What Is Lightning?

Related Subject: Climate and Weather
Group Size: 10-15
Length of Activity: 10 minutes

Objective

Demonstrate what simple electricity is and relate how it works as lightning.

Students will understand the following:

- Static electricity is the cause of lightning.
- Lightning forms because of an accumulation of electrical charges inside a cloud due to friction from dust, ice, and water droplets.
- The bottom of a cloud becomes negatively charged and discharges a lightning strike when enough charge has built up.

Overview

Participants will see electricity with a hands-on experiment using a light bulb and a balloon to understand lightning.

Materials and Supplies

For each pair of participants, have the following:

- fluorescent light bulb
- balloon

Activity Description

- Ask the participants to blow up the balloons and tie the ends.
- Have one participant hold the balloon and one participant hold the light bulb
- Turn all of the lights off in the room. (The darker the better!)
- Ask the participant holding the balloon to rub the balloon on her/his hair for several seconds.
- Next, quickly hold the statically charged balloon near the end of the light bulb.

- What happens to the light bulb?
- Repeat the demonstration as many times as desired.

Discussion

- What happened when you rubbed the balloon on your hair? (The balloon builds up an electrical charge or static electricity.)
- What happened when the charged balloon was touched to the end of the fluorescent light bulb? (The electrical charge jumped from the balloon to the bulb.)
- What caused the light bulb to illuminate?
- Compare how each pair youth's experience was the same or different.
- What is an electrical charge?
- What are positive (protons) and negative (electrons) charges?
- How does this experiment relate to weather and clouds?
- Describe how electrical charges are formed in clouds?
- Where are positive charges and negative charges usually located when lightning strikes the ground?
- What are the four ways lightning strikes?
- How long can lightning become?
- Is lightning hot or cold? How hot?
- Name one critical ingredient in the formation of lightning.
- Why do some clouds produce lightning and others do not?
- Discuss Lightning safety: When Thunder Roars, Go Indoors!
- What kind of scientist studies climate? Climatologist

Background:

What is lightning?

Lightning is a bright flash of electricity produced by a thunderstorm. All thunderstorms produce lightning and are very dangerous. If you hear the sound of thunder, then you are in danger from lightning. In the United States, there are an estimated 25 million lightning flashes each year. During the past 30 years, lightning killed an average of 66 people per year. While documented lightning injuries in the United States average about 300 per year, undocumented injuries likely much higher.

What causes lightning?

Lightning is an electric current. Within a thundercloud many small bits of ice (frozen raindrops) bump into each other or collide as they move around in the air. Those collisions create an electric charge.

After a period of time, the whole cloud fills up with electrical charges. The positive charges, or protons, form at the top of the cloud and the negative charges, or electrons, form at the bottom of the cloud. Since opposites attract, that causes a positive charge to build up on the ground beneath the cloud.

The ground's electrical charge concentrates around anything that sticks up, such as mountains, people, or single trees. The charge coming up from these points eventually connects with a charge reaching down from the thundercloud and lightning strikes!

As storms develop, clouds become charged with electricity. Scientists are still not sure exactly what causes this, but they do know that when the voltage becomes high enough for the electricity to leap across the air from one place to another, lightning flashes!

Lightning can strike within a cloud, from one cloud to another, from a cloud to the ground, or from the ground to a cloud.

How Powerful is Lightning?

Each spark of lightning can reach over five miles in length, soar to temperatures of approximately 54,000 degrees Fahrenheit (30,000 Celsius), and contain 100 million electrical volts.

Lightning is a Random, Chaotic and a Dangerous Fact of Nature

At any given moment, there are 1,800 thunderstorms in progress somewhere on the earth. This amounts to 16 million storms each year! Scientists that study lightning have a better understanding today of the process that produces lightning, but there is still more to learn. We know the cloud conditions needed to produce lightning, but cannot forecast the location or time of the next strike of lightning. There are lightning detection systems in the United States and they monitor an average of 25 million flashes of lightning from the cloud to ground every year!

Lightning has been seen in volcanic eruptions, extremely intense forest fires, surface nuclear detonations, heavy snowstorms, and in large hurricanes, however, lightning is most often seen in thunderstorms. A thunderstorm forms in air that has three components: 1) moisture, 2) instability and 3) something such as a cold front to cause the air to rise. Continued rising motions within the storm may build the cloud to a height of 35,000 to 60,000 feet (6 to 10 miles) above sea level. Temperatures higher in the atmosphere are colder; ice forms in the higher parts of the cloud.

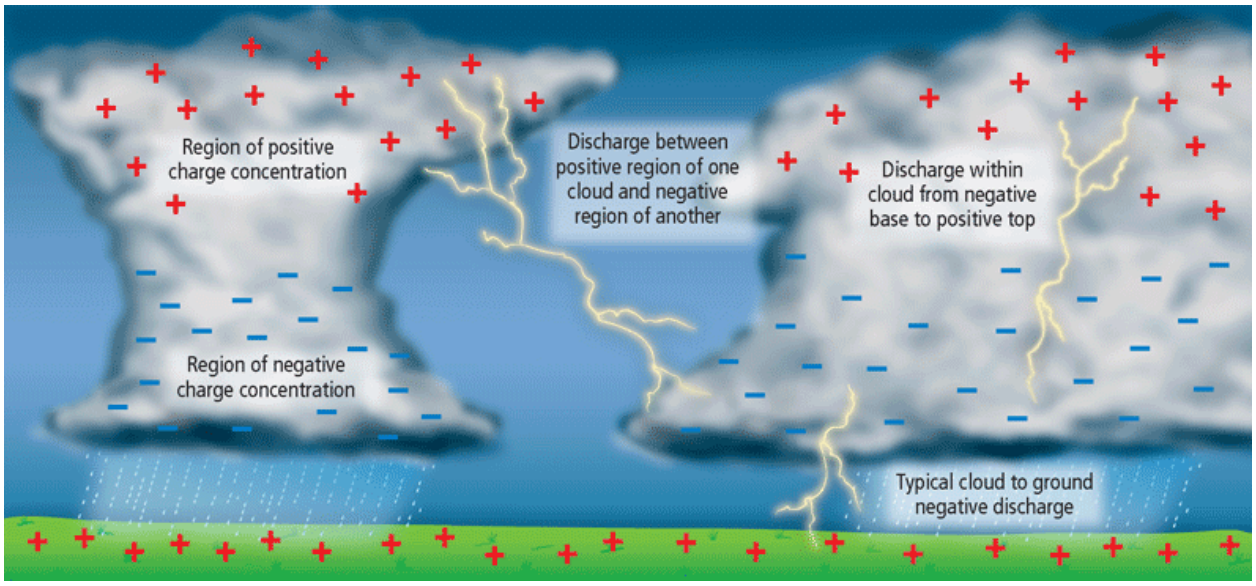
Ice in the Cloud is Critical to the Lightning Process

Ice in a cloud seems to be a key element in the development of lightning. Storms that fail to produce quantities of ice may also fail to produce lightning. In a storm, the ice particles vary in size from small ice crystals to larger hailstones, but in the rising and sinking motions within the storm there are a lot of collisions between the particles. This causes a separation of electrical charges. Positively charged ice crystals rise to the top of the thunderstorm, and negatively charged ice particles and hailstones drop to the middle and lower parts of the storm. Enormous charge differences (electrical differential) develop.

How Lightning Develops Between the Cloud and the Ground

A moving thunderstorm gathers another pool of positively charged particles along the ground that travel with the storm. As the differences in charges continue to increase, positively charged particles rise up taller objects such as trees, houses, and telephone poles. Have you ever been under a storm and had your hair stand up? Yes, the particles also can move up you! This is one of nature's warning signs that says you are in the wrong place, and you may be a lightning target!

The negatively charged area in the storm will send out a charge toward the ground called a stepped leader. It is invisible to the human eye, and moves in steps in less than a second toward the ground. When it gets close to the ground, it is attracted by all these positively charged objects, and a channel develops. You see the electrical transfer in this channel as lightning. There may be several return strokes of electricity within the established channel that you will see as flickering lightning.



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Lightning Safety Tips

IF YOU'RE OUTDOORS: Keep an eye at the sky. Look for darkening skies, flashes of lightning, or increasing winds. Lightning often proceeds rain, so don't wait for the rain to begin. If you hear the sound of thunder, go to a safe place immediately. The best place to go is a sturdy building or a car, but make sure the windows in the car are shut. Avoid sheds, picnic areas, baseball dugouts and bleachers. If there is no shelter around you, stay away from trees. Crouch down in the open area, keeping twice as far away from a tree as far as it is tall. Put your feet together and place your hands over your ears to minimize hearing damage from thunder. If you're with a group of people stay about 15 feet from each other. Stay out of water, because it's a great conductor of electricity. Swimming, wading, snorkeling and scuba diving are not safe. Also, don't stand in puddles and avoid metal. Stay away from clotheslines, fences, and drop your backpacks because they often have metal on them. If you're playing an outdoor activity, wait at least 30 minutes after the last observed lightning strike or thunder.

IF YOU'RE INDOORS: Avoid water. It's a great conductor of electricity, so do not take a shower, wash your hands, wash dishes or do laundry. Do not use a corded telephone. Lightning may strike exterior phone lines. Do not use electric equipment like computers and appliances during a storm. Stay away from windows and doors and stay off porches.

IF SOMEONE IS STRUCK BY LIGHTNING: Call for help. Call 9-1-1 or send for help immediately. The injured person does not carry an electrical charge, so it is okay to touch them.

Sources: http://www.lightningsafety.noaa.gov/overview.htm, www.weatherwizkids.com/lightning3.htm and http://www.srh.weather.gov/jetstream/lightning/lightning_intro.htm
The JASON Project: http://www.jason.org/digital_library/110.aspx

National Science Education Standards:

NSES K-4:

- Science as Inquiry (4ASI)
  - Abilities necessary to do scientific inquiry (4ASI 1)
  - Understandings about scientific inquiry (4ASI 2)
- Physical Science (4BPS)
  - Light, heat, electricity, and magnetism (4BPS 3)
- Earth and Space Science (4DESS)
  - Changes in earth and sky (4DESS 3)

NSES 5-8:

- Science as Inquiry (8ASI)
  - Abilities necessary to do scientific inquiry (8ASI 1)
  - Understandings about scientific inquiry (8ASI 2)
- Physical Science (8BPS)
  - Transfer of energy (8BPS 3)
- Earth and Space Science (8DESS)
  - Structure of the earth system (8DESS 1)
- Science in Personal and Social Perspectives (8FSPSP)
  - Natural hazards (8FSPSP 3)

NSES 9-12:

- Science as Inquiry (12ASI)
  - Abilities necessary to do scientific inquiry (12ASI 1)
  - Understandings about scientific inquiry (12ASI 2)
- Physical Science (12BPS)
  - Motions and forces (12BPS 4)
- Earth and Space Science (12DESS)
  - Energy in the earth system (12DESS 1)
- Science in Personal and Social Perspectives (12FSPSP)
  - Natural and human-induced hazards (12FSPSP 5)