What causes lightning?
Lightning originates around 15,000 to 25,000 feet above sea level when raindrops are carried upward until some of them convert to ice. For reasons that are not widely agreed upon, a cloud-to-ground lightning flash originates in this mixed water and ice region. The charge then moves downward in 50-yard sections called step leaders. It keeps moving toward the ground in these steps and produces a channel along which charge is deposited. Eventually, it encounters something on the ground that is a good connection. The circuit is complete at that time, and the charge is lowered from cloud to ground. The return stroke is a flow of charge (current) which produces a luminosity much brighter than the part that came down. This entire event usually takes less than half a second.

What causes thunder?
Thunder is caused by lightning. The bright light of the lightning flash caused by the return stroke mentioned above represents a great deal of energy. This energy heats the air in the channel to above 50,000 degrees F in only a few millionths of a second! The air that is now heated to such a high temperature had no time to expand, so it is now at a very high pressure. The high pressure air then expands outward into the surrounding air compressing it and causing a disturbance that propagates in all directions away from the stroke. The disturbance is a shock wave for the first 10 yards, after which it becomes an ordinary sound wave, or thunder.
Thunder can seem like it goes on and on because each point along the channel produces a shock wave and sound wave.

How far away from a storm can lightning strike?
It's not clear what the maximum possible distance might be. Lightning has been known to strike more than 10 miles from the storm in an area of clear sky above.

How long can a lightning bolt be?
Recent research from Vaisala-GAI's LDAR and LDAR II lightning detection networks show that lightning can travel 60 miles or more. They find the longest bolts originate in the front of a squall line and travel 62 miles horizontally back into the trailing stratiform region behind the squall line. The longest bolt they have seen to date was 118 miles long in the Dallas-Ft. Worth, TX area. Since 3-D lightning measurements are relatively new, however, scientists are learning more every day and these numbers may change.

Where does lightning usually strike?
Lightning comes from a parent cumulonimbus cloud. These thunderstorm clouds are formed wherever there is enough upward motion, instability in the vertical, and moisture to produce a deep cloud that reaches up to levels somewhat colder than freezing. These conditions are most often met in summer. In general, the US mainland has a decreasing amount of lightning toward the northwest. Over the entire year, the highest frequency of cloud-to-ground lightning is in Florida between Tampa and Orlando. This is due to the presence, on many days during the year, of a large moisture content in the atmosphere at low levels (below 5,000 feet), as well as high surface temperatures that produce strong sea breezes along the Florida coasts. The western mountains of the US also produce strong upward motions and contribute to frequent cloud-to-ground lightning. There are also high frequencies along the Gulf of Mexico coast westward to Texas, the Atlantic coast in the southeast US, and inland from the Gulf. Regions along the Pacific west coast have the least cloud-to-ground lightning.
Flashes that do not strike the surface are called cloud flashes. They may be inside a cloud, travel from one part of a cloud to another, or from cloud to air.

Why isn't there much lightning in the winter?

Lightning occurs less frequently in the winter because there is not as much instability and moisture in the atmosphere as there is in the summer. These two ingredients work together to make convective storms that can produce lightning. Without instability and moisture, strong thunderstorms are unlikely.

Instability

During the winter, the land surface is cooler because there is not as much heating by the sun to warm it up. Without warm surface temperatures, the near-surface air wouldn't rise in the atmosphere very far. Thus, the kinds of deep (8-15 km deep) thunderstorms that develop in the summertime wouldn't develop.

Moisture

Warm air holds more water vapor. And, when water vapor condenses into liquid water cloud drops, latent heat is released which fuels the thunderstorm.

So, warm, moist air near the surface (and the proper conditions aloft to give you lots of instability) can result in deep convection, which may produce lightning discharges. Clouds become electrified when strong updrafts (fueled by the instability and moisture) bring supercooled liquid water drops and ice crystals at temperatures less than freezing (0 deg C) together. In this environment, interactions between the ice crystals and supercooled water droplets produce electric charges. The exact mechanisms by which this charging happens remain unknown. The electrical charges build up until they are strong enough to overcome the resistance of the surrounding air. The breakdown of the electric fields produced by these charges is the lightning bolt.

Thundersnow

Although thunderstorms are less common in the winter, sometimes lightning can occur within snowstorms. Called thundersnow, relatively strong instability and abundant moisture may be found above the surface, such as above a warm front, rather than at the surface where it may be below freezing. Thundersnow is sometimes observed downstream of the Great Salt Lake and the Great Lakes during lake-effect snowstorms, too.

Can lightning be detected?

Since the 1980s, cloud-to-ground lightning flashes have been detected and mapped in real time across the entire US by several networks.

In 1994, the networks were combined into one national network consisting of antennas that detect the angle from ground strike points to an antenna (direction-finder antenna), that detect the time it took for them to arrive at an antenna (time-of-arrival method), or a combination of both detection methods. The network is operated by Global Atmospherics, Inc.

Flashes have also been detected from space during the past few years by an optical sensor. This experimental satellite covers the earth twice a day in tropical regions. The satellite also detects flashes that do not strike the ground, but cannot tell the difference between ground strikes and cloud flashes.

How many flashes are there?

Over the continental 48 states, an average of 20,000,000 cloud-to-ground flashes have been detected every year since the lightning detection network covered all of the continental US in 1989. In addition, about half of all flashes have more than one ground strike point, so at least 30 million points on the ground are struck on the average each year in the US. Besides cloud-to-ground flashes, there are roughly 5 to 10 times as many cloud flashes as there are to ground.

What types of damage can lightning cause?
Cloud-to-ground lightning can kill or injure people by direct or indirect means. The lightning current can branch off to a person from a tree, fence, pole, or other tall object. It is not known if all people are killed who are directly struck by the flash itself. In addition, flashes may conduct their current through the ground to a person after the flash strikes a nearby tree, antenna, or other tall object. The current also may travel through power or telephone lines, or plumbing pipes to a person who is in contact with an electric appliance, telephone, or plumbing fixture.
Similarly, objects can be directly struck and this impact may result in an explosion, burn, or total destruction. Or, the damage may be indirect when the current passes through or near it. Sometimes, current may enter a building and transfer through wires or plumbing and damage everything in its path. Similarly, in urban areas, it may strike a pole or tree and the current then travels to several nearby houses and other structures and enter them through wiring or plumbing.

How to stay safe when lightning is around: use the 30-30 Rule!
The best defense is to plan ahead and avoid exposure to lightning when a thunderstorm occurs. Know where safe shelter is located and leave enough time to reach safe shelter before your danger level is high. Don't be an isolated tall object, and don't be connected to anything that may be an isolated tall object.
NSSL's scientists and collaborators did a study to find out how close is too close. They found that 80% of the next lightning strikes in a storm are within 2 to 3 miles of each other in Florida, but as far as 6 miles from each other in Oklahoma. Use the 'flash-to-bang' method to find the distance to lightning. Safe shelter must be reached by the time a flash is within **30 seconds flash-to-bang**. In most cases, then, when you can hear thunder you are no longer safe.

Lightning safety is also considered at:
- National Lightning Safety Institute
- Kid's Lightning Information
- Lightning Safety from NOAA

But there is often blue sky in some direction while lightning is occurring nearby, and it may not be raining, so pay much more attention to the lightning than the rain. A particularly difficult situation is the first flash from a storm--watch for a storm that is growing quickly, such as when a storm is becoming very dark at its base or is growing very tall. An equally dangerous situation is when a storm appears to be finished, and only light rain and/or occasional thunder are heard, but the cloud overhead continues to be fairly dark. The most common situation for a lightning death or injury in Florida was found NOT to be in the heaviest rain area with lots of flashes, but after or before the time when rain and lightning was the most intense. So, the weak storm without too many flashes, at the edge of a larger storm, or early or late in the life of a storm is most dangerous.
The best shelter is a substantial building that has plumbing and wiring--in other words, one that is used or lived in by people for a major portion of the day. A very unsafe building for lightning has only a roof and some supports, but no wiring or pipes extending into the ground. A vehicle with a metal roof provides good shelter, and is much better than being in the open or in an ungrounded building, but is not as good as being in a building that is grounded by wires and pipes.
Call to Action!

Bill Roeder recently shared these levels of safety with the National Weather Association (http://www.nwas.org):

The most important statement for everyone to understand, memorize and to act on is:
NO PLACE OUTSIDE IS SAFE from lightning NEAR THUNDERSTORMS!
Level-1: Plan your activities around the weather to avoid the lightning strike hazard. If you are going to be outside, know the weather forecast beforehand. Know the local weather patterns.
Level-2: While outside, use the "**30-30 Rule**" to know when to seek a safer location. When you see lightning, count the time until you hear thunder. If this time **is 30 seconds or less**, go to a safer place. If you can't see the lightning, just hearing the thunder is a good back up rule to use to take cover.
Wait 30 minutes or more after hearing the last thunder before leaving the safer location. The "30-30 Rule" will not work well for "first-strike" lightning from locally developing thunderstorms. Watch for brewing convection and seek shelter before the first lightning is produced.
Level-3: Go to a safer location when required. Don't hesitate; go to a safer place immediately! The safest place commonly available is a large fully enclosed substantially constructed building, e.g. a typical house. Once inside, stay away from any electrical conducting path from the outside, e.g., corded telephones, electrical appliances, and plumbing. If you can't get to a substantial building, a vehicle with a solid metal roof and metal sides is a reasonable second choice. Avoid contact with conducting paths going outside. Convertibles and open-framed vehicles do not count as lightning shelters.
Level-4: If you can't get to a safer location, avoid the most dangerous locations and activities. Avoid higher elevations, wide-open areas, tall isolated objects, water-related activities, and open vehicles. Avoid unprotected open structures like picnic pavilions, rain shelters, and bus stops. **DO NOT GO UNDER TREES TO KEEP DRY DURING THUNDERSTORMS!**
Level-5: **USE THIS ONLY AS A DESPERATE LAST RESORT!** If you are outside and far away from a safer place, proceed to the safest location. If lightning is imminent, it will often give a few seconds of warning: hair standing up, tingling skin, light metal objects vibrating, seeing corona discharge, and/or hearing a crackling or "kee-kee" sound. If you are in a group, spread out so there are several body lengths between each person. Once spread out, use the lightning crouch - put your feet together, squat down, tuck your head, and cover your ears.
When the immediate threat of lightning has passed, continue heading to the safest place possible. Remember, this is a desperate last resort; you are much safer following the previous guidance and avoiding this high-risk situation.
Level-6: The first step in lightning first aid is to call 911. All deaths from lightning are from cardiac arrest or stopped breathing at the time of the strike. CPR or mouth-to-mouth-resuscitation is the recommended first aid.
No lightning safety guidelines will give 100% guaranteed total safety, but these steps will help you avoid the vast majority of lightning casualties.
Lightning is THE underrated weather hazard. Fortunately, the vast majority of these casualties can be easily avoided.