the sky is blue! At sunrise or at sunset, there is even more scattering taking place due to the angle of the sun. This causes the reds and oranges to scatter into our atmosphere. That's why our sunsets and sunrises are so colorful!

Unit: Weather and Climate - Storms

Instructions: Read the following text as an introduction/continuation of the weather unit. Define the vocabulary terms on a separate sheet of paper and answer the questions at the end of the reading on a separate sheet of paper.

Lesson Objectives

- Describe how atmospheric circulation patterns cause storms to form and travel.
- Understand the weather patterns that lead to tornadoes, and identify the different types of cyclones.
- Know what causes a hurricane to form, what causes it to disappear, and what sorts of damage it can do.
- Know the damage that heat waves and droughts can cause.

Vocabulary

- anticyclone
- blizzard
- cyclone
- heat wave
- hurricane
- lake-effect snow
- lightning
- mid-latitude cyclone
- nor'easter
- thunder
- thunderstorm
- tornado
- tropical depression

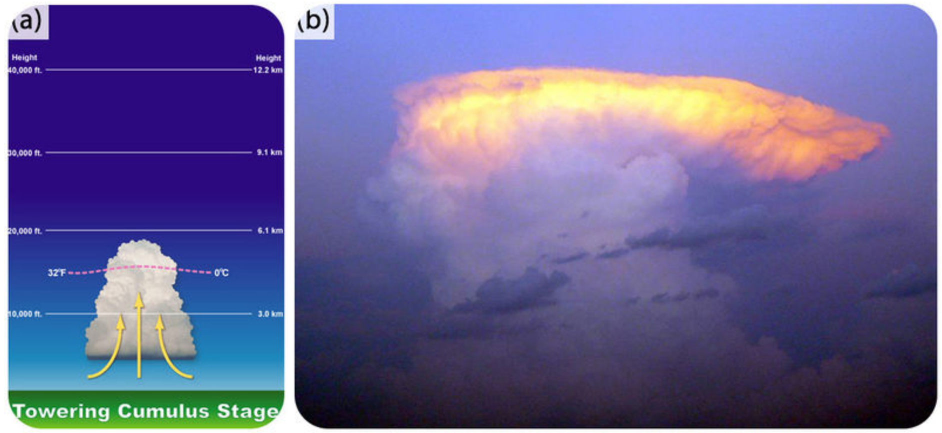
Introduction

Weather happens every day, but only some days have storms. Storms vary immensely depending on whether they're warm or cold, coming off the ocean or off a continent, occurring in summer or winter, and many other factors. The effects of storms also vary depending on whether they strike a populated area or a natural landscape. Hurricane Katrina is a good example, since the flooding after the storm severely damaged New Orleans, while a similar storm in an unpopulated area would have done little damage.

Thunderstorms

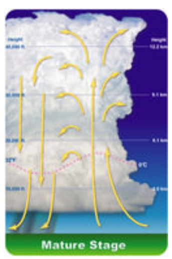
Thunderstorms are extremely common: Worldwide there are 14 million per year; that's 40,000 per day! Most drop a lot of rain on a small area quickly, but some are severe and highly damaging.

Thunderstorms form when ground temperatures are high, ordinarily in the late afternoon or early evening in spring and summer. The **Figure** below show two stages of thunderstorm buildup.



(a) As temperatures increase, warm, moist air rises. These updrafts first form cumulus and then cumulonimbus clouds. (b) Winds at the top of the stratosphere blow the cloud top sideways to make the anvil shape that characterizes a cloud as a thunderhead. [Figure1]

As water vapor condenses to form a cloud, the latent heat makes the air in the cloud warmer than the air outside the cloud. Water droplets and ice fly up through the cloud in updrafts. When these droplets get heavy enough, they fall. This starts a downdraft, and soon there is a convection cell within the cloud. The cloud grows into a cumulonimbus giant. Eventually, the drops become large enough to fall to the ground. At this time, the thunderstorm is mature, and it produces gusty winds, lightning, heavy precipitation, and hail (**Figure** below).

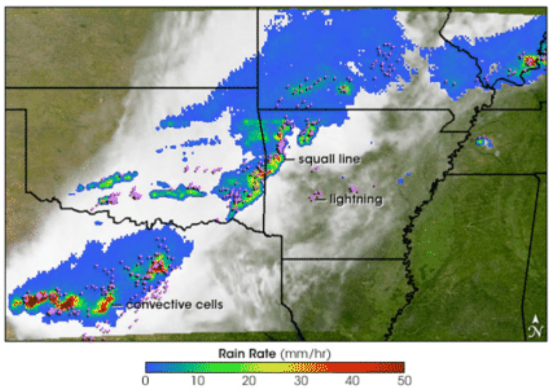


A mature thunderstorm with updrafts and downdrafts that reach the ground. [Figure2]

The downdrafts cool the air at the base of the cloud, so the air is no longer warm enough to rise. As a result, convection shuts down. Without convection, water vapor does not condense, no latent heat is released, and the thunderhead runs out of energy. A thunderstorm usually ends only 15 to 30 minutes after it begins, but other thunderstorms may start in the same area.

With severe thunderstorms, the downdrafts are so intense that when they hit the ground it sends warm air from the ground upward into the storm. The warm air gives the convection cells more energy. Rain and hail grow huge before gravity pulls them to Earth. Severe thunderstorms can last for hours and can cause a lot of damage because of high winds, flooding, intense hail, and tornadoes.

Thunderstorms can form individually or in squall lines along a cold front. In the United States, squall lines form in spring and early summer in the Midwest where the maritime tropical (mT) air mass from the Gulf of Mexico meets the continental polar (cP) air mass from Canada (**Figure**below).



Cold air from the Rockies collided with warm, moist air from the Gulf of Mexico to form this squall line. [Figure3]

So much energy collects in cumulonimbus clouds that a huge release of electricity, called **lightning**, may result (**Figure** below). The electrical discharge may be between one part of the cloud and another, two clouds, or a cloud and the ground.

Lightning behind the town of Diamond Head, Hawaii. [Figure4]

Lightning heats the air so that it expands explosively. The loud clap is **thunder**. Light waves travel so rapidly that lightning is seen instantly. Sound waves travel much more slowly, so a thunderclap may come many seconds after the lightning is spotted.

Thunderstorms kill approximately 200 people in the United States and injure about 550 Americans per year, mostly from lightning strikes. Have you heard the common misconception that lightning doesn't strike the same place twice? In fact, lightning strikes the New York City's Empire State Building about 100 times per year (**Figure** below).

Lightning strikes some places many times a year, such as the Eiffel Tower in Paris. [Figure5]

Tornadoes

Tornadoes, also called twisters, are fierce products of severe thunderstorms (**Figure** below). As air in a thunderstorm rises, the surrounding air races in to fill the gap, forming a funnel.

A tornado is a funnel shaped, whirling column of air extending downward from a cumulonimbus cloud. The formation of this tornado outside Dimmit, Texas, in 1995 was well studied. [Figure6]

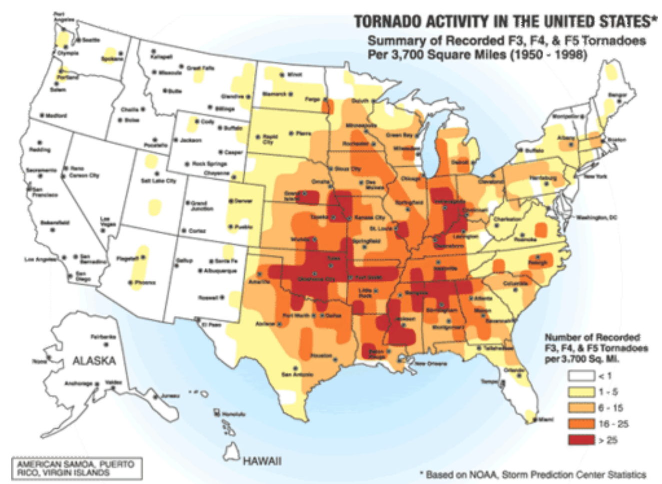
A tornado lasts from a few seconds to several hours. The average wind speed is about 177 kph (110 mph), but some winds are much faster. A tornado travels over the ground at about 45 km per hour (28 miles per hour) and goes about 25 km (16 miles) before losing energy and disappearing (**Figure**below).

This tornado struck Seymour, Texas, in 1979. [Figure7]

An individual tornado strikes a small area, but it can destroy everything in its path. Most injuries and deaths from tornadoes are caused by flying debris (**Figure** below). In the United States an average of 90 people are killed by tornadoes each year. The most violent two percent of tornadoes account for 70% of the deaths by tornadoes.

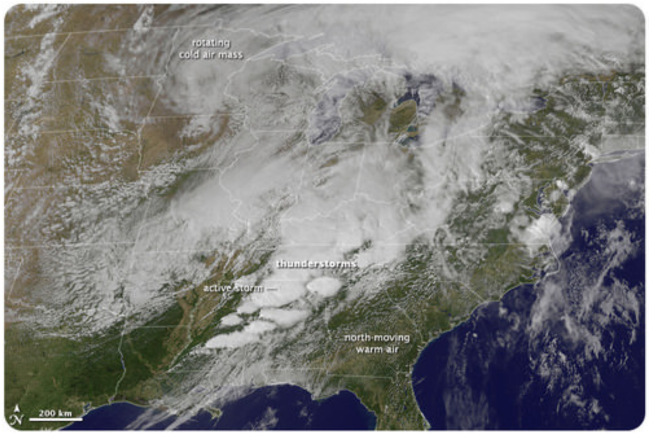
Tornado damage at Ringgold, Georgia in April 2011. [Figure8]

Tornadoes form at the front of severe thunderstorms. Lines of these thunderstorms form in the spring where where maritime tropical (mT) and continental polar (cP) air masses meet. Although there is an average of 770 tornadoes annually, the number of tornadoes each year varies greatly (**Figure** below).



The frequency of F3, F4, and F5 tornadoes in the United States. The red region that starts in Texas and covers Oklahoma, Nebraska, and South Dakota is called Tornado Alley because it is where most of the violent tornadoes occur. [Figure9]

In late April 2011, the situation was ripe for the deadliest set of tornadoes in 25 years. In addition to the meeting of cP and mT mentioned above, the jet stream was blowing strongly in from the west. The result was more than 150 tornadoes reported throughout the day (**Figure** below).



The severe thunderstorms pictured in this satellite image spawned the deadliest set of tornadoes in more than 25 years on April 27-28, 2011. The cold air mass is shown by the mostly continuous clouds. Warm moist air blowing north from the Atlantic Ocean and Gulf of Mexico is indicated by small low clouds. Thunderstorms are indicated by bright white patches. [Figure10]

The entire region was alerted to the possibility of tornadoes in those late April days. But meteorologists can only predict tornado danger over a very wide region. No one can tell exactly where and when a tornado will touch down. Once a tornado is sighted on radar, its path is predicted and a warning is issued to people in that area. The exact path is unknown because tornado movement is not very predictable.

The intensity of tornadoes is measured on the Fujita Scale (see **Table** below), which assigns a value based on wind speed and damage.

The Fujita Scale (F Scale) of Tornado Intensity

F Scale	(km/hr)	(mph)	Damage
F0	64-116	40-72	Light - tree branches fall and chimneys may collapse
F1	117-180	73-112	Moderate - mobile homes, autos pushed aside
F2	181-253	113-157	Considerable - roofs torn off houses, large trees uprooted
F3	254-33	158-206	Severe - houses torn apart, trees uprooted, cars lifted
F4	333-419	207-260	Devastating - houses leveled, cars thrown
F5	420-512	261-318	Incredible - structures fly, cars become missiles
F6	>512	>318	Maximum tornado wind speed

Cyclones

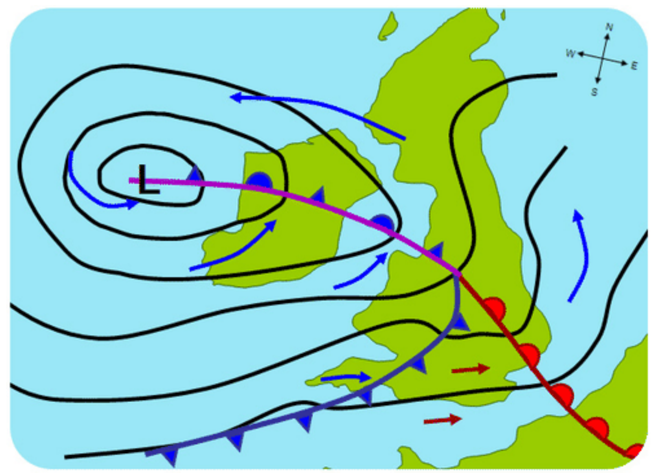
Cyclones can be the most intense storms on Earth. A **cyclone** is a system of winds rotating counterclockwise in the Northern Hemisphere around a low pressure center. The swirling air rises and cools, creating clouds and precipitation.

There are two types of cyclones: middle latitude (mid-latitude) cyclones and tropical cyclones. Mid-latitude cyclones are the main cause of winter storms in the middle latitudes. Tropical cyclones are also known as hurricanes.

An **anticyclone** is the opposite of a cyclone. An anticyclone's winds rotate clockwise in the Northern Hemisphere around a center of high pressure. Air comes in from above and sinks to the ground. High pressure centers generally have fair weather.

Mid-Latitude Cyclones

Mid-latitude cyclones, sometimes called extratropical cyclones, form at the polar front when the temperature difference between two air masses is large. These air masses blow past each other in opposite directions. Coriolis Effect deflects winds to the right in the Northern Hemisphere, causing the winds to strike the polar front at an angle. Warm and cold fronts form next to each other. Most winter storms in the middle latitudes, including most of the United States and Europe, are caused by mid-latitude cyclones (**Figure** below).

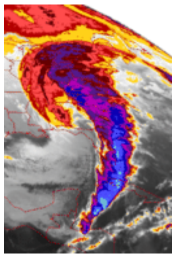


A hypothetical mid-latitude cyclone affecting the United Kingdom. The arrows point the wind direction and its relative temperature; L is the low pressure area. Notice the warm, cold, and occluded fronts. [Figure11]

The warm air at the cold front rises and creates a low pressure cell. Winds rush into the low pressure and create a rising column of air. The air twists, rotating counterclockwise in the Northern Hemisphere and clockwise in the Southern Hemisphere. Since the rising air is moist, rain or snow falls.

Mid-latitude cyclones form in winter in the mid-latitudes and move eastward with the westerly winds. These two- to five-day storms can reach 1,000 to 2,500 km (625 to 1,600 miles) in diameter and produce winds up to 125 km (75 miles) per hour. Like tropical cyclones, they can cause extensive beach erosion and flooding.

Mid-latitude cyclones are especially fierce in the mid-Atlantic and New England states where they are called **nor'easters**, because they come from the northeast. About 30 nor'easters strike the region each year. (**Figure** below).



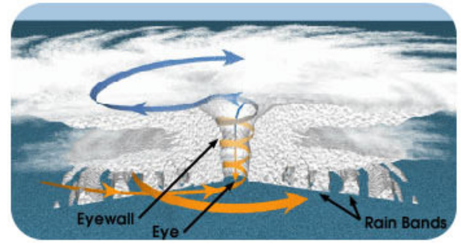
The 1993 "Storm of the Century" was a nor'easter that covered the entire eastern seaboard of the United States. [Figure12]

Hurricanes

Tropical cyclones have many names. They are called **hurricanes** in the North Atlantic and eastern Pacific oceans, typhoons in the western Pacific Ocean, tropical cyclones in the Indian Ocean, and willi-willi's in the waters near Australia (**Figure** below). By any name, they are the most damaging storms on Earth.

Hurricanes arise in the tropical latitudes (between 10° and 25°N) in summer and autumn when sea surface temperature are 28°C (82°F) or higher. The warm seas create a large humid air mass. The warm air rises and forms a low pressure cell, known as a **tropical depression**. Thunderstorms materialize around the tropical depression.

If the temperature reaches or exceeds 28°C (82°F) the air begins to rotate around the low pressure (counterclockwise in the Northern Hemisphere and clockwise in the Southern Hemisphere). As the air rises, water vapor condenses, releasing energy from latent heat. If wind shear is low, the storm builds into a hurricane within two to three days.



A cross-sectional view of a hurricane. [Figure13]

Hurricanes are huge with high winds. The exception is the relatively calm eye of the storm where air is rising upward. Rainfall can be as high as 2.5 cm (1") per hour, resulting in about 20 billion metric tons of water released daily in a hurricane. The release of latent heat generates enormous amounts of energy, nearly the total annual electrical power consumption of the United States from one storm. Hurricanes can also generate tornadoes.

Hurricanes are assigned to categories based on their wind speed. The categories are listed on the Saffir-Simpson hurricane scale (**Table** below).

Saffir - Simpson Hurricane Scale

Category	Kph	Mph	Estimated Damage
1 (weak)	119-153	74-95	Above normal; no real damage to structures
2 (moderate)	154-177	96-110	Some roofing, door, and window damage, considerable damage to vegetation, mobile homes, and piers
3 (strong)	178-209	111-130	Some buildings damaged; mobile homes destroyed
4 (very strong)	210-251	131-156	Complete roof failure on small residences; major erosion of beach areas; major damage to lower floors of structures near shore
5 (devastating)	>251	>156	Complete roof failure on many residences and industrial buildings; some complete building failures

Hurricanes move with the prevailing winds. In the Northern Hemisphere, they originate in the trade winds and move to the west. When they reach the latitude of the westerlies, they switch direction and travel toward the north or northeast. Hurricanes may cover 800 km (500 miles) in one day.

Damage from hurricanes comes from the high winds, rainfall, and storm surge. Storm surge occurs as the storm's low pressure center comes onto land, causing the sea level to rise unusually high. A storm surge is often made worse by the hurricane's high winds blowing seawater across the ocean onto the shoreline. Flooding can be devastating, especially along low-lying coastlines such as the Atlantic and Gulf Coasts. Hurricane Camille in 1969 had a 7.3 m (24 foot) storm surge that traveled 125 miles (200 km) inland.

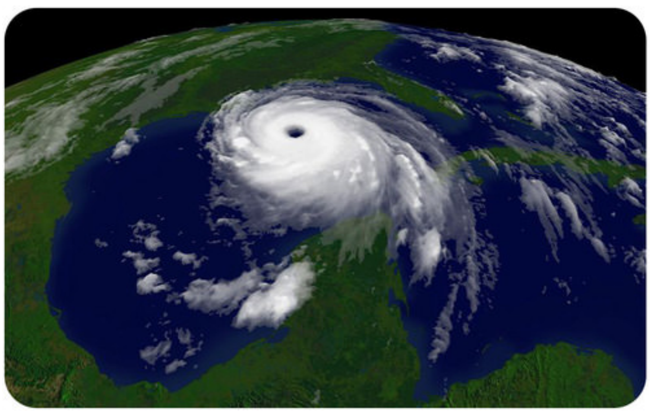
Hurricanes typically last for 5 to 10 days. Over cooler water or land, the hurricane's latent heat source shut downs and the storm weakens. When a hurricane disintegrates, it is replaced with intense rains and tornadoes.

Hurricanes are explored in a set of National Geographic videos found at National Geographic Video, Natural disaster, Hurricanes:

- "Hurricanes 101" is an introduction to the topic.
- "How Katrina Formed" looks at the history of Hurricane Katrina as it formed and passed through the Gulf coast.
- Follow that up with "Doomed New Orleans," which explores how the devastation to the city is a man-made disaster.
- "The Hurricane Ike of 1900" looks at what happened in the days when there was little warning before a hurricane hit a coastal city.

There are about 100 hurricanes around the world each year, plus many smaller tropical storms and tropical depressions. As people develop coastal regions, property damage from storms continues to rise. However, scientists are becoming better at predicting the paths of these storms and fatalities are decreasing. There is, however, one major exception to the previous statement: Hurricane Katrina.

The 2005 Atlantic hurricane season was the longest, costliest, and deadliest hurricane season so far. Total damage from all the storms together was estimated at more than $128 billion, with more than 2,280 deaths. Hurricane Katrina was both the most destructive hurricane and the most costly (**Figure** below and **Figure** below).



Hurricane Katrina nears its peak strength as it travels across the Gulf of Mexico. [Figure14]

News about Hurricane Katrina from the New Orleans Times-Picayune: http://www.nola.com/katrina/graphics/flashflood.swf.

An animation of a radar image of Hurricane Katrina making landfall is seen here: http://upload.wikimedia.org/wikipedia/commons/9/97/Hurricane_Katrina_LA_landfall_radar.gif.

NASA's short video, In Katrina's Wake: http://www.youtube.com/watch?v=HZjqvqaLtI.

Flooding in New Orleans after Hurricane Katrina caused the levees to break and water to pour through the city. [Figure15]

Blizzards and Lake-Effect Snow

A **blizzard** is distinguished by certain conditions (**Figure** below):

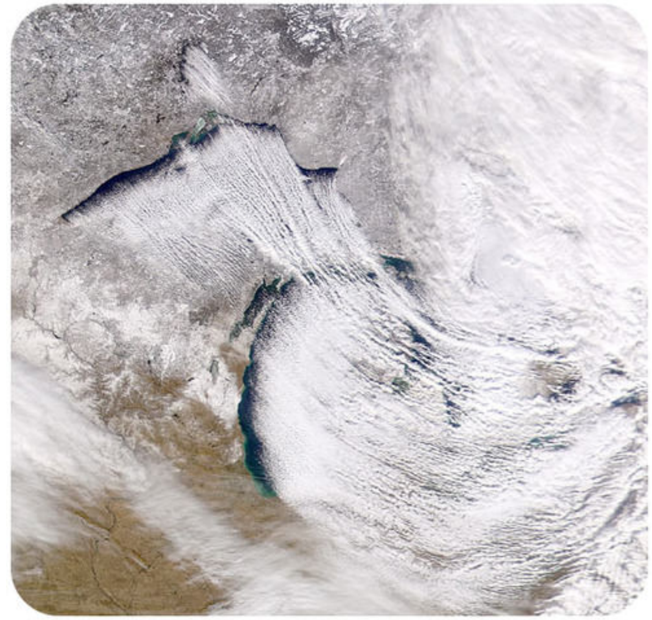
- Temperatures below –7°C (20°F); –12°C (10°F) for a severe blizzard.
- Winds greater than 56 kmh (35 mph); 72 kmh (45 mph) for a severe blizzard.
- Snow so heavy that visibility is 2/5 km (1/4 mile) or less for at least three hours; near zero visibility for a severe blizzard.

A near white out in a blizzard in Massachusetts. [Figure16]

Blizzards happen across the middle latitudes and toward the poles, usually as part of a mid-latitude cyclone. Blizzards are most common in winter, when the jet stream has traveled south and a cold, northern air mass comes into contact with a warmer, semitropical air mass (**Figure** below). The very strong winds develop because of the pressure gradient between the low pressure storm and the higher pressure west of the storm. Snow produced by the storm gets caught in the winds and blows nearly horizontally. Blizzards can also produce sleet or freezing rain.

Blizzard snows blanket the East Coast of the United States in February 2010. [Figure17]

In winter, a continental polar air mass travels down from Canada. As the frigid air travels across one of the Great Lakes, it warms and absorbs moisture. When the air mass reaches the leeward side of the lake, it is very unstable and it drops tremendous amounts of snow. This **lake-effect snow** falls on the snowiest, metropolitan areas in the United States: Buffalo and Rochester, New York (**Figure** below).

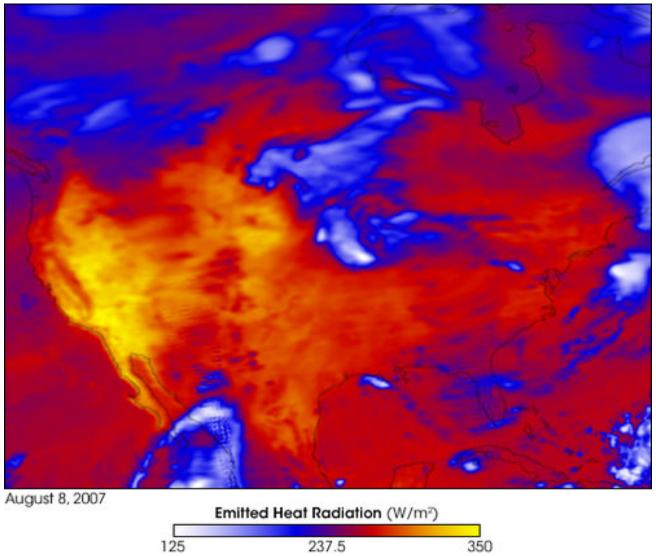


Frigid air travels across the Great Lakes and dumps lake-effect snow on the leeward side. [Figure18]

Heat Wave

Even more insidious are the deadliest weather phenomena, a **heat wave**. A heat wave is different for different locations; it is a long period of hot weather, at least 86°F (30°C) for at least three days in cooler locations but much more in hotter locations. Heat waves have increased in frequency and duration in recent years.

What do you think caused the heat wave in the **Figure** below? A high pressure zone kept the jet stream further north than normal for August.



A heat wave over the United States as indicated by heat radiated from the ground. The bright yellow areas are the hottest and the blue and white are coolest. [Figure19]

Lesson Summary

- Thunderstorms arise over warm ground when updrafts form cumulonimbus clouds that rain and hail.
- Tornadoes form most commonly from thunderstorms. They are relatively short-lived and small, but they do an enormous amount of damage where they strike.
- Cyclones of all sorts are large and damaging; they include nor'easters and hurricanes.

Review Questions

1. Describe in detail how a thunderstorm forms and where the energy to fuel it comes from. Start with a warm day and no clouds.

2. How does a thunderstorm break apart and disappear?

3. Why does a thunderstorm get more severe rather than losing energy and disappearing?

4. What are lightning and thunder?

5. Discuss the pros and cons of living in an area that is prone to tornadoes versus one that is prone to hurricanes.

6. Where are tornadoes most common in the United States?

7. What is a cyclone? What are the two types of cyclone and how do they differ?

8. Describe in detail how a hurricane forms.

9. What level is the most damaging hurricane on the Saffir-Simpson scale? What sorts of damage do you expect from such a strong hurricane?

10. What causes damage from hurricanes?

11. What could have been done in New Orleans to lessen the damage and deaths from Hurricane Katrina?

12. Do you think New Orleans should be rebuilt in its current location?

13. Where do blizzards develop?

Lesson 16.3: True or False

Name___________________ Class______________ Date________

Write true if the statement is true or false if the statement is false.

_____ 1. Anticyclones are cyclones that occur in the Southern Hemisphere.

_____ 2. Cyclones can be the most intense storms on Earth.

_____ 3. Hurricanes can produce higher winds than tornadoes.

_____ 4. It is easier to predict the path of a hurricane than a tornado.

_____ 5. Tornado activity in the U.S. is greatest along the East Coast.

_____ 6. A category 5 hurricane is described as “strong” on the Saffir-Simpson scale.

_____ 7. There are about 40,000 hurricanes around the world each year.

_____ 8. Blizzards can produce sleet or freezing rain.

_____ 9. Heat waves are the deadliest weather phenomena.

_____ 10. Heat waves have increased in frequency and duration in recent years.

Lesson 16.3: Critical Reading

Name___________________ Class______________ Date________

Read this passage based on the text and answer the questions that follow.

Cyclones and Anticyclones

A cyclone is a large system of winds that are rotating around a low-pressure center. The winds rotate because of the Coriolis effect. They rotate counterclockwise in the Northern Hemisphere and clockwise in the Southern Hemisphere. Low pressure occurs because the swirling air rises. The rising air cools, creating clouds and precipitation. Stormy weather is likely. There are two types of cyclones: mid-latitude cyclones and tropical cyclones.

- Mid-latitude cyclones are the main cause of mid-latitude winter storms, such as blizzards and nor-easters.

- Tropical cyclones are very large storms that are also known as hurricanes, typhoons, or other local names.

The opposite of a cyclone is an anticyclone. An anticyclone is a large system of winds that are rotating around a high-pressure center. The winds rotate in the opposite direction to a cyclone, and the air sinks to the ground instead of rising. Anticyclones generally bring fair weather rather than storms.

Questions

1. Describe a Northern Hemisphere cyclone. How would a cyclone in the Southern Hemisphere be different?
2. Identify storms caused by mid-latitude cyclones and tropical cyclones.
3. Compare and contrast cyclones and anticyclones.

Lesson 16.3: Multiple Choice

Name___________________ Class______________ Date________

Circle the letter of the correct choice.

1. Which type of storm is most common worldwide?

   a. blizzard

   b. tornado

   c. hurricane

   d. thunderstorm

2. Lightning may move

   a. from a cloud to the ground.

   b. from one cloud to another.

   c. within a cloud.

   d. all of the above

3. Characteristics of a Southern Hemisphere anticyclone include

   a. winds rotating clockwise.

   b. a high-pressure center.

   c. rising air.

   d. all of the above

4. The Fujika scale measures storm intensity by

   a. wind speed.

   b. duration of storm.

   c. damage done by storm.

   d. two of the above

5. Tropical cyclones may be called

   a. nor-easters.

   b. typhoons.

   c. tornadoes.

   d. thunderstorms.

6. Storm surge caused by a hurricane occurs when the

   a. low-pressure center of the storm comes on land.

   b. leading edge of the storm reaches the coast.

   c. trailing edge of the storm goes ashore.

   d. none of the above

7. To be a blizzard, a storm must have

   a. temperatures below -7 °C.

   b. winds faster than 56 km per hour.

   c. visibility of 2/5 km or less for at least 3 hours.

   d. all of the above

Lesson 16.3: Matching

Name____________________ Class_______________ Date________

Match each definition with the correct term.

Definitions

_____ 1. storm that develops from a tropical depression

_____ 2. huge release of electricity from a cumulonimbus cloud

_____ 3. mid-latitude cyclone in the mid-Atlantic and New England states

_____ 4. large system of rotating winds around a low pressure center

_____ 5. storm with low temperatures, high winds, and reduced visibility

_____ 6. twirling whirling funnel cloud with high-speed winds

_____ 7. large system of rotating winds around a high pressure center

Terms

a. anticyclone

b. tornado

c. blizzard

d. cyclone

e. lightning

f. hurricane

g. nor'easter

Lesson 16.3: Fill in the Blank

Name____________________ Class_______________ Date________

Fill in the blank with the appropriate term.

1. Tornadoes form at the front of severe __________.
2. Cyclones rotate __________ in the Northern Hemisphere.
3. Most winter storms in New England are caused by __________ cyclones.
4. The low-pressure zone of a tropical cyclone is known as a tropical __________.
5. __________ are measured on the Fujita scale.
6. __________ are measured on the Saffir-Simpson scale.
7. Heavy snow that falls on the leeward side of the Great Lakes is called __________ snow.

Lesson 16.3: Critical Writing

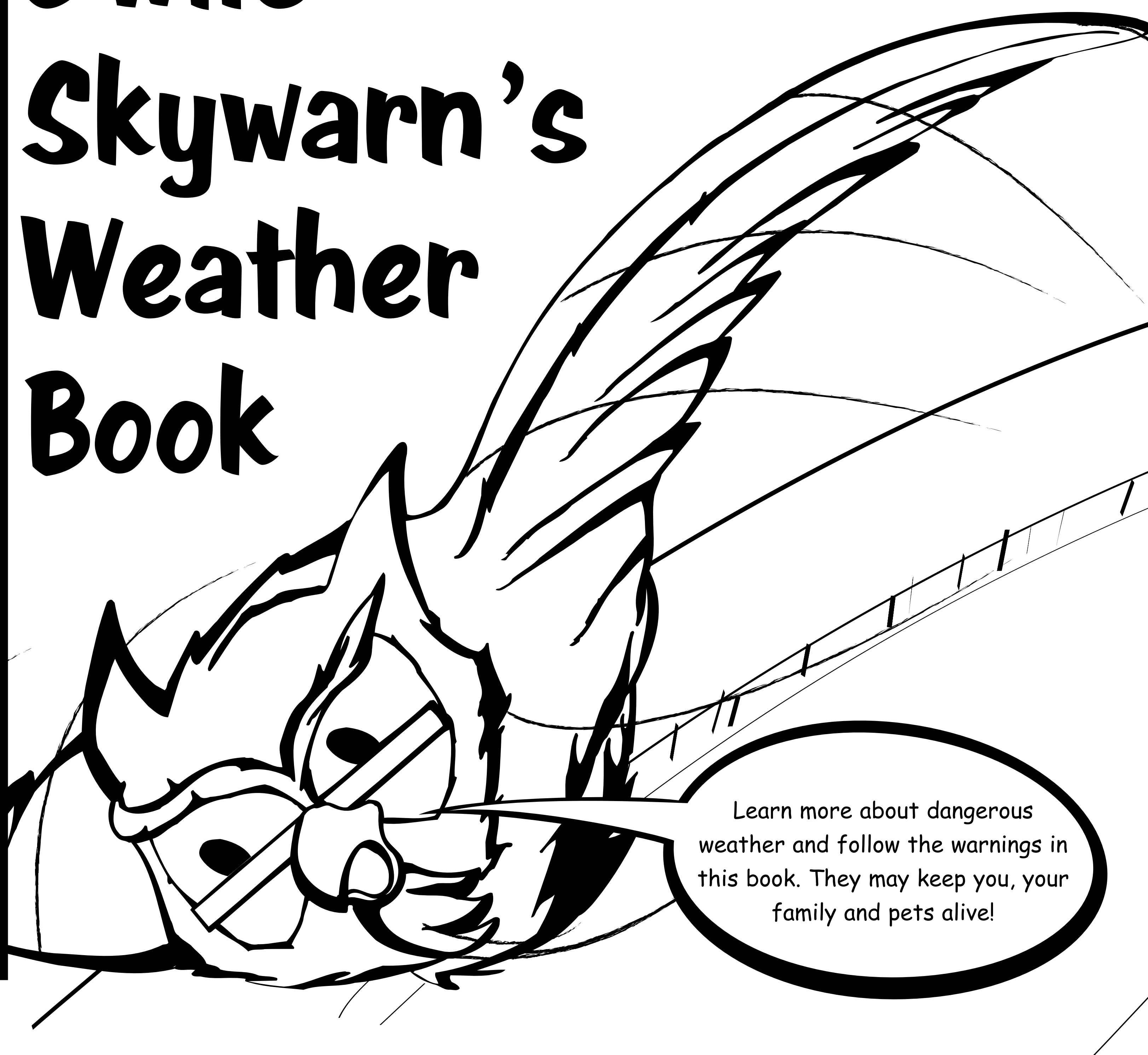
Name___________________ Class______________ Date________

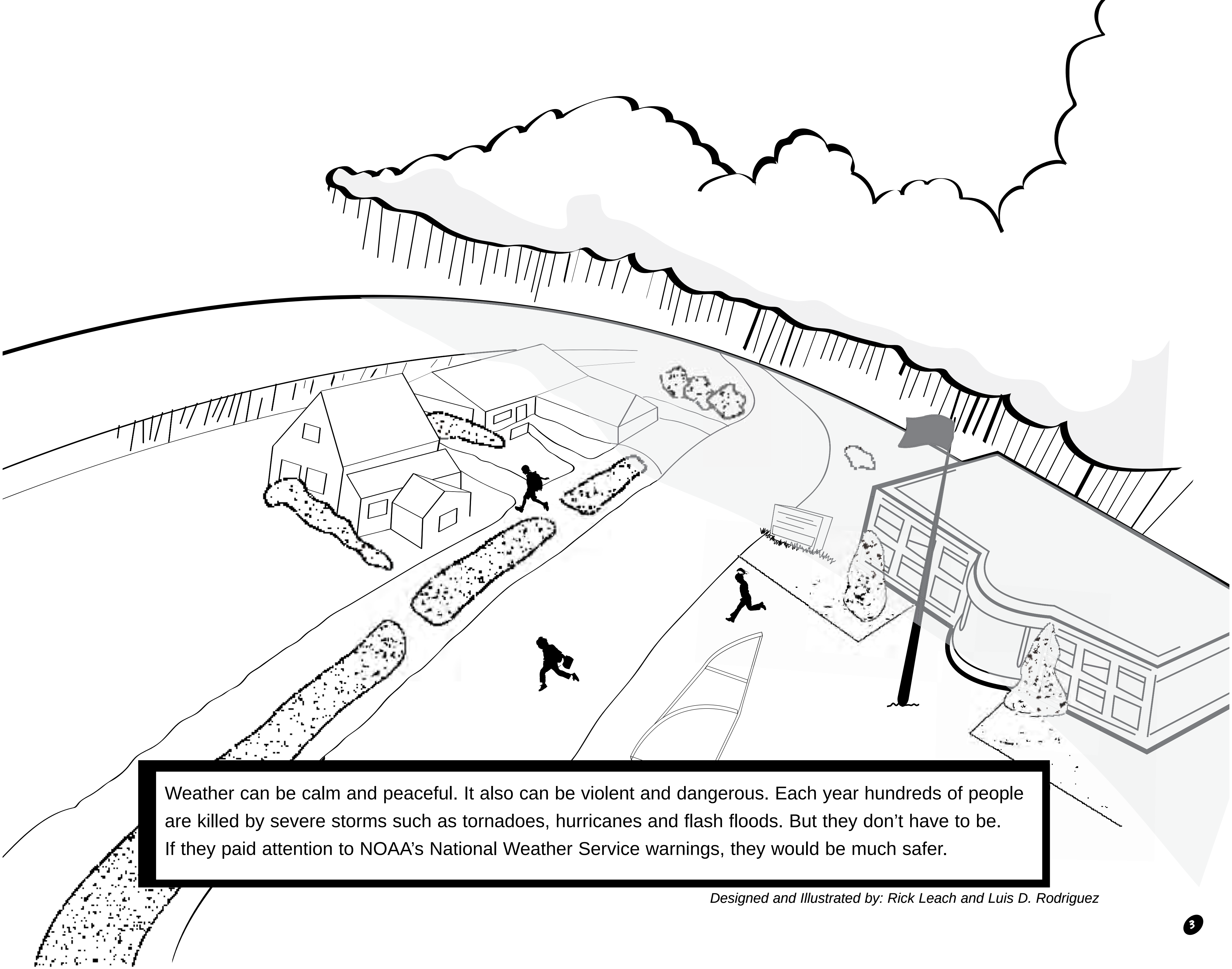
Thoroughly answer the question below. Use appropriate academic vocabulary and clear and complete sentences.

Both tornadoes and hurricanes cause death and destruction, but the two types of storms have many differences. Explain how they differ and how the differences relate to their potential destructiveness.

Owlie Skywarn's Weather Book

What's Inside:





Weather can be calm and peaceful. It also can be violent and dangerous. Each year hundreds of people are killed by severe storms such as tornadoes, hurricanes and flash floods. But they don't have to be. If they paid attention to NOAA's National Weather Service warnings, they would be much safer.

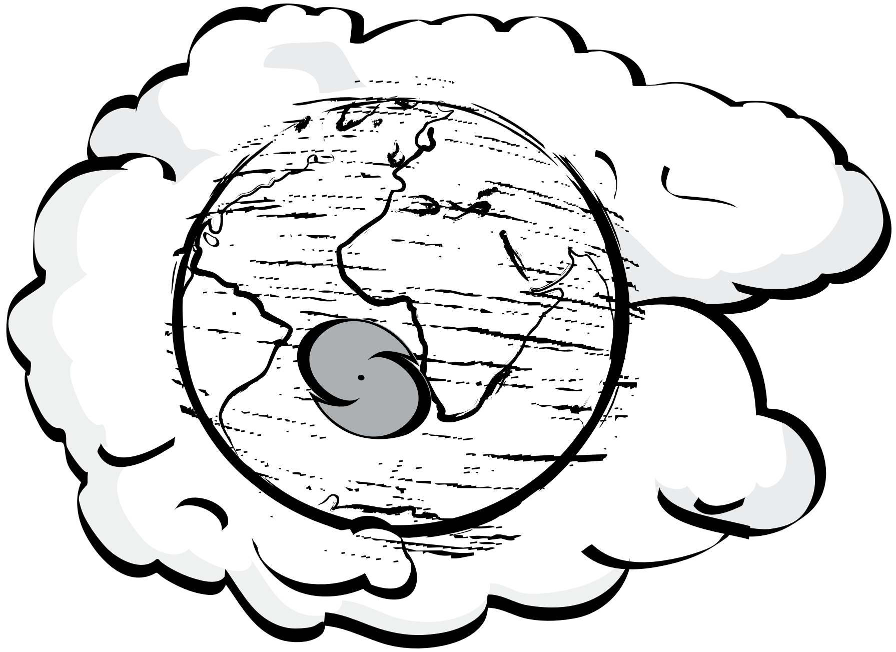
Designed and Illustrated by: Rick Leach and Luis D. Rodriguez

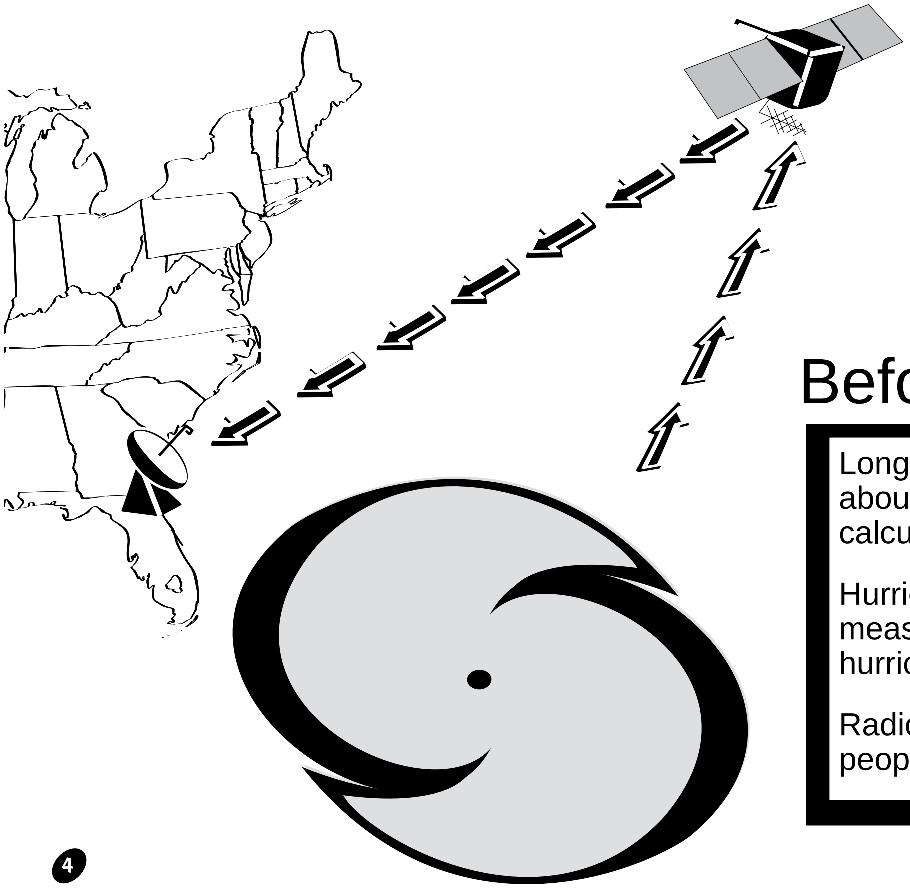
Hurricanes

The air that surrounds our planet weights 5,000,000,000,000,000 (5 quadrillion) tons! That's 13,700,000,000 (13 billion, 700 million) Empire State Buildings!

Air is moving all the time—swirling, blowing, sinking, rising. In summer and early fall, great masses of air move over the warm oceans. The oceans get hot, pick up lots of water and start swirling, blowing, sinking and rising.

A hurricane is born. If the hurricane moves toward the shore, powerful winds, high tides and flooding could wipe out cities, towns, farms and schools.





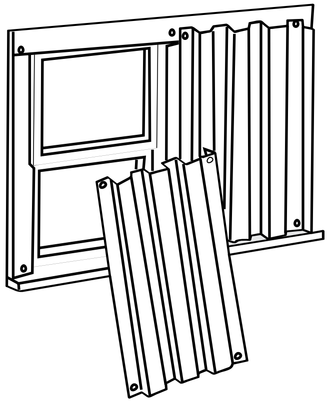
Before the hurricane reaches you . . .

Long before a hurricane hits land, the National Weather Service knows about it. Satellites have taken pictures of the storm and computers have calculated where it is going.

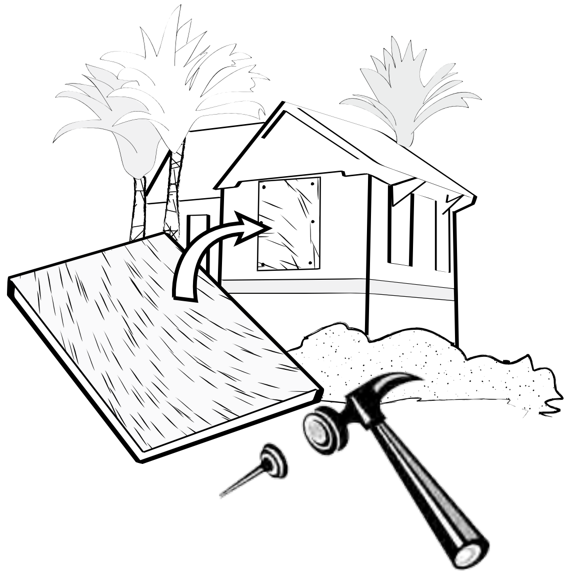
Hurricane Hunter airplanes fly into the storm and report more exact measurements. As it comes closer to land, special weather radars track the hurricane.

Radio, television and more than 1000 NOAA Weather Radio stations warn people about the hurricane. It may reach land. Get ready!

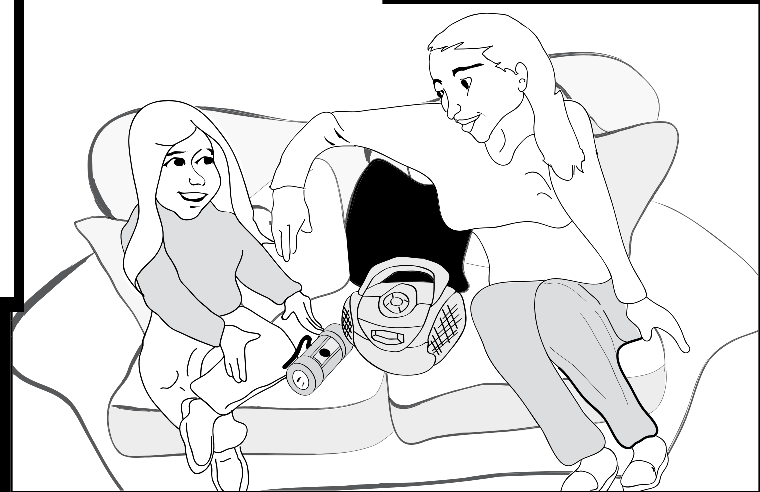
Before the Storm Comes . . .



Put boards or storm shutters over windows. Do NOT tape the windows. Taping just leaves gunk on your windows, it doesn't protect them.



Pick up all the small things laying around your yard, like toys, tools and flower pots and bring them inside. The wind could pick them up and send them slamming into windows, cars or you!



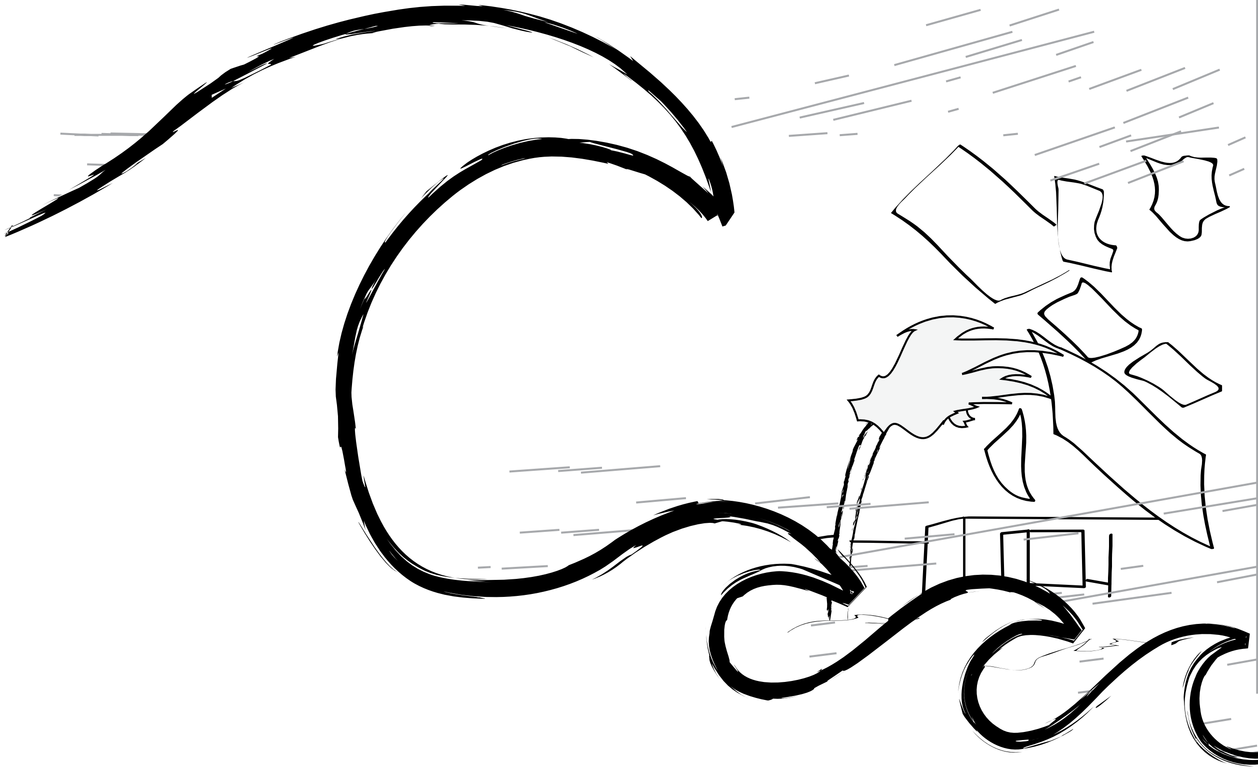
If you're not close to shore and plan to stay in your home during the storm, clean drains and prepare for flooding. Always evacuate immediately if ordered to do so!

When National Weather Service meteorologists decide a storm might reach land within 2 days, they issue a Hurricane Watch. In the western North Pacific, hurricanes are called typhoons. Both have a well-defined circulation and sustained winds over 73 miles per hour. A Watch tells people who live or work near the coast that the hurricane will likely impact them. The National Weather Service works together with emergency managers and the news media. We will tell you what is happening. Stay tuned!

Hurricane Warning

When the National Weather Service puts out a Hurricane Warning for your area, it means the storm is likely to generate winds more than 73 miles per hour! That's hard enough to blow down trees and other big objects that could hit you or your home. Ouch! A Warning also means dangerous high water, coastal flooding and very rough seas are expected. Hurricanes also create lots of thunderstorms with deadly lightning and even some tornadoes. You definitely need to seek safe shelter during a hurricane. Listen to what the emergency managers in your state are advising. They might tell you to get away from the coast and inland to safety.

Get out when you are told.



When the hurricane hits, the sea may rise as high as 25 feet above normal high tide! That is taller than six kids standing on each other's shoulders!

This extreme coastal flooding due to hurricanes is called the storm surge. The surge can sink boats, destroy piers and damage buildings. Many people who die during a hurricane drown from inland flooding–not due to the high winds.

In a major hurricane, wind speed may be more than 150 miles per hour! Trees are blown down and houses can be damaged. Windows in buildings are blown out. Watch out for flying debris!

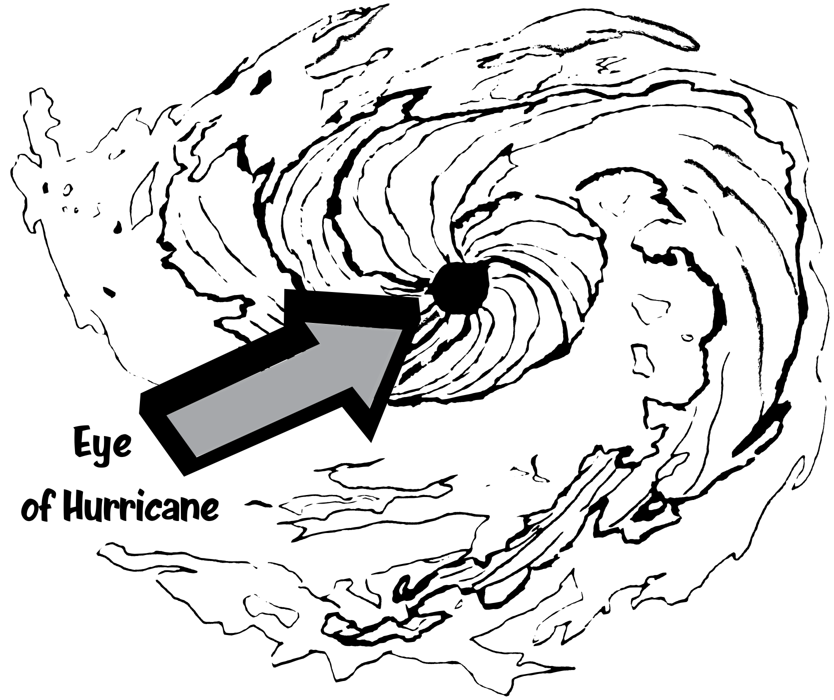
It rains hard in hurricanes. Slow moving storms produce more rain. There may be flooding hundreds of miles from the coast due to heavy rain.

When the Hurricane Comes . . .

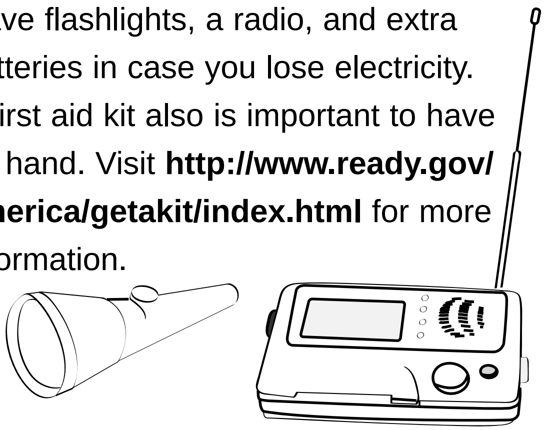
Stay safe by staying indoors. Falling trees, flying debris, downed power lines, flooded roads–it is just not safe to be outdoors. Any decision to evacuate the coast should be made well in advance of the storm's arrives. Follow the guidance of the emergency managers in your area.

Beware of the eye of the hurricane. A hurricane is a big doughnut of wind with a calm section at the middle.

- The whole hurricane can be 300 miles across. The calm center may last from a few minutes to an hour.
- The sun may even come out in the eye and you might think the storm is over. But it isn't. As the hurricane moves on, winds will blow just as hard, but from the opposite direction.

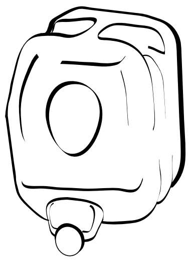


Have flashlights, a radio, and extra batteries in case you lose electricity. A first aid kit also is important to have on hand. Visit **http://www.ready.gov/america/getakit/index.html** for more information.



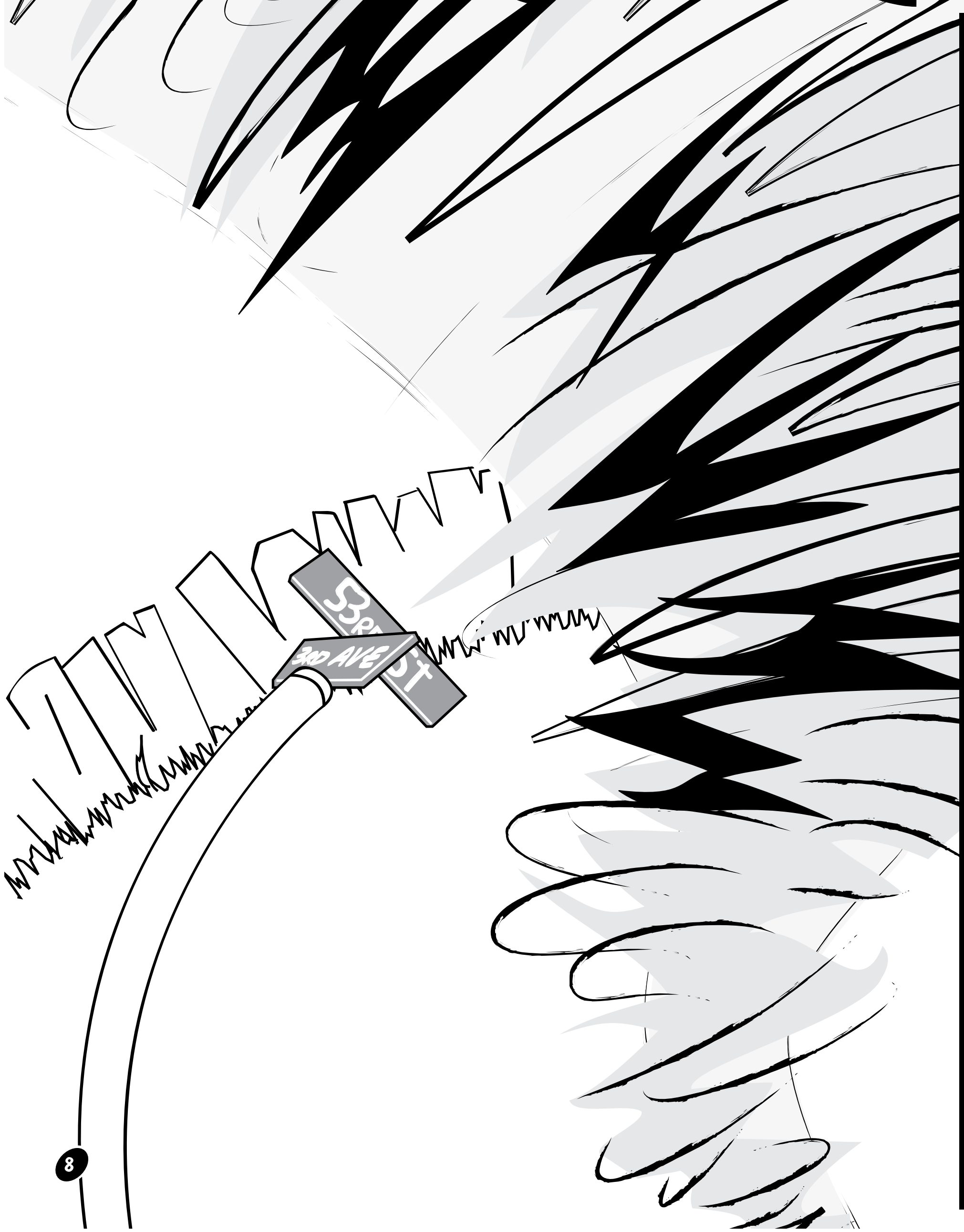
Hurricanes and Tropical Storms can kill. Don't be caught by one!

Ensure you have enough water and food stocked up. Water–1 gallon per person, per day (2 week supply for home). Food–2 week supply of non-perishable food. And don't forget food and water for your pets!



Get out of its way. Go inland. Do it immediately!

Tornadoes



If you ever see a big, black cloud with a funnel shaped cloud beneath it, watch out. It could be a tornado.

A tornado looks like a funnel with the fat part at the top. Inside winds may swirl up to 200 miles an hour.

If it goes through a town, the tornado could flatten homes and buildings, throw cars and trucks through the air and shatter mobile homes into splinters.

It could just hit your home and leave your neighbor’s home alone or could destroy an entire town.

Sometimes you don’t see the funnel first. It may be raining too hard. Or the tornado may come at night. Listen for the tornado’s roar—it sounds like 1,000 trains coming!

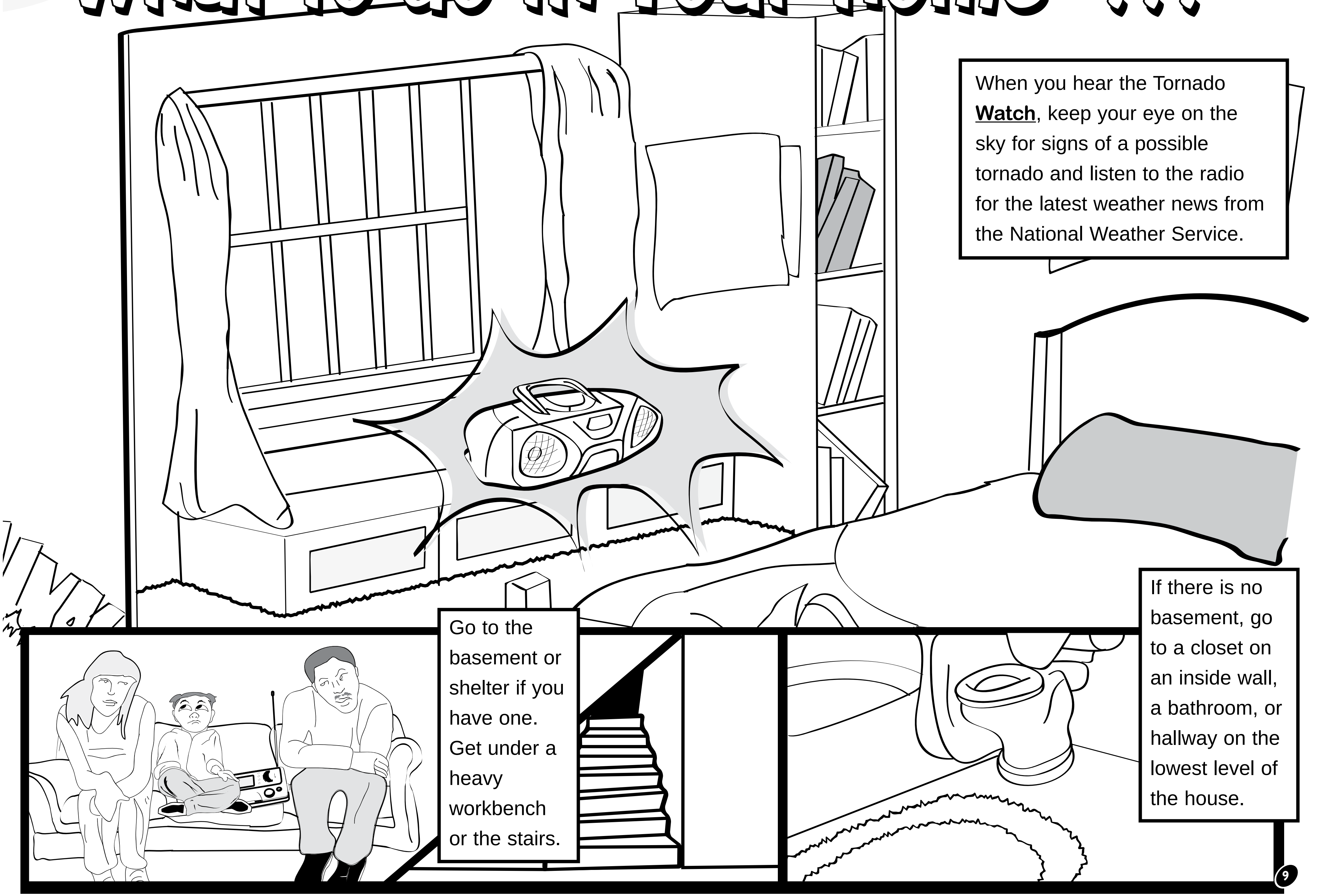
Tornado Watch

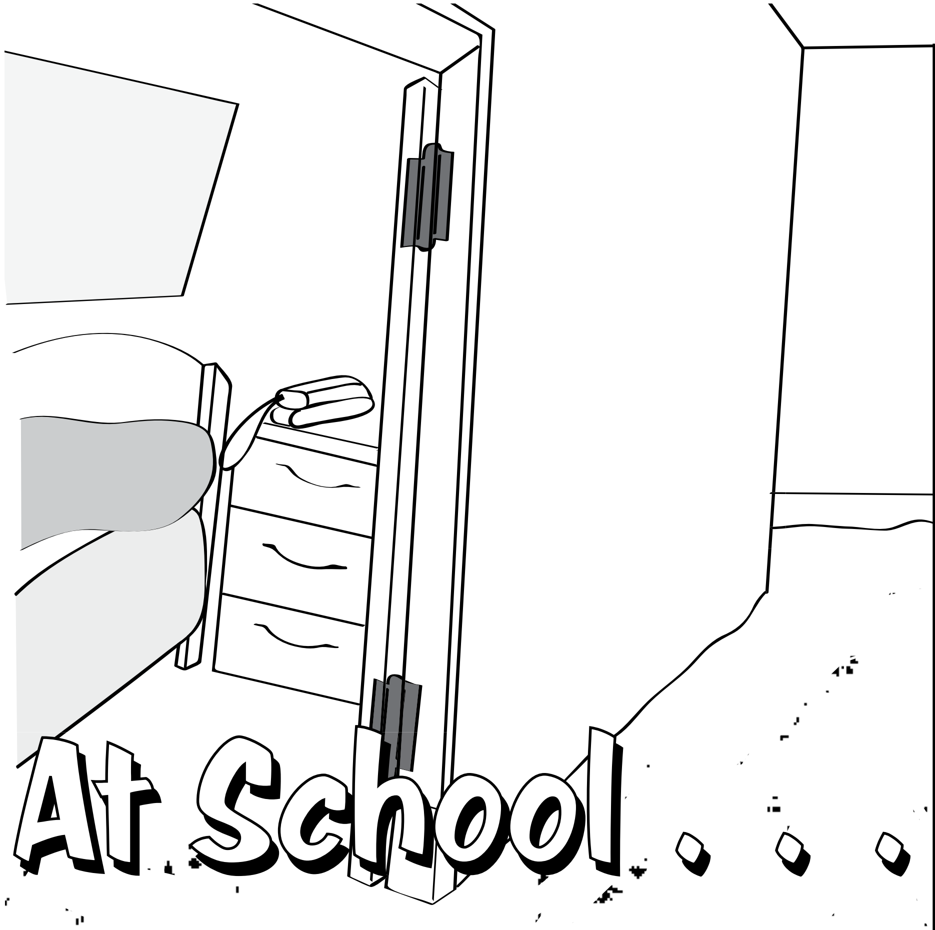
The National Weather Service forecasts that a tornado MAY develop later. The sky may be clear at the time you hear the Watch. Don’t be fooled. Listen to the radio for the latest news and get to safety.

Tornado Warning

When someone has seen a tornado or radar detects one, the NWS issues a **Warning**. The tornado may be moving toward you! Dark clouds swirl in the sky. There may be thunder, lightning, heavy rain or hail. When you see large hail, you may be close to a tornado. Power may go off. You should already be inside!

What to do In Your Home . . .



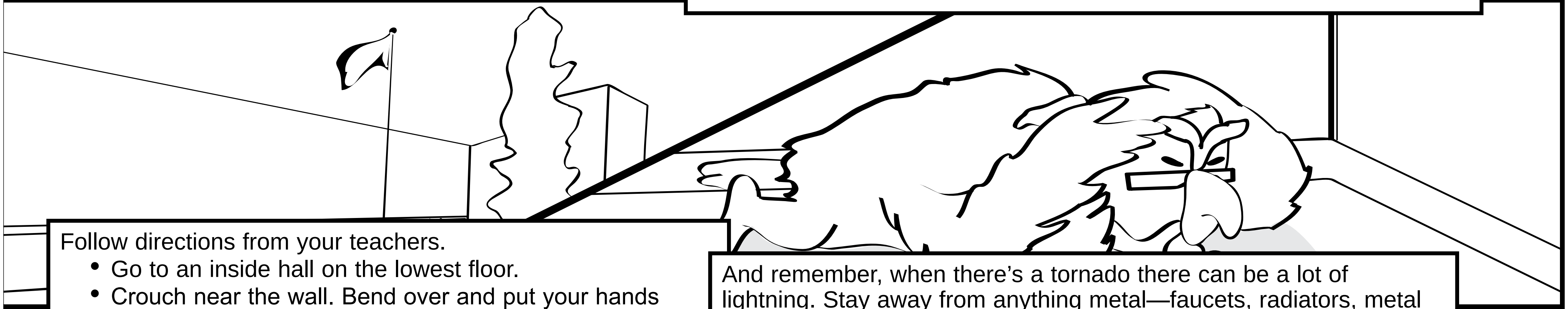


Outside . . .

- Immediately seek shelter in a nearby sturdy building, shelter or basement.
- If you're caught outside, crouch low in a ditch or crouch near a strong building.
- Cover your head with your hands.

In a car or truck...

- Immediately go to a nearby sturdy building, shelter or basement.
- If flying debris occurs while you are driving, pull over and park. Now you have the following options as a last resort:
- Stay in the car with the seat belt on. Put your head down below the windows, covering with your hands and a blanket if possible.
- If you can safely get noticeably lower than the level of the roadway, exit your car, and lie in that area, covering your head with your hands.
- If you can safely get noticeably lower than the level of the roadway, exit your car, and lie in that area, covering your head with your hands.
- Your choice should be driven by your specific circumstances.



Follow directions from your teachers.

- Go to an inside hall on the lowest floor.
- Crouch near the wall. Bend over and put your hands on the back of your head.
- Keep away from glass windows and stay out of big rooms like the gym, cafeteria or auditorium.
- Listen to NOAA Weather Radio or a battery powered radio for warnings.

And remember, when there's a tornado there can be a lot of lightning. Stay away from anything metal—faucets, radiators, metal sinks and tubs.

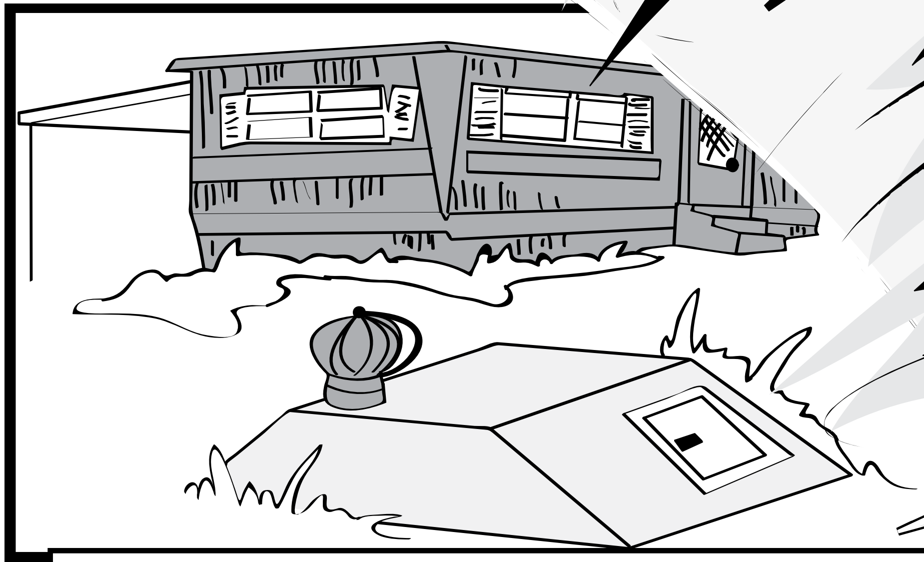
Tornadoes are scary. They pack a lot of energy, enough to blow down a whole town! But you can live through a tornado. Be smart. Know what to do and do it!

Owlie's True Tornado Facts

In Texas, a mother huddled in an inside closet with six children. A tornado ripped off the roof of their house, tore down one wall and destroyed their garage. But all seven people in the closet weren't even scratched.

In 1931, a tornado in Minnesota lifted an 83-ton railroad train with 117 passengers and carried it for 80 feet.

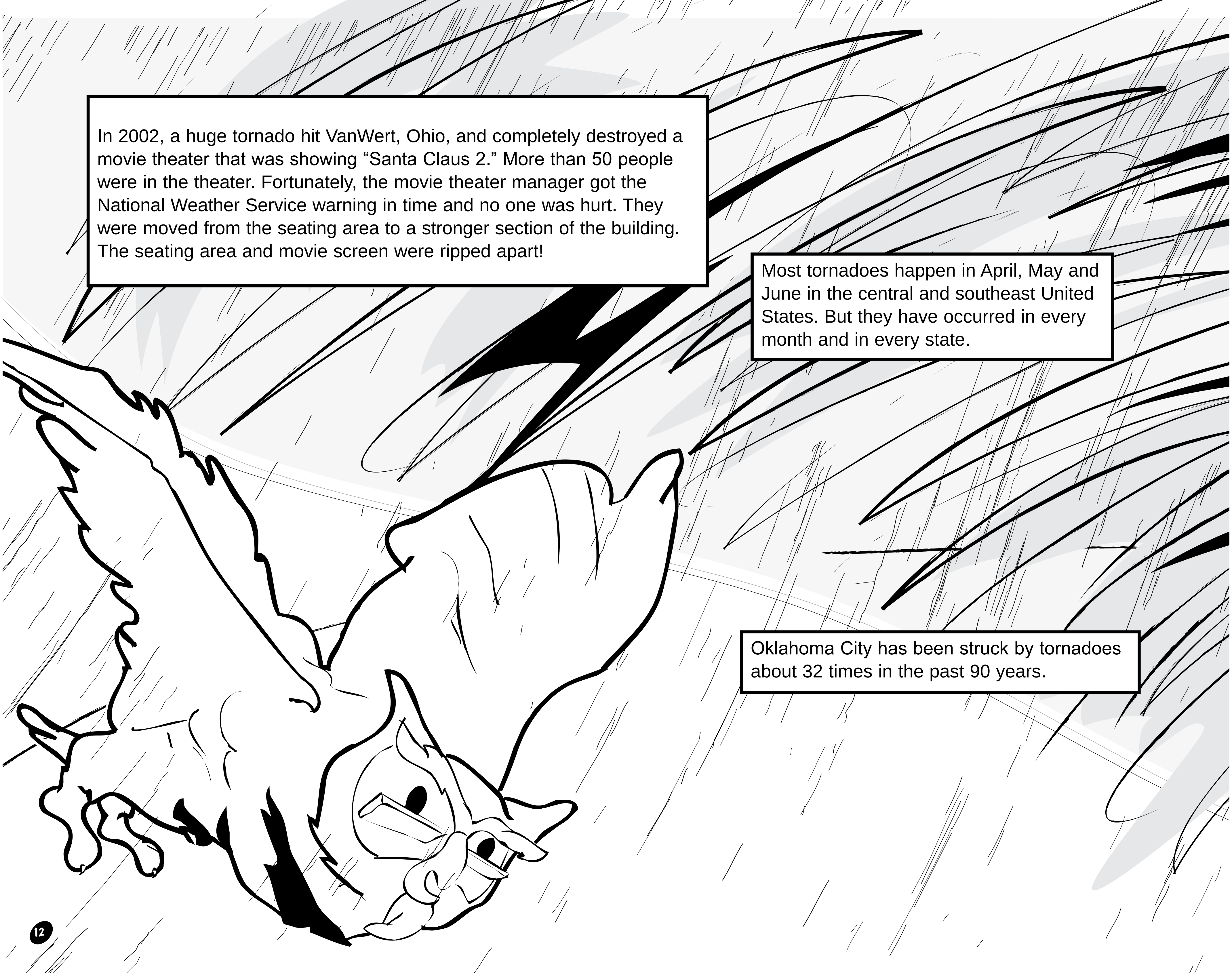
Tornadoes are rare in many parts of the United States, but they have occurred in all 50 states.

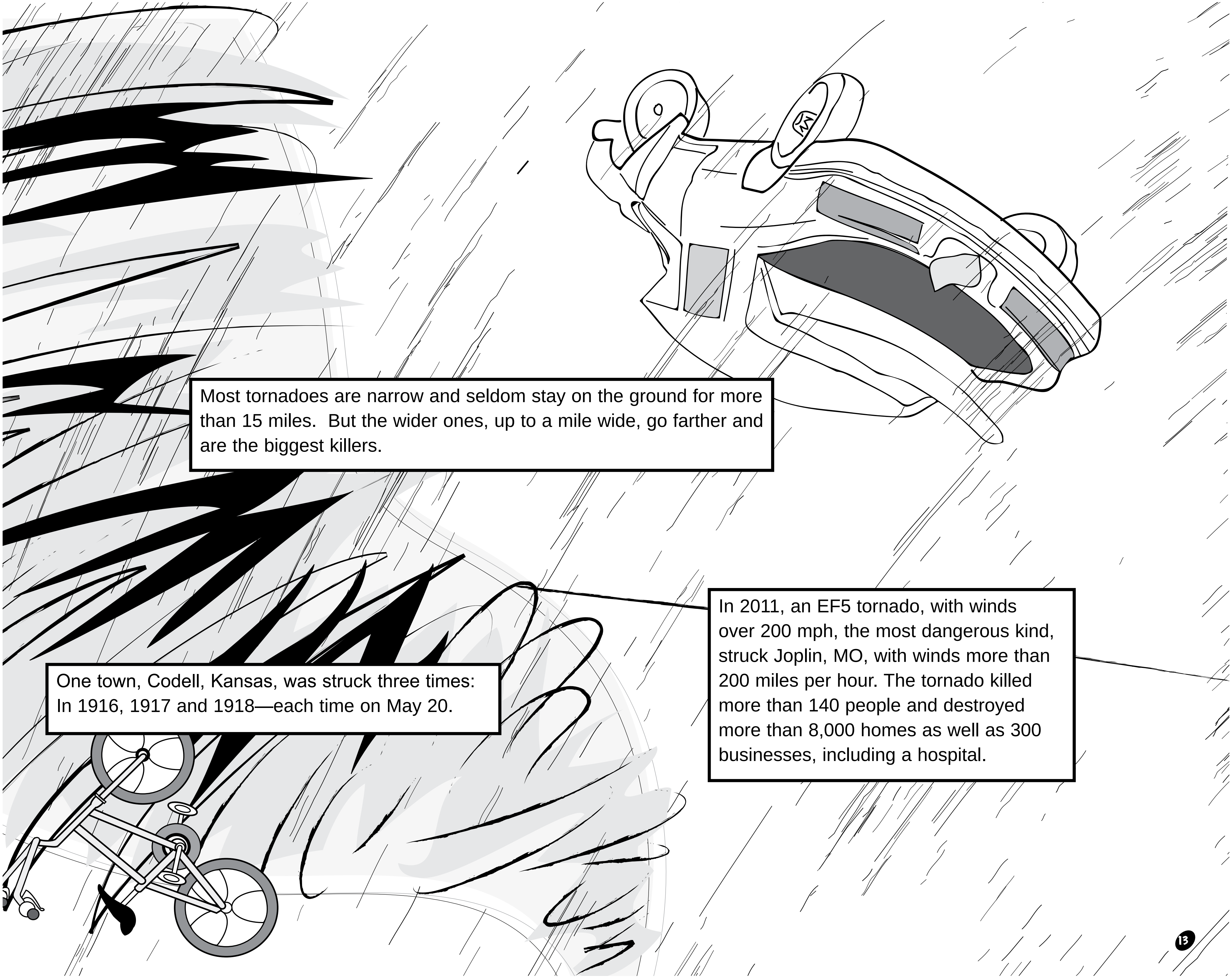


In a Mobile Home or Trailer

Mobile homes and trailers are not safe during tornadoes. If you live in a mobile home or trailer you should plan in advance where the nearest shelter or sturdy structure is located. If a tornado is spotted or a warning issued for your area, GET OUT! Act on your plan to safely evacuate until the danger passes.

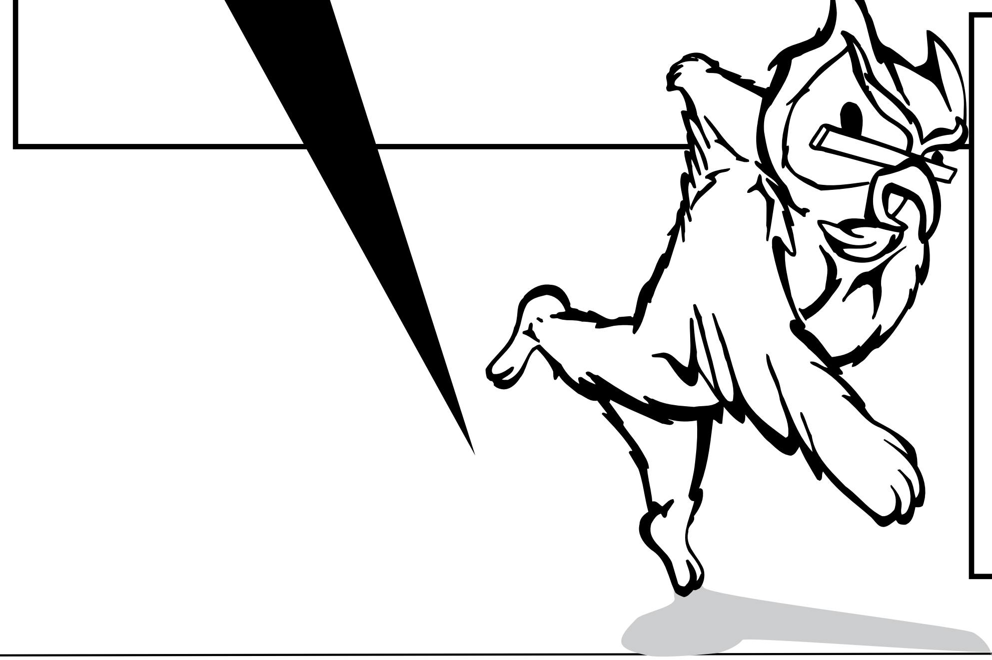
In Mississippi, a mother and her daughter sought shelter in their bathtub. After the tornado hit, the only room left was the bathroom.


In 2002, a huge tornado hit VanWert, Ohio, and completely destroyed a movie theater that was showing “Santa Claus 2.” More than 50 people were in the theater. Fortunately, the movie theater manager got the National Weather Service warning in time and no one was hurt. They were moved from the seating area to a stronger section of the building. The seating area and movie screen were ripped apart!
Most tornadoes happen in April, May and June in the central and southeast United States. But they have occurred in every month and in every state.
Oklahoma City has been struck by tornadoes about 32 times in the past 90 years.



Most tornadoes are narrow and seldom stay on the ground for more than 15 miles. But the wider ones, up to a mile wide, go farther and are the biggest killers.
One town, Codell, Kansas, was struck three times: In 1916, 1917 and 1918—each time on May 20.
In 2011, an EF5 tornado, with winds over 200 mph, the most dangerous kind, struck Joplin, MO, with winds more than 200 miles per hour. The tornado killed more than 140 people and destroyed more than 8,000 homes as well as 300 businesses, including a hospital.

Lightning



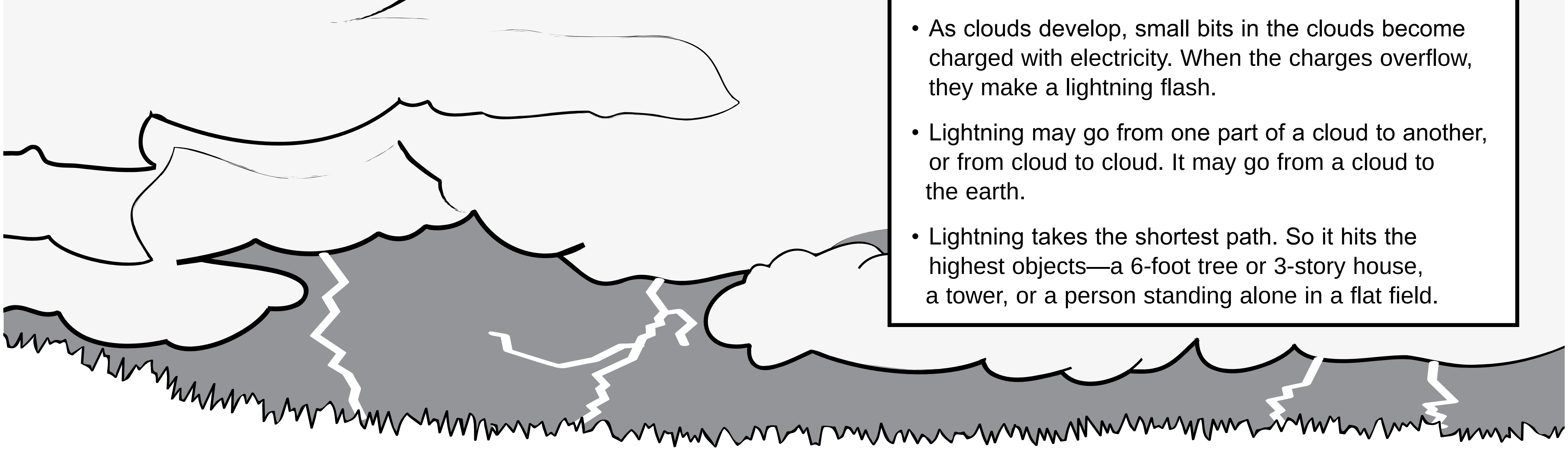
At any moment, there are 2,000 lightning storms around the world.

Almost every day someone is struck by lightning. Most of these people survive—with lifelong health problems—but many are killed. In the United States about 50 people die each year from lightning or from fires caused by lightning.

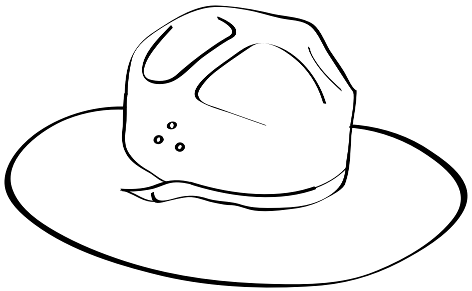
In addition to lightning, thunderstorms also produce strong winds and hail. Some hail may be as big as golf balls or baseballs. Thunderstorms occur all year but are most common in spring and summer.

Before a Storm

- Keep an eye on the sky. On a hot day, clouds build up. They grow larger, towering higher and higher. They darken. The top of the clouds may be spread out by winds at high altitudes.
- As clouds develop, small bits in the clouds become charged with electricity. When the charges overflow, they make a lightning flash.
- Lightning may go from one part of a cloud to another, or from cloud to cloud. It may go from a cloud to the earth.
- Lightning takes the shortest path. So it hits the highest objects—a 6-foot tree or 3-story house, a tower, or a person standing alone in a flat field.

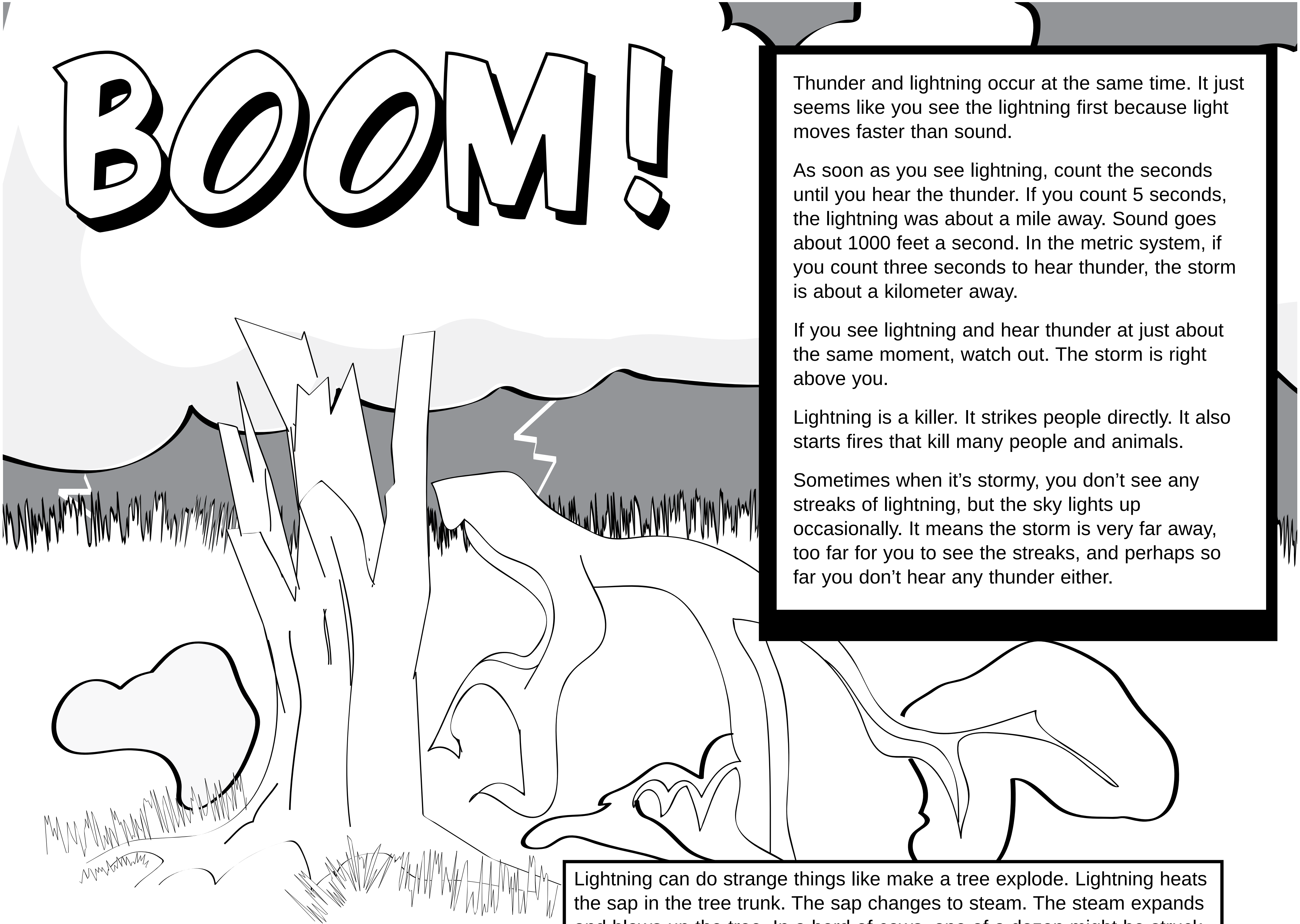


Lightning may hit the same place or person several times.



Ray Sullivan, a retired National Park Ranger, was hit 7 times by lightning. He has been knocked down, picked up and thrown into the air. He has lost his shoes and a toenail, and he can't hear as well, but at least he's still alive.

Now he lives in a mobile home with lightning rods on each end and lightning rods on trees around his home. Hopefully, lightning will follow the rods and leave Ray alone.



Thunder and lightning occur at the same time. It just seems like you see the lightning first because light moves faster than sound.

As soon as you see lightning, count the seconds until you hear the thunder. If you count 5 seconds, the lightning was about a mile away. Sound goes about 1000 feet a second. In the metric system, if you count three seconds to hear thunder, the storm is about a kilometer away.

If you see lightning and hear thunder at just about the same moment, watch out. The storm is right above you.

Lightning is a killer. It strikes people directly. It also starts fires that kill many people and animals.

Sometimes when it's stormy, you don't see any streaks of lightning, but the sky lights up occasionally. It means the storm is very far away, too far for you to see the streaks, and perhaps so far you don't hear any thunder either.

Lightning can do strange things like make a tree explode. Lightning heats the sap in the tree trunk. The sap changes to steam. The steam expands and blows up the tree. In a herd of cows, one of a dozen might be struck. The others may be untouched. Lightning can also kill a whole herd.

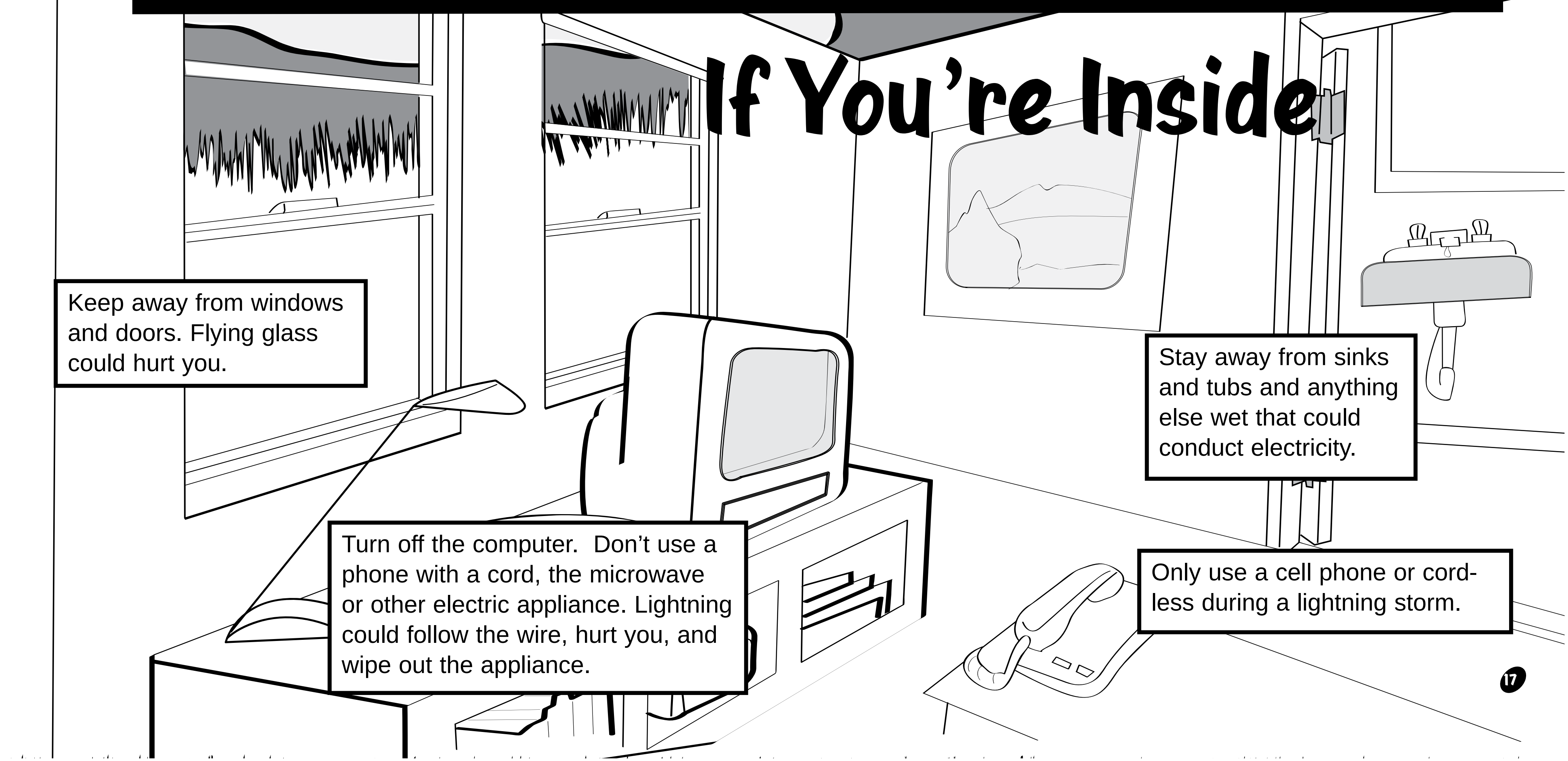
What To Do When You Hear Lightning

- Get into your home or a large building.
- Get inside a hard-topped car.
- If you are in a field, run to a safe building or your car. Don't lie down because wet ground can carry electricity.
- If you are in water, get out. Get away from the beach.

When Thunder Roars, Go Indoors!

- If you can't get to a building or car, stay in the open, not under a tree or in a picnic shelter or shed. It's better to get wet than fried! Lightning hits the tallest object.
- Move away from anything made of metal like a framed backpack. Metal carries electricity to you.
- Get to the lowest point possible if you are on a hill or mountain.
- Get out of a boat and into a building.

If You're Inside



Keep away from windows and doors. Flying glass could hurt you.

Stay away from sinks and tubs and anything else wet that could conduct electricity.

Turn off the computer. Don't use a phone with a cord, the microwave or other electric appliance. Lightning could follow the wire, hurt you, and wipe out the appliance.

Only use a cell phone or cordless during a lightning storm.

Floods and Flash Floods

Flash floods are fast moving water that can sweep you or your car away in seconds.

Floods are too much water on normally dry land. Rivers can flood after heavy rain has fallen over a long period of time. River flooding can last weeks or longer. River floods usually occur slowly enough to allow people to move to safety.

Flooding can occur anytime of the year. Some floods are seasonal, when winter or spring rains combine with melting snows and fill rivers with too much water quickly. Other floods are associated with hurricanes and tropical storms in the summer and fall.

Whenever it rains heavily, there may be flash floods. Flash floods occur in mountain streams, canyons or dry washes. They also happen on low spots in cities and suburbs.

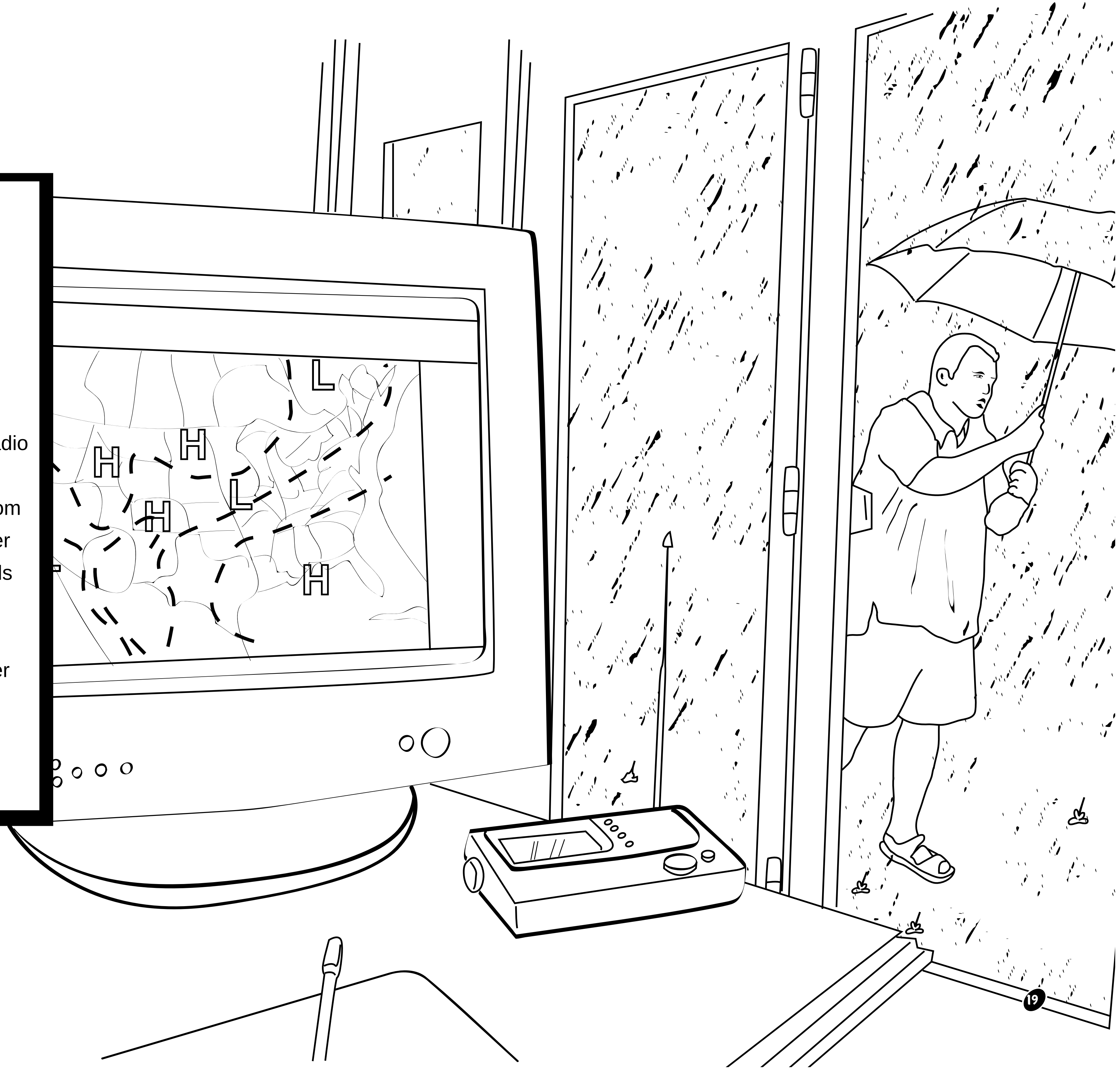
Flash floods can occur even though it's not raining where you are. It may be raining so hard upstream that water cannot sink into the ground. Water rushes down to the stream, which fills up past its banks and overflows.

A flash flood may come at you like a high wall of water. To save yourself and your parents, you need a plan.

Flash Flood Warning

When you hear a Flash Flood Warning on the radio or TV, there is flooding right NOW. Get away from low-lying roads and other low spots NOW. Seconds count.

Two feet of moving water is enough to sweep a car or truck away. **Turn Around Don’t Drown!**



Stay Calm

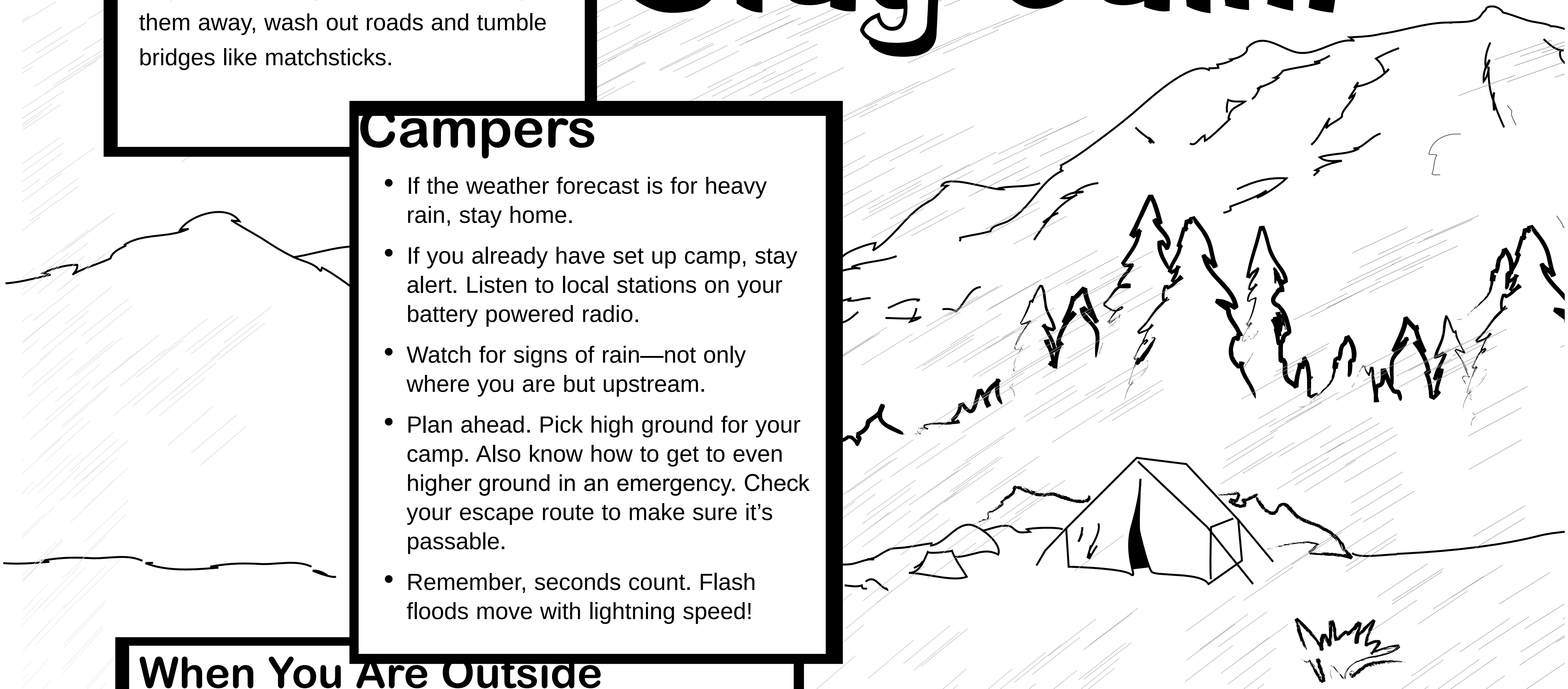
Move to higher ground—leave everything and run. A flash flood can pick up cars, campers, vans and recreational vehicles and roll them downstream. It can tumble huge boulders, uproot trees and carry them away, wash out roads and tumble bridges like matchsticks.

Campers

- If the weather forecast is for heavy rain, stay home.
- If you already have set up camp, stay alert. Listen to local stations on your battery powered radio.
- Watch for signs of rain—not only where you are but upstream.
- Plan ahead. Pick high ground for your camp. Also know how to get to even higher ground in an emergency. Check your escape route to make sure it's passable.
- Remember, seconds count. Flash floods move with lightning speed!

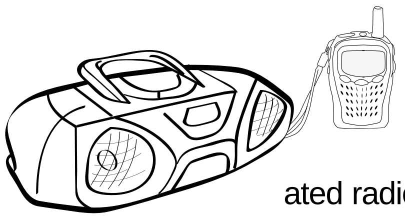
When You Are Outside

- Keep out of storm drains, irrigation ditches, dry washes or other waterways. When it rains, the water can rush through too fast for you to escape.
- There will probably be lots of lightning. Go to higher ground, but stay off hilltops.
- Don't get under lone trees. Follow lightning safety guidelines.



In a Car or Truck

- Watch for flooding on bridges and low points in the road.
- Stay off bridges or roads under water. All of a sudden the bridge or the road could be washed out. They may not even be there under the water.
- If you are in a car, truck or other vehicle and become washed away by water, get out and swim to higher ground if you can.
- If you're riding in a car at night, be specially careful. If you drive into deep water, get out of your car. Climb to higher ground.
- If you're driving through canyon country along a stream and hear a Flash Flood Warning, leave your car and climb to higher ground. Don't try to outrun the flash flood.



In areas with frequent flash floods, keep a battery operated radio with you. Tune to a local station or stay tuned to NOAA Weather Radio. The flood may get worse. Keep away from streams and rivers.

Unit: Weather and Climate - Weather Forecasting

Instructions: Read the following text as an introduction/continuation of the weather unit. Define the vocabulary terms on a separate sheet of paper and answer the questions at the end of the reading on a separate sheet of paper

Lesson Objectives

- List some of the instruments that meteorologists use to collect weather data.
- Describe how these instruments are used to collect weather data from many geographic locations and many altitudes.
- Discuss the role of satellites and computers in modern weather forecasting.
- Describe how meteorologists develop accurate weather forecasts.

Vocabulary

- barometer
- isobars
- isotachs
- isotherms
- radar
- radiosonde
- thermometer
- weather map

Introduction

Weather forecasts are better than they ever have been. According to the World Meteorological Organization (WMO), a 5-day weather forecast today is as reliable as a 2-day forecast was 20 years ago! This is because forecasters now use advanced technologies to gather weather data, along with the world's most powerful computers. Together, the data and computers produce complex models that more accurately represent the conditions of the atmosphere. These models can be programmed to predict how the atmosphere and the weather will change. Despite these advances, weather forecasts are still often incorrect. Weather is extremely difficult to predict because it is a complex and chaotic system.

Collecting Weather Data

To make a weather forecast, the conditions of the atmosphere must be known for that location and for the surrounding area. Temperature, air pressure, and other characteristics of the atmosphere must be measured and the data collected.

Thermometer

Thermometers measure temperature. In an old-style mercury thermometer, mercury is placed in a long, very narrow tube with a bulb. Because mercury is temperature sensitive, it expands when temperatures are high and contracts when they are low. A scale on the outside of the thermometer matches up with the air temperature.

Some modern thermometers use a coiled strip composed of two kinds of metal, each of which conducts heat differently. As the temperature rises and falls, the coil unfolds or curls up tighter. Other modern thermometers measure infrared radiation or electrical resistance. Modern thermometers usually produce digital data that can be fed directly into a computer.

Barometer

Meteorologists use **barometers** to measure air pressure (**Figure** below). A barometer may contain water, air, or mercury, but like thermometers, barometers are now mostly digital.

Barometers use mercury columns to measure air pressure. [Figure1]

A change in barometric pressure indicates that a change in weather is coming. If air pressure rises, a high-pressure cell is on the way and clear skies can be expected. If pressure falls, a low-pressure cell is coming and will likely bring storm clouds. Barometric pressure data over a larger area can be used to identify pressure systems, fronts, and other weather systems.

Weather Stations

Weather stations contain some type of thermometer and barometer. Other instruments measure different characteristics of the atmosphere such as wind speed, wind direction, humidity, and amount of precipitation. These instruments are placed in various locations so that they can check the atmospheric characteristics of that location (**Figure** below).

A land-based weather station. Weather stations are located on land, the surface of the sea, and in orbit all around the world. [Figure2]

According to the WMO, weather information is collected from 15 satellites, 100 stationary buoys, 600 drifting buoys, 3,000 aircraft, 7,300 ships, and some 10,000 land-based stations.

Radiosondes

Radiosondes measure atmospheric characteristics, such as temperature, pressure, and humidity as they move through the air (**Figure** below). Radiosondes in flight can be tracked to obtain wind speed and direction. Radiosondes use a radio to communicate the data they collect to a computer.

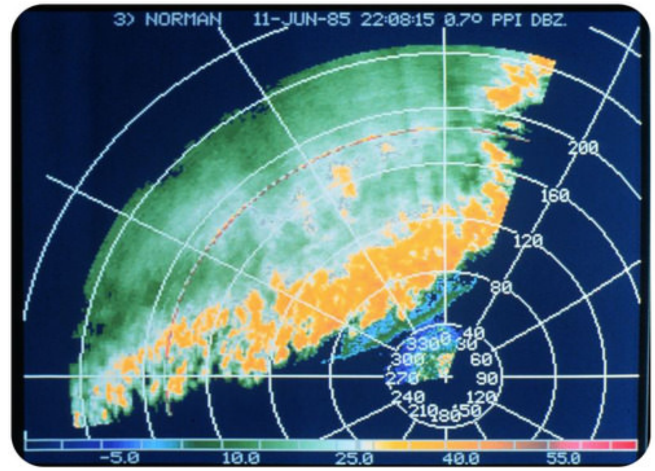
A weather balloon with a radiosonde beneath it. The radiosonde is the bottom piece and the parachute that will bring it to the ground is above it. [Figure3]

Radiosondes are launched from about 800 sites around the globe twice daily to provide a profile of the atmosphere. Radiosondes can be dropped from a balloon or airplane to make measurements as they fall. This is done to monitor storms, for example, since they are dangerous places for airplanes to fly.

Radar

Radar stands for Radio Detection and Ranging (**Figure** below). A transmitter sends out radio waves that bounce off the nearest object and then return to a receiver. Weather radar can sense many characteristics of precipitation: its location, motion, intensity, and the likelihood of future precipitation.

Doppler radar can also track how fast the precipitation falls. Radar can outline the structure of a storm and can be used to estimate its possible effects.

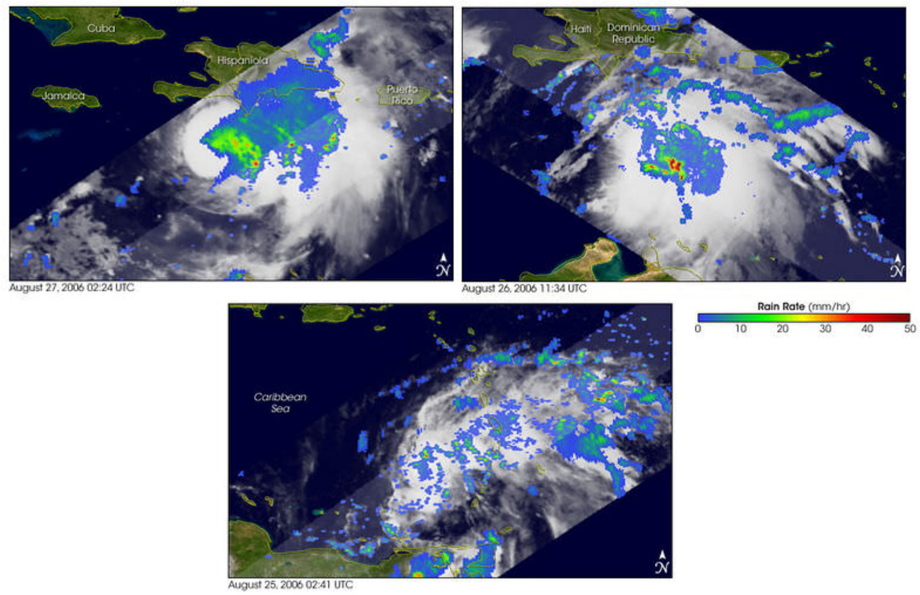


Radar view of a line of thunderstorms. [Figure4]

Satellites

Weather satellites have been increasingly important sources of weather data since the first one was launched in 1952. Weather satellites are the best way to monitor large scale systems, such as storms. Satellites are able to record long-term changes, such as the amount of ice cover over the Arctic Ocean in September each year.

Weather satellites may observe all energy from all wavelengths in the electromagnetic spectrum. Visible light images record storms, clouds, fires, and smog. Infrared images record clouds, water and land temperatures, and features of the ocean, such as ocean currents (**Figure** below).

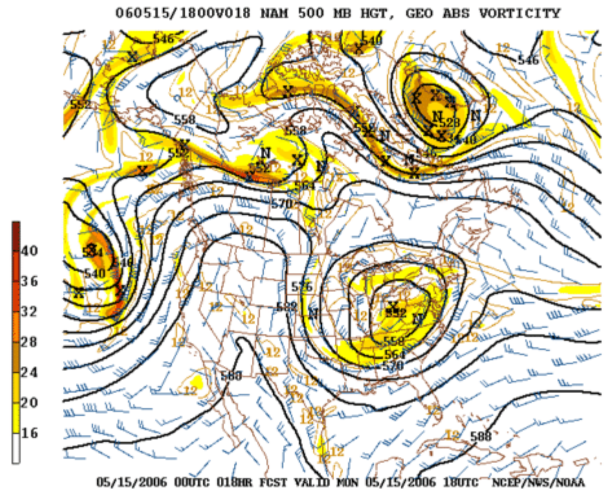


Infrared data superimposed on a satellite image shows rainfall patterns in Hurricane Ernesto in 2006. [Figure5]

Numerical Weather Prediction

The most accurate weather forecasts are made by advanced computers, with analysis and interpretation added by experienced meteorologists. These computers have up-to-date mathematical models that can use much more data and make many more calculations than would ever be possible by scientists working with just maps and calculators. Meteorologists can use these results to give much more accurate weather forecasts and climate predictions.

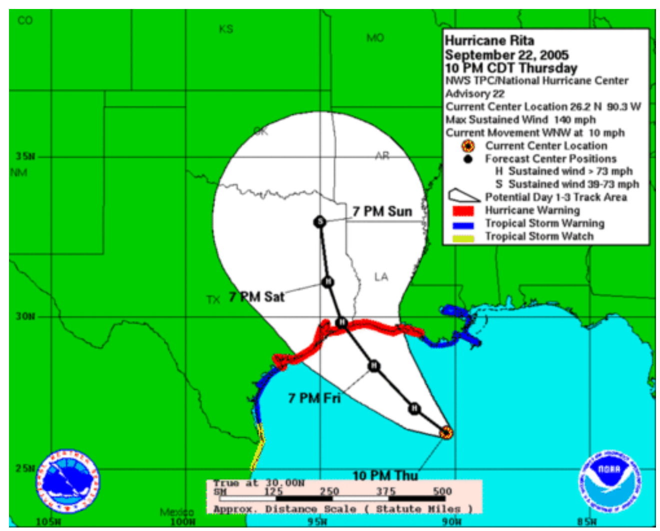
In Numerical Weather Prediction (NWP), atmospheric data from many sources are plugged into supercomputers running complex mathematical models (**Figure** below). The models then calculate what will happen over time at various altitudes for a grid of evenly spaced locations. The grid points are usually between 10 and 200 kilometers apart. Using the results calculated by the model, the program projects weather further into the future. It then uses these results to project the weather still further into the future, as far as the meteorologists want to go. Once a forecast is made, it is broadcast by satellites to more than 1,000 sites around the world.



A weather forecast using numerical weather prediction. [Figure6]

NWP produces the most accurate weather forecasts, but as anyone knows, even the best forecasts are not always right.

Weather prediction is extremely valuable for reducing property damage and even fatalities. If the proposed track of a hurricane can be predicted, people can try to secure their property and then evacuate (**Figure** below).

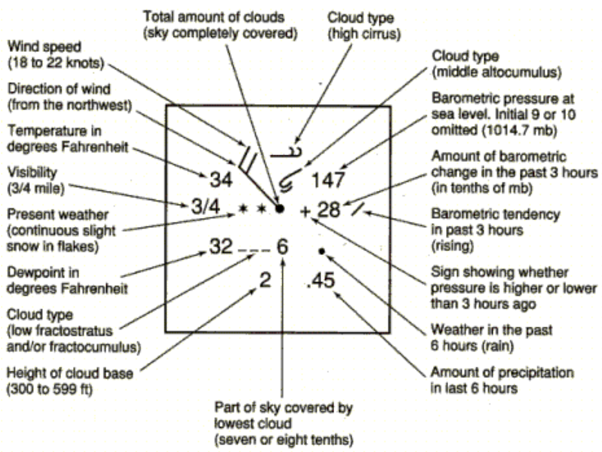


By predicting Hurricane Rita's path, it is likely that lives were saved. [Figure7]

Weather Maps

Weather maps simply and graphically depict meteorological conditions in the atmosphere. Weather maps may display only one feature of the atmosphere or multiple features. They can depict information from computer models or from human observations.

On a weather map, important meteorological conditions are plotted for each weather station. Meteorologists use many different symbols as a quick and easy way to display information on the map (**Figure** below).

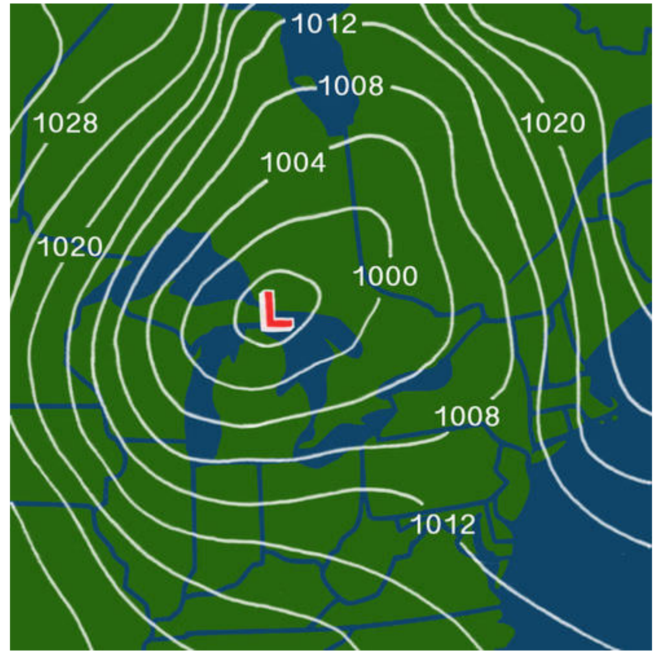


Explanation of some symbols that may appear on a weather map. [Figure8]

Once conditions have been plotted, points of equal value can be connected by isolines. Weather maps can have many types of connecting lines. For example:

- Lines of equal temperature are called **isotherms**. Isotherms show temperature gradients and can indicate the location of a front. In terms of precipitation, what does the 0°C (32°F) isotherm show?

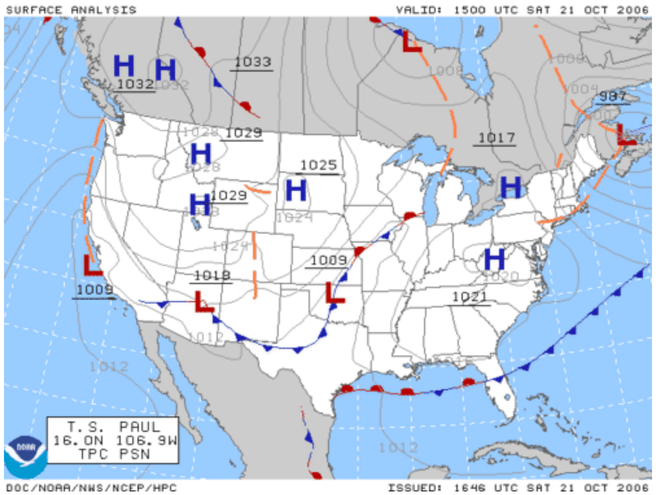
- **Isobars** are lines of equal average air pressure at sea level (**Figure** below). Closed isobars represent the locations of high and low-pressure cells.



Isobars can be used to help visualize high pressure (H) and low pressure (L) cells. [Figure9]

- **Isotachs** are lines of constant wind speed. Where the minimum values occur high in the atmosphere, tropical cyclones may develop. The highest wind speeds can be used to locate the jet stream.

Surface weather analysis maps are weather maps that only show conditions on the ground (**Figure**below).



Surface analysis maps may show sea level mean pressure, temperature, and amount of cloud cover. [Figure10]

Lesson Summary

- Weather forecasts are more accurate than ever before. Older instruments and data collection methods, such as radiosondes and weather balloons, are still used.
- Satellites and computers create much more detailed and accurate forecasts.
- Forecasts are often wrong, particularly those that predict the weather for several days.

Review Questions

1. What types of instruments would you expect to find at a weather station and what do these instruments measure?

2. How does a thermometer work?

3. How could a barometer at a single weather station predict an approaching storm?

4. Why are weather balloons important for weather prediction? What information do they give that isn't obtainable in other ways?

5. How does radar work, and what is its value in weather prediction?

6. Imagine that your teacher asks you to predict what the weather will be like tomorrow. You can go outside or use a telephone, but you can't use a TV or computer. What method will you use?

7. Same as above only now you have access to electronics but not weather forecasts. You can look at weather maps and radar images but not look at interpretations made by a meteorologist. What method will you use?

8. No rain is in the forecast, but it's pouring outside. How could the NWP weather forecast have missed this weather event?

9. What does it mean to say that the weather is a chaotic system? How does this affect the ability to predict the weather?

Lesson 16.4: True or False

Name___________________ Class______________ Date________

Write true if the statement is true or false if the statement is false.

_____ 1. Weather forecasts are more accurate than ever before.

_____ 2. A change in barometric pressure indicates that a change in weather is coming.

_____ 3. Weather stations are located only on land.

_____ 4. Weather radar detects water in the atmosphere when it reflects radio waves.

_____ 5. Weather satellites detect only visible and infrared light.

_____ 6. Numerical weather prediction uses complex mathematical models to forecast weather.

_____ 7. Numerical weather prediction is not as accurate as prediction by experienced meteorologists.

_____ 8. Closed isobars on a weather map represent high and low pressure cells.

_____ 9. Weather map symbols include symbols for cloud type and wind speed.

_____ 10. The first weather satellite was launched in 1992.

Lesson 16.4: Critical Reading

Name___________________ Class______________ Date________

Read this passage based on the text and answer the questions that follow.

Collecting Weather Data

A great deal of weather data must be collected in order to forecast the weather. Examples of devices used to measure specific weather factors include thermometers and barometers. Thermometers measure temperature, and barometers measure air pressure. Measurements of barometric pressure are especially important for weather forecasting. A change in barometric pressure indicates that a change in weather is coming. If air pressure rises, clear weather can be expected. If air pressure falls, storms are likely. Barometric pressure data from a large area can be used to identify pressure systems, fronts, and other weather systems.

Thermometers and barometers are found in weather stations. These are small collections of weather instruments, which may also include devices for measuring wind speed, wind direction, humidity, and precipitation. About 10,000 weather stations are located on land all over the world. In addition, weather stations are located on about 15 satellites, 700 buoys, 3000 aircraft, and 7300 ships. All of these weather stations constantly collect data on the condition of the atmosphere where they are located.

Other devices that measure atmospheric conditions include radiosondes, weather radar, and weather satellites.

- Radiosondes measure atmospheric characteristics such as temperature and air pressure as they travel through the atmosphere after being launched by a balloon or airplane. Radiosondes use radios to communicate the data they collect to a computer.
- Weather radar sends out radio waves that bounce off precipitation in the atmosphere and then return to the radar device. Weather radar can sense many characteristics of precipitation, such as its location, intensity, and movement.
- Weather satellites observe all wavelengths of electromagnetic radiation. They can create visible light images of features such as storms, clouds, fires, and smog. They can create infrared images of characteristics such as water and land temperatures.

Questions

1. Identify two weather instruments and the weather factors they measure.
2. What are weather stations? Where are they located?
3. Explain how radiosondes, weather radar, and weather satellites add to our knowledge of atmospheric conditions.

Lesson 16.4: Multiple Choice

Name____________________ Class_______________ Date_________

Circle the letter of the correct choice.

1. A thermometer may detect changes in temperature with
   a. a coil of metal.
   b. infrared radiation.
   c. electrical resistance.
   d. any of the above

2. Weather instruments that may contain a column of mercury include

    a. barometers.
    b. radar devices.
    c. thermometers.
    d. two of the above

3. Weather maps always show

    a. weather for a particular area.
    b. multiple weather factors.
    c. data from computer models.
    d. two of the above

4. Barometric pressure can be used to

    a. identify pressure systems.
    b. locate fronts.
    c. predict weather.
    d. all of the above

5. All of the weather stations around the world number in the

    a. tens.
    b. hundreds.
    c. thousands.
    d. millions.

6. Tracking the movement of a radiosonde in flight produces data on

    a. air pressure.
    b. air temperature.
    c. wind direction.
    d. precipitation.

7. Weather satellites take infrared images to record

    a. smog.

b. clouds.

c. storms.

d. temperatures.

Lesson 16.4: Matching

Name____________________ Class_______________ Date________

Match each definition with the correct term.

Definitions

_____ 1. device that measures atmospheric conditions as it moves through the air

_____ 2. line connecting places with the same air pressure

_____ 3. device containing a temperature-sensitive indicator such as mercury

_____ 4. line connecting places with the same wind speed

_____ 5. device used to measure air pressure

_____ 6. visual depiction of one or more weather factors for a particular area

_____ 7. radio detection and ranging device

Terms

a. weather map

b. barometer

c. isotach

d. radar

e. thermometer

f. isobar

g. radiosonde

Lesson 16.4: Fill in the Blank

Name____________________ Class______________ Date________

Fill in the blank with the appropriate term.

1. If air pressure __________, stormy weather is on its way.
2. Weather __________ uses radio waves to detect water in the atmosphere.
3. Weather __________ are the best way to monitor large-scale weather systems such as cyclones.
4. Numerical weather prediction is carried out using __________.
5. Lines of equal temperature on a weather map are called __________.
6. A rising barometric reading suggest that __________ weather is coming.
7. A weather __________ may be used to launch a radiosonde into the atmosphere.

Lesson 16.4: Critical Writing

Name____________________ Class______________ Date________

Thoroughly answer the question below. Use appropriate academic vocabulary and clear and complete sentences.

How has the accuracy of weather forecasting changed? What role do you think technology has played in this change?

Packet 1 - Earth Science - Remote Learning

Packet 1 Assessment

At the conclusion of the first packet of work for Earth Science, please complete the following probe. This document can be used with your teacher to talk about the work that you have been doing and to assess your level of understanding while also addressing any misconceptions that arise. Please use the life skill of integrity and attempt this on your own without the assistance of any resource.

Are They Talking About Climate or Weather?

People like to talk about conditions that affect their lives. Climate and weather are two of those conditions. Put a **C** next to all the things people say that have to do with climate. Put a **W** next to all the things people say that have to do with weather.

____ **A.** "What shall I wear today?"

____ **B.** "What equipment do I need for the camping trip next summer?"

____ **C.** "It has rained on my birthday for the past three years."

____ **D.** "We just got three feet of snow in March. So much for global warming!"

____ **E.** "I wonder when I should plant the tomato seeds in my garden?"

____ **F.** "Our state has experienced the worst drought since records began more than 120 years ago."

____ **G.** "News flash! The drought in California has ended with the first significant storm this year dumping more than 10 inches of rain in many locations and filling most of the reservoirs to pre-drought conditions."

____ **H.** "We can't get low-cost flood insurance for our house anymore. The insurance company says this area is too great a risk."

Explain your thinking (in detail). What rule or reasoning did you use to decide if a statement is related to climate or weather?

____

____

____

____

____

____

____

REMOTE PHYSICS: NUCLEAR REACTIONS & RADIOACTIVITY

Name:____________________________ period:_______ teacher:_____________________

READ THIS!

If you have questions: email your teacher or email Dr. Jennifer Miller (milleje3@tulsaschools.org) for help. You may also call 918.925.1118 if you need help and do not have internet access.

Goal: Explain and predict nuclear reactions and the types of radiation/ amount of energy they emit.

BIG QUESTION: Why are nuclear reactions such a powerful source of energy and why are there such great risks associated with nuclear energy?

Standards:

HS-PS1-8 Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay.

Student outcomes:

By the end of this unit you should be able to:

- ❏ Students develop models to identify and describe the relevant components of the models, including:
  - ❏ Identification of an element by the number of protons;
  - ❏ Calculating the number of protons and neutrons in the nucleus before and after the decay;
  - ❏ Identification of the emitted particles (i.e., alpha, beta — both electrons and positrons, and gamma);
  - ❏ The scale of energy changes associated with nuclear processes, relative to the scale of energy changes associated with chemical processes.
- ❏ develop five distinct models to illustrate the relationships between components underlying the nuclear processes of 1) fission, 2) fusion and 3) three distinct types of radioactive decay.
  - ❏ include the following features, based on evidence, in all five models:
    - ❏ The total number of neutrons plus protons is the same both before and after the nuclear process, although the total number of protons and the total number of neutrons may be different before and after.
    - ❏ The scale of energy changes in a nuclear process is much larger (hundreds of thousands or even millions of times larger) than the scale of energy changes in a chemical process.
- ❏ develop a fusion model that illustrates a process in which two nuclei merge to form a single, larger nucleus with a larger number of protons than were in either of the two original nuclei.
- ❏ develop a fission model that illustrates a process in which a nucleus splits into two or more fragments that each have a smaller number of protons than were in the original nucleus.

- ❏ In both the fission and fusion models, students illustrate that these processes may release energy and may require initial energy for the reaction to take place.

- ❏ Students develop radioactive decay models that illustrate the differences in type of energy (e.g., kinetic energy, electromagnetic radiation) and type of particle (e.g., alpha particle, beta particle) released during alpha, beta, and gamma radioactive decay, and any change from one element to another that can occur due to the process.
- ❏ Students develop radioactive decay models that describe that alpha particle emission is a type of fission reaction, and that beta and gamma emission are not.

NUCLEAR REACTIONS & RADIOACTIVITY

Radioactivity was discovered quite by accident. In 1896, Henri Becquerel was studying the effect of certain uranium salts on photographic film plates. He believed that the salts had an effect on the film only when they had been exposed to sunlight. He accidentally found that uranium salts that had not been exposed to sunlight still had an effect on the photographic plates. The Curies, associates of Becquerel at the time, showed that the uranium was emitting a type of ray that interacted with the film. Marie Curie called this radioactivity. Radioactivity is the spontaneous breakdown of an atom's nucleus by the emission of particles and/or radiation. RadiatIon is the emission of energy through space in the form of particles and/or waves.

Nuclear reactions are very different from chemical reactions. In chemical reactions, atoms become more stable by participating in a transfer of electrons or by sharing electrons with other atoms. In nuclear reactions, it is the nucleus of the atom that gains stability by undergoing a change of some kind. Some elements have no stable isotopes, which means that any atom of that element is radioactive. For some other elements, only certain isotopes are radioactive. A radioisotope is an isotope of an element that is unstable and undergoes radioactive decay. The energies that are released in nuclear reactions are many orders of magnitude greater than the energies involved in chemical reactions. Unlike chemical reactions, nuclear reactions are not noticeably affected by changes in environmental conditions, such as temperature or pressure. Major differences between nuclear and chemical reactions include:

1. Nuclear reactions involve a change in an atom's nucleus, usually producing a different element. Chemical reactions, on the other hand, involve only a rearrangement of electrons and do not involve changes in the nuclei.
2. Chemical reactions always conserve mass. Nuclear reactions do not, but only conserve the total number of protons + neutrons.
3. Different isotopes of an element normally behave similarly in chemical reactions. The nuclear chemistry of different isotopes vary greatly from each other.
4. Rates of chemical reactions are influenced by temperature and catalysts. Rates of nuclear reactions are unaffected by such factors.
5. Nuclear reactions are independent of the chemical form of the element.
6. Energy changes accompanying nuclear reactions are much larger. This energy comes from destruction of mass.

The discovery of radioactivity and its effects on the nuclei of elements disproved Dalton's assumption that atoms are indivisible. A nuclide is a term for an atom with a specific number of protons and neutrons in its nucleus. As we will see, when nuclides of one type emit radiation, they are changed into different nuclides.

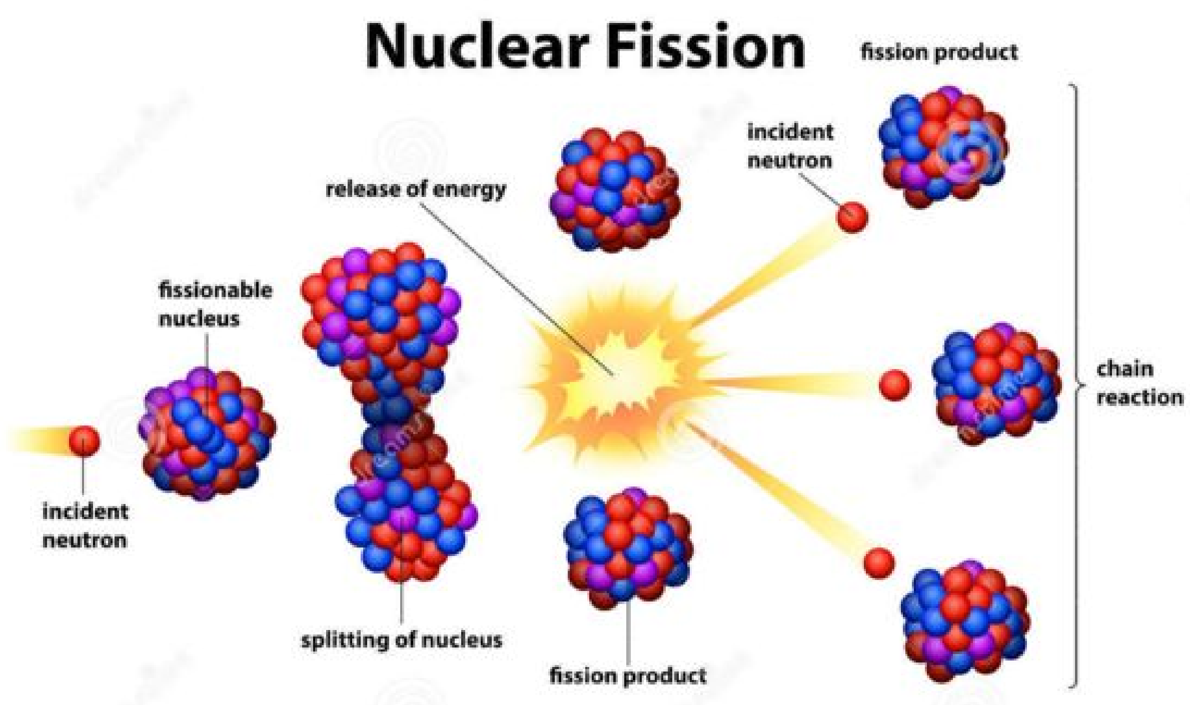
Radioactive decay is spontaneous and does not require an input of energy to occur. The stability of a particular nuclide depends on the composition of its nucleus, including the number of protons, the number of neutrons, and the proton-to-neutron ratio.

If you have internet access: https://www.youtube.com/watch?v=TJgc28csgV0

(Fission Reactions)

Fission reactions occur when the nuclei of an isotope are bombarded with neutrons, causing the isotopes to split into two smaller fragments of the same size.

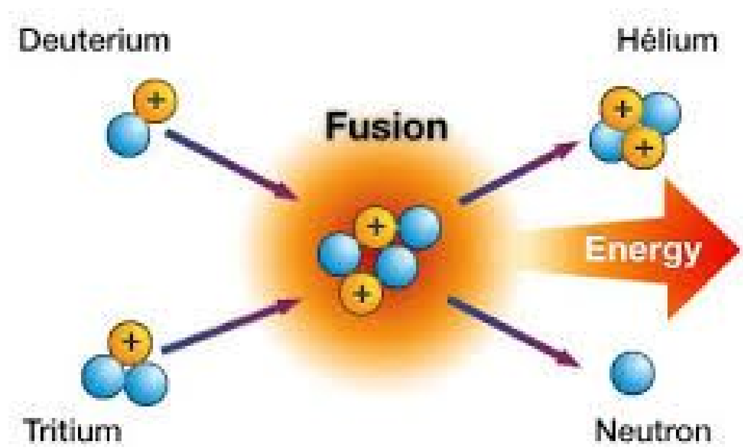
- Release large amounts of energy
- Atomic bombs are uncontrolled fission reactions
- Controlled fission is how we harness nuclear energy
    - Lots of nuclear waste from fuel rods made of “used up” isotopes
    - Highly radioactive
    - Usually Pu-239 or U-235
    - It takes ~20,000 years for used Pu-239 to decay to safe levels



[Fusion Reactions]

Fusion reactions occur when nuclei combine to form a nucleus of a greater mass.

- Release much more energy than Fission
- Process that occurs on the sun, providing energy for the universe.
- Occurs at extremely high temperatures
    - The Hydrogen bomb was an uncontrolled fusion reaction
    - Humans are currently unable to harness fusion energy in a controlled way



Radioactive Decay

Radioactive decay is when an atomic nucleus of an unstable atom loses energy by emitting nuclear radiation.

- ALL atoms with atomic numbers greater than 83 are radioactive due to instability.

IF you have internet access→ https://www.youtube.com/watch?v=FU6y1XIADdg

Note: in a balanced nuclear equation, the sum of the atomic numbers (subscripts) and the sum of the mass numbers (superscripts) must be equal on both sides of the equation. Recall the notation system for isotopes, which shows both the atomic number and mass number along with the chemical symbol.

Alpha decay

- Alpha decay is the loss of an α-particle (which is a helium nucleus)
- Alpha decay typically occurs for very heavy nuclei in which the nuclei are unstable due to large numbers of nucleons. For nuclei that undergo alpha decay, their stability is increased by the subtraction of two protons and two neutrons. For example, polonium-210 decays into lead-206 by the emission of an alpha particle (see equation below).

$$^{210}_{84}\mathrm{Po} \rightarrow {}^{206}_{82}\mathrm{Pb} + {}^{4}_{2}\mathrm{He}$$

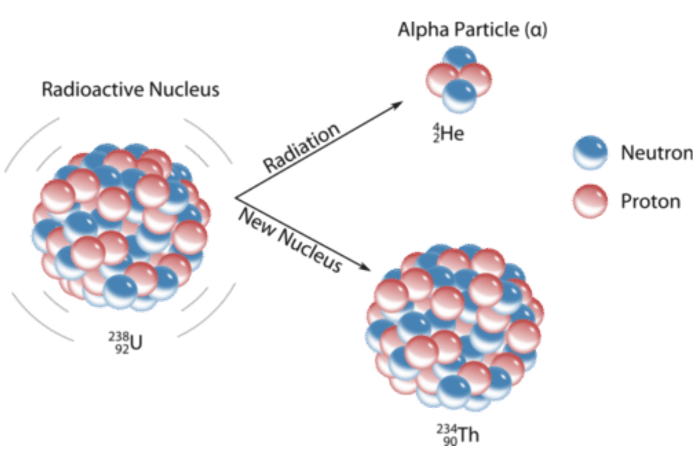


Figure: The unstable uranium-238 nucleus spontaneously decays into a thorium-234 nucleus by emitting an alpha particle

Health Impacts:

- Not harmful unless ingested or inhaled (e.g. cigarettes and Po-210)
- Blocked by skin

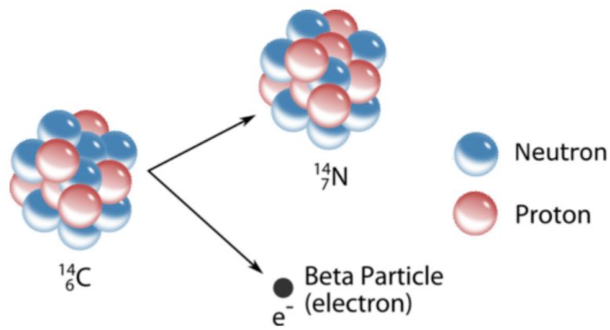
Beta Decay

A beta particle (β) is a high-speed electron emitted from the nucleus of an atom during some kinds of radioactive decay (see figure below).

- The symbol for a beta particle in an equation is either β or ${}^{0}_{-1}e$.
- or Carbon-14 undergoes beta decay, transmutating into a nitrogen-14 nucleus.
- The beta decay of a carbon-14 nuclide involves the conversion of a neutron to a proton and an electron, with the electron being emitted from the nucleus

$$^{14}_{6}\mathrm{C} \rightarrow {}^{14}_{7}\mathrm{N} + {}^{0}_{-1}\mathrm{e}$$

Note that beta decay increases the atomic number by one, but the mass number remains the same.



Health Impacts:

- More penetrating than alpha particles
- Blocked by a few cm plastic/ mm of metal

Positron Emission (aka Beta positive decay)

A positron is a particle with the same mass as an electron, but with a positive charge. Like the beta particle, a positron is immediately ejected from the nucleus upon its formation. The symbol for a positron in an equation is ${}^{0}_{+1}e$. For example, potassium-38 emits a positron, becoming argon-38.

$$^{38}_{19}\mathrm{K} \rightarrow {}^{38}_{18}\mathrm{Ar} + {}^{0}_{1}\mathrm{e}$$

Positron emission decreases the atomic number by one, but the mass number remains the same.

Electron Capture

An alternate way for a nuclide to increase its neutron to proton ratio is by a phenomenon called electron capture. In electron capture, an electron from an inner orbital is captured by the nucleus of the atom and combined with a proton to form a neutron. For example, silver-106 undergoes electron capture to become palladium-106.

$$^{106}_{47}\mathrm{Ag} + \, ^{0}_{-1}\mathrm{e} \rightarrow \, ^{106}_{46}\mathrm{Pd}$$

Note that the overall result of electron capture is identical to positron emission. The atomic number decreases by one while the mass number remains the same.

Gamma Decay

Gamma rays (γ) are very high energy electromagnetic waves emitted from a nucleus. Gamma rays are emitted by a nucleus when nuclear particles undergo transitions between nuclear energy levels. This is analogous to the electromagnetic radiation emitted when excited electrons drop from higher to lower energy levels; the only difference is that nuclear transitions release much more energetic radiation. Gamma ray emission often accompanies the decay of a nuclide by other means.

$$^{230}_{90}\mathrm{Th} \rightarrow \, ^{226}_{88}\mathrm{Ra} + \, ^{4}_{2}\mathrm{He} + \gamma$$

The emission of gamma radiation has no effect on the atomic number or mass number of the products, but it reduces their overall energy.

Health Impacts:

- High penetration levels
- Dampened by heavy metals (mm of lead) or thick dense material (e.g. block of solid concrete)

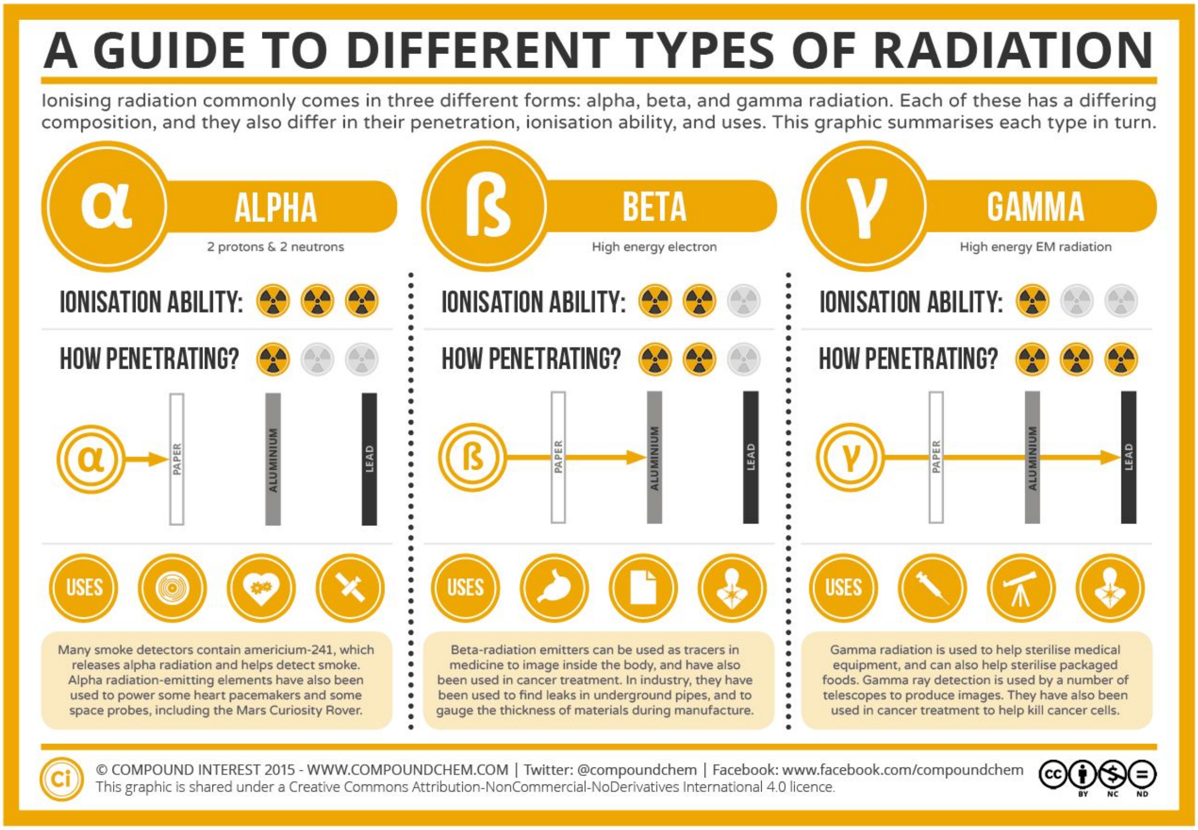


Table 10.1.1 *Summary of types of nuclear radiation.*

Type	Symbol	Mass number	Charge	Penetration Power	Shielding
Alpha particle	${}^{4}_{2}\mathrm{He}$ or α	4	$2+$	Low	Paper, skin
Beta particle	${}^{0}_{-1}\mathrm{e}$ or β	0	$1-$	Moderate	Heavy cloth, plastic
Positron	${}^{0}_{1}\mathrm{e}$ or β^{+}	0	$1+$	Moderate	Heavy cloth, plastic
Gamma ray	γ or ${}^{0}_{0}\gamma$	0	0	High	Lead, concrete
Neutron	${}^{1}_{0}\mathrm{n}$	1	0	High	Water, lead

For questions 1-7 identify each as a fusion or fission. For 8-13 circle the correct choice and correct any false statements.

1. Used in nuclear power plants: fusion or fission

2. Occurs on the sun: fusion or fission

3. More power per gram: fusion or fission

4. A larger nucleus divides to make a smaller nucleus: fusion or fission

5. Two hydrogen atoms fuse to make a helium atom: fusion or fission

6. An atomic bomb: fusion or fission

7. A hydrogen bomb: fusion or fission

8. What characteristic defines an element?
   a. number of protons
   b. number of electrons
   c. number of neutrons
   d. sum of protons and neutrons
   e. atomic weight
9. The disintegration of certain isotopes by the emission of subatomic particles is:
   a. radioactive decay
   b. Fusion
   c. daughter production
   d. Fission
   e. carbon dating
10. Alpha decay involves the:
    a. loss of 2 protons and 2 neutrons
    b. conversion of a neutron to proton
    c. combining of a proton and an electron to form a neutron
    d. loss of a proton and gain of a neutron
    e. capture of a neutron
11. Fission produces heavier elements than the starting ones. True/False

12. Gamma rays are a form of:
    a. neutron radiation
    b. particle radiation
    c. electromagnetic radiation
    d. beta radiation
    e. alpha radiation
13. Alpha radiation is extremely dangerous because it is a highly penetrating form of radiation. True/False

14. For each of the nuclear reactions below, identify them as fission, fusion, or radioactive decay

$^{235}_{92}\mathrm{U} + ^{1}_{0}\mathrm{n} \rightarrow ^{80}_{38}\mathrm{Sr} + ^{153}_{54}\mathrm{Xe} + 3\ ^{1}_{0}\mathrm{n}$	a.
$^{13}_{7}\mathrm{N} \rightarrow ^{13}_{6}\mathrm{C} + ^{0}_{1}\mathrm{e}$	b.
$^{241}_{95}\mathrm{Am} \rightarrow ^{237}_{93}\mathrm{Np} + ^{4}_{2}\mathrm{He}$	c.
$^{2}_{1}\mathrm{H} + ^{2}_{1}\mathrm{H} \rightarrow ^{3}_{2}\mathrm{He} + ^{1}_{0}\mathrm{n}$	d.
$^{14}_{7}\mathrm{N} + ^{4}_{2}\alpha \rightarrow ^{17}_{8}\mathrm{O} + ^{1}_{1}\mathrm{p}$	e. transmutation
$^{14}_{6}\mathrm{C} \rightarrow ^{14}_{7}\mathrm{N} + ^{0}_{-1}\mathrm{e}$	f.
$^{97}_{42}\mathrm{Mo} + ^{2}_{1}\mathrm{H} \rightarrow ^{97}_{43}\mathrm{Tc} + 2\ ^{1}_{0}\mathrm{n}$	g. transmutation
$^{26}_{13}\mathrm{Al} + ^{0}_{-1}\mathrm{e} \rightarrow ^{26}_{12}\mathrm{Mg} + ^{0}_{0}\gamma$	h.
$^{58}_{26}\mathrm{Fe} + 2\ ^{1}_{0}\mathrm{n} \rightarrow ^{60}_{27}\mathrm{Co} + 2\ ^{0}_{-1}\mathrm{e}$	i. transmutation
$^{2}_{1}\mathrm{H} + ^{3}_{1}\mathrm{H} \rightarrow ^{4}_{2}\mathrm{He} + ^{1}_{0}\mathrm{n}$	J.

15. Use 2 of the nuclear reactions in question 14 above to prove that the number of protons and neutrons are conserved in nuclear reactions.

Resources:
https://chem.libretexts.org/Bookshelves/Introductory_Chemistry/Book%3A_Chemistry_for_Allied_Health_(Soult)/11%3A_Nuclear_and_Chemical_Reactions/11.1%3A_Nuclear_Radiation
http://ch302.cm.utexas.edu/worksheets/Identifying%20Nuclear%20Reactions%20-%20KEY.pdf