LIGHTNING

KNOW THE FACTS

Inside.....

-can electricity from lightning be harnessed
-common myths about Lightning
-the lightning Rod, how it works
-Teach yourself Cardiopulmonary Resuscitation (CPR)

ACLENet
Lightning and Electromagnetics Network

African Centers for Lightning and Electromagnetics Network– www.aclenet.org

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EDITOR'S NOTE

Lightning is a phenomenon as old, or even older than man kind. For very many centuries, lightning was largely a mystery, and different cultural, ethnic and religious groups explained it in different ways. For example, the early Greeks thought that the king of the gods, Zeus, threw thunderbolts down from stormy skies. The Vikings imagined Thor, their god of weather, striking a powerful hammer against an anvil to produce thunder and lightning, while Native American tribes believed the flashing feathers and flapping wings of the mighty Thunderbird caused lightning. In Africa, the traditional Kikuyu believed that *"Ngai"* (God) punished those who failed to keep their oath sworn in his name, by striking them with lightning. In the traditional African Bantu tribes, such as the Baganda and Banyoro of Uganda, lightning was a sign of the ire of the gods. The Baganda specifically attributed the lightning phenomenon to the god Kiwanuka, one of the main trio in the Lubaale gods of the sea or lake. Kiwanuka started wild fires, struck trees and other high buildings, and a number of shrines were established in the hills, mountains and plains to stay in his favor. Lightning was also believed to be invoked upon one's enemies by uttering certain chants, prayers, and making sacrifices.

In Islam, the Quran states: "He it is Who shows you the lightning, a fear and a hope, and raises the heavy clouds. The thunder hymns His praise and (so do) the angels for awe of Him. He launches the thunder-bolts and smites with them whom He will." (Qur'an 13:12–13) and, "Have you not seen how God makes the clouds move gently, then joins them together, then makes them into a stack, and then you see the rain come out of it..." (Quran, 24:43). The preceding verse, after mentioning clouds and rain, speaks about hail and lightning, "...And He sends down hail from mountains (clouds) in the sky, and He strikes with it whomever He wills, and turns it from whomever He wills."

Artistic impression of the Greek god Zeus
Source: www.groths.org

In the Bible, several verses mention lightning, some suggesting it as weapon used by God. Psalms 18:14 reads, "He sent out his arrows, and scattered them; Yes, great lightning bolts, and routed them." And according to Exodus 9:23, "Moses stretched forth his rod toward the heavens, and Yahweh sent thunder, hail, and lightning flashed down to the earth. Yahweh rained hail on the land of Egypt,"

WHAT DOES SCIENCE SAY?

It was not until the 1700's when the first scientific breakthrough in regards to lightning was got. An experiment proposed by American Scientist Benjamin Franklin, and carried out under the supervision of Frenchman, Thomas-Francois Dalibard, proved that lightning was actually electricity. Since that time, many different experiments on lightning have been conducted to show that lightning really is electricity, and to explain how it is formed in the clouds.

Despite disagreements on the nature and source of Lightning, one thing is undisputed anywhere in the world; its devastating effects. December 8, 1963, Pan Am Flight 214, a Boeing 707-121 registered as N709PA, which was in a holding pattern near Elkton, Maryland, crashed after being struck by lightning, killing all 81 on board. On 28th October 1998, lightning struck dead 11 members of a football team on the pitch in Congo, and in an almost similar incident that same weekend, a football match in Johannesburg between Moroka Swallows and Jomo Cosmos was abandoned after lightning struck; fortunately, though half of the players from both teams dropped to the turf, no one was killed.

Here in Uganda, lightning has destroyed human lives, livestock, crops and property on countless occasions, but most notably on the 28th of June 2011, lightning struck Runyanya Primary School in Kiryandongo district, instantly killing 18 pupils, and injuring more than 50 others. And again, on 6th March 2013, it was all grief at Kyabagoma Muslim Primary School at Mwalo village, in Bukomansimbi district, when lightning struck dead two teachers. According to Refugees and Disaster Preparedness minister, Musa Ecweru, a total of 205 primary school children had been killed by lightning as of 22nd march 2013.

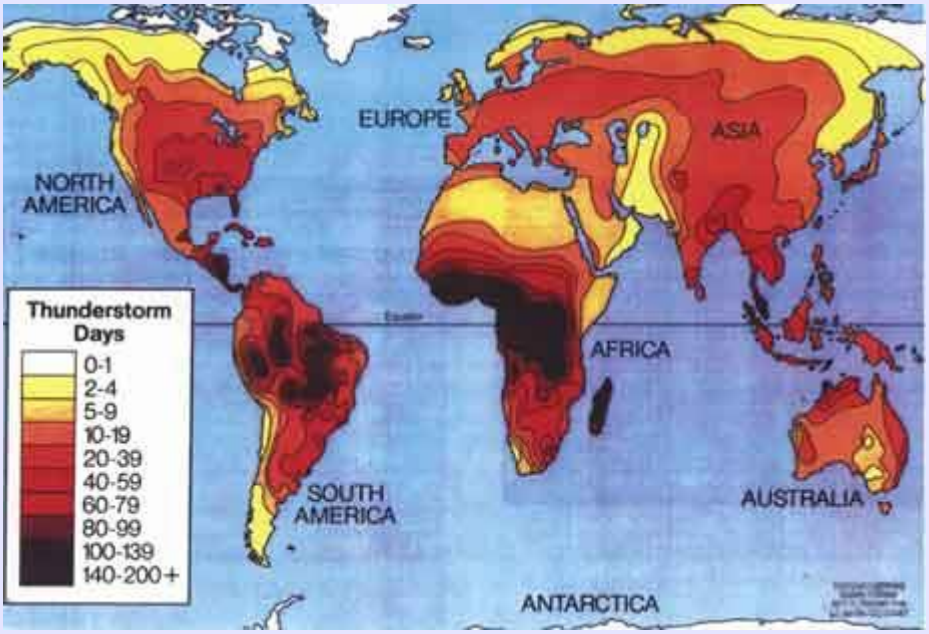
Bodies of the dead pupils of Runyanya Primary School

Source: http://www.demotix.com

INCREASED LIGHTNING FREQUENCY?

Much as some may argue that the frequency of lightning strikes has increased in recent years, it is instead the reporting of lightning related incidences that has increased. This is owed to the increasing access to advanced communication technology, to the effect that what happens in one area can get know in the rest of the world now in a matter of minutes.

Uganda has one of the highest rates of lightning strike deaths in the world and the capital Kampala has more days of lightning per year than any other city, according to the World Meteorological Organization. This is supported by data from the USA's National Lightning Safety Institute (NLSI) as shown below:

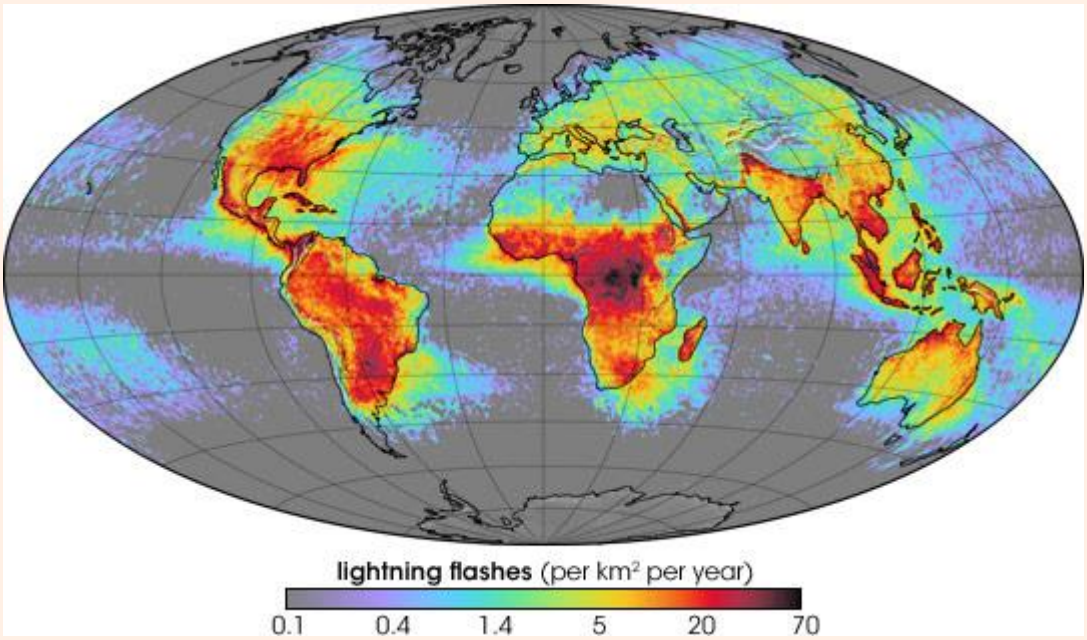


Average World Thunderstorm Days per Year

Source: http://www.lightningsafety.com

WHY UGANDA?

Of course there will be several arguments to try and explain this, which could be political, economic, or even spiritual. But the answer to that is mostly geographic. The region located between the tropics gets more lightning activity than the regions outside. Therefore, geographically, Uganda being in the tropics, is the epicenter of lightning activity.



Lightning flashes per square kilometer per year for 1995-2002 observed by NASA satellites. Uganda is in the region with the highest number.

Source: http://www.earthzine.org

Since we now know that we are in the hottest part of the flame, there's need to improve on both our national and personal alertness. During the African Regional Training Program on Lightning Protection, held at Commonwealth Resort Hotel in Munyonyo, Kampala, from 4th– 8th February 2013, the Vice president of Earth Networks, Mr. Jeremy Usher introduced to the participants a possible National Lightning real time detection and warning system, which we should hope gets adopted by our meteorology department.

This journal aims at giving you an insight into how lightning is formed, how it strikes, and how to increase our chances of survival and reduce deaths resulting from lightning related incidences. I hope you find it helpful, and that you'll help disseminate this information to as many people as you can.

I would like to say a big thank you to the experts, Prof Rakov, Dr. Estelle, Dr. MaryAnn, and Dr. Chandima Gomes, who took time off their busy schedules to contribute to this journal.

Nice reading

EDMUND ATAREMWA

WHAT EVERYONE NEEDS TO KNOW ABOUT LIGHTNING

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Lightning is a gigantic electric spark in the atmosphere. Most lightning that people see takes place between a cloud and the ground. But lightning more often occurs within a cloud, between a cloud and the air, and between two clouds. The latter three types of lightning may damage aircraft in flight, but they usually do not cause harm on the ground. It is lightning striking the earth that can kill people and cause fire. Lightning occurs on the Earth about 100 times each second. Lightning heats the air explosively, creating the pressure wave that we hear as thunder.

A lightning flash from a cloud to the ground consists of one or more strokes. A stroke appears as a single brightening of a channel (path) between the cloud and the ground. Typical cloud-to-ground flashes are 5 to 7 kilometers long. Flashes in clouds may travel horizontally up to 10 kilometers or more. Roughly half of all lightning discharges to earth strike ground at more than one point with the spatial separation between the channel terminations being up to many kilometers.

Until the mid-1700's, lightning was a great mystery of nature. The ancient Greeks and Romans thought lightning was a weapon of the gods. Some African peoples believed individuals and places hit by lightning were cursed. For several centuries people in Europe and America naively thought that they could keep lightning away by ringing church bells, which caused the deaths of many of those pulling the ropes. Systematic studies of thunderstorm electricity can be traced back to May 10, 1752 in the village of Marly-la-Ville, near Paris, France. On that day, in the presence of a nearby storm, a retired French dragoon, acting on instructions from French scientist Thomas-Francois Dalibard, drew sparks from a tall iron rod that was insulated from ground by wine bottles.

The results of this experiment, proposed by Benjamin Franklin, provided the first direct proof that thunderclouds contain electricity. The Marly experiment was repeated thereafter in several countries including Italy, Germany, Russia, Holland, England, Sweden, and again France. Franklin himself drew sparks from the probably moist hemp string of a kite after the success at Marly, but before he knew about it. In addition to kites, balloons, mortars, and rockets were used to extend conducting strings into the electric field of the cloud. In all these experiments, the metallic rod (such as in the experiment at Marly) or the conducting string was polarized by the electric field of the cloud, so that charges of opposite polarities accumulated at the opposite ends of the conductor. As the gap between the bottom end of the conductor and ground was decreased, a spark discharge to ground occurred. The scale and effect of this spark discharge are orders of magnitude smaller than those of lightning. In designing his experiments, Franklin did not consider the possibility of a direct lightning strike to the rod or the kite. Such a strike would almost certainly have killed the experimenter. Thus all those who performed these experiments risked their lives.

Benjamin Franklin
Source: www.biography.com

Types of lightning

The most common source of lightning is the type of cloud known as a *cumulonimbus* or a *thundercloud.* Lightning can be classified in two ways: (1) by its origin and initial direction of propagation and (2) by the appearance of the flash.

Origin and direction of propagation. The most common type of lightning is *intracloud lightning,* which occurs within a cloud. Intracloud lightning neutralizes positive and negative charges that have built up in a thundercloud. Charges that flow from the cloud to the air create *cloud-to-air lightning.* A flow of charges between two clouds—a relatively rare event—produces *cloud-to-cloud lightning.*

Intra-cloud Lightning
Source:www. Australiasevereweather.com

Lightning between a cloud and the earth may be of either downward or upward type, depending on the direction in which the charges first flow. Downward lightning originates in the cloud, while upward lightning is initiated from tall objects on the ground. About 90% of cloud-to-ground lightning transport negative charge to ground, and 10% transfer positive charge. Occasionally, both positive and negative charges are consecutively transferred to ground by the same flash.

Appearance. People have given names to various visual aspects of lightning: forked lightning; streak lightning; ribbon lightning; bead lightning, also called chain lightning; heat lightning; sheet lightning; and ball lightning. Forked lightning is a flash that has several visible branches. Streak lightning appears to illuminate a single jagged line. Ribbon lightning appears as parallel streaks of light. It occurs when wind separates the individual strokes of a flash. Bead or chain lightning is a flash that breaks up into a dotted line as it ends.

Forked Lightning
Source: http://cacarc.wordpress.com

Heat lightning, often seen on summer nights, seems to occur without thunder. Actually, it is lightning that occurs so far away from an observer that its accompanying thunder cannot be heard. Generally, the distance from the observer is beyond about 25 kilometers or so. But the people underneath heat lightning experience a normal thunderstorm. Sheet lightning appears as an illumination of part of the sky. The flashes that produce sheet lightning are either so far away that their characteristic shape cannot be seen, or the flashes are hidden by clouds.

Ribbon Lightning
Source: www.students.cis.uab.ed

Ball lightning usually occurs after a cloud-to-ground flash. It appears as a glowing, fiery ball that floats for several seconds before disappearing.

How lightning develops

Charges in a cloud. The development of all types of lightning requires a cloud becoming electrically charged. Most researchers believe that charging occurs when various forms of water and ice within the cloud collide with one another.

Tiny pieces of ice that are rising in updrafts within the cloud collide with heavier soft hail that is falling. Interactions between these particles in the presence of small water droplets facilitate mass and charge transfer between the particles. At relatively low temperatures (relatively high altitudes) the small ice crystals become positively charged and the heavier soft hail negatively charged. Separation of oppositely charged particles by distances of the order of kilometers is accomplished by action of updrafts and gravity.

The top of the cloud becomes positively charged, and the bottom becomes negatively charged. In addition, a small positively charged region can be created below the negative region.

Lightning processes. Each negative downward flash typically contains 3 to 5 component strokes or just strokes, the observed range being 1 to 26. Time intervals between these strokes are typically of the order of tens of milliseconds and they explain why lightning often appears to the human eye to “flicker”. Each lightning stroke is composed of a downward-moving process, termed a leader, and an upward-moving process, termed a return stroke. The leader creates a conducting path between the cloud charge source and ground and distributes negative charge from the cloud source along this path, and the return stroke traverses that path moving from ground toward the cloud charge source and neutralizes the negative leader charge. Thus, both leader and return stroke processes serve to effectively transport negative charge from the cloud to ground.

Lightning strikes the Burj Dubai Tower
Source: http://www.guy-sports.com

The first-stroke leader appears optically to be an intermittent process, hence the term stepped leader, while the tip of a subsequent-stroke leader appears to move continuously. The continuously moving subsequent-stroke leader tip appears on time-resolved photographs as a downward-moving "dart", hence the term dart leader. The apparent difference between the two types of leaders is related to the fact that the stepped leader develops in virgin air, while the dart leader follows the "preconditioned" path of the preceding stroke or strokes. Both types of leaders produce bursts of x-ray emission with energies up to about 250 keV (twice the energy of a chest x-ray). The electric potential difference between a downward-moving stepped-leader tip and ground is probably some tens of millions of volts.

Triggered Lightning at the University of Florida's, International Centre for Lightning research and Testing

Source: http://www.lightning.ece.ufl.edu/

When the descending stepped leader attaches to the ground, the first return stroke begins. The first return-stroke current measured at ground is a pulse with a peak of about 30 kiloamperes (thousands of amperes). The return stroke effectively lowers to ground the charge originally deposited on the stepped-leader channel including all the branches, as well as any additional cloud charge that may enter the return-stroke channel.

The high-current return-stroke wave rapidly heats the channel to a peak temperature near or above 30,000 K and creates a channel pressure of 10 atm or more, resulting in channel expansion, intense optical radiation, and an outward propagating shock wave that eventually becomes the thunder (sound wave) we hear at a distance.

In the second stroke, once the bottom of the dart leader channel is connected to the ground, the second (or any subsequent) return-stroke wave is launched upward, which again serves to neutralize the leader charge. The subsequent return-stroke current at ground typically has a peak of 10 to 15 kiloamperes.

Each cloud-to-ground lightning flash involves energy of the order of 102 joules, which is approximately equal to the energy required to operate five 100-watt light bulbs continuously for one month.

Note that not all the lightning energy is delivered to the strike point, only 0.1 to 1% of the total energy.

Triggered lightning:

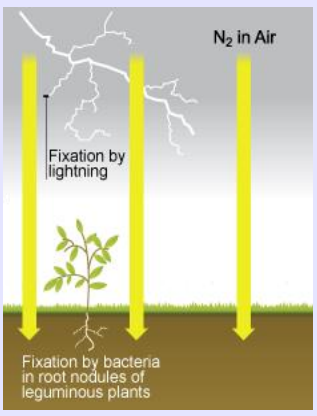
Lightning can be artificially initiated (triggered) launching a small rocket trailing a thin grounded wire toward a charged cloud overhead. To date, approximately 1,000 lightning flashes were triggered worldwide using this technique. The results of triggered-lightning experiments have provided considerable insight into natural lightning processes that would not have been possible from studies of natural lightning due to its random occurrence in space and time. Triggered lightning is a very useful tool to study the interaction of lightning with various objects and systems.

Extraterrestrial lightning:

Lightning occurrence is not limited to the Earth's atmosphere. There exists convincing evidence for lightning or lightning-like discharges on Jupiter and Saturn. Currents in Jovian lightning are expected to be 10 to 100 times larger than in Earth lightning.

ANY POSITIVES FROM LIGHTNING?

After a thunderstorm passes and it's safe to venture outside, take a deep breath. The air will smell very fresh and clean, with perhaps an earthy perfume caused by the release of oils from pine trees and other plants. Both rain and lightning help to clear the atmosphere of dust, pollens, and pollutants. A spark of lightning does this by combining those particles; the heavier mass is more apt to fall to the ground.



Lightning combines Nitrogen with Oxygen to give vital plant nutrients

Source: www.bbc.co.uk

Heat and pressure from lightning also turns nitrogen and other gases in the air into useful compounds such as nitrogen oxides (NO and NO2) and nitric acid (HNO3). These compounds act as a natural fertilizer to help plants make vital proteins.

MECHANISMS OF LIGHTNING INJURY

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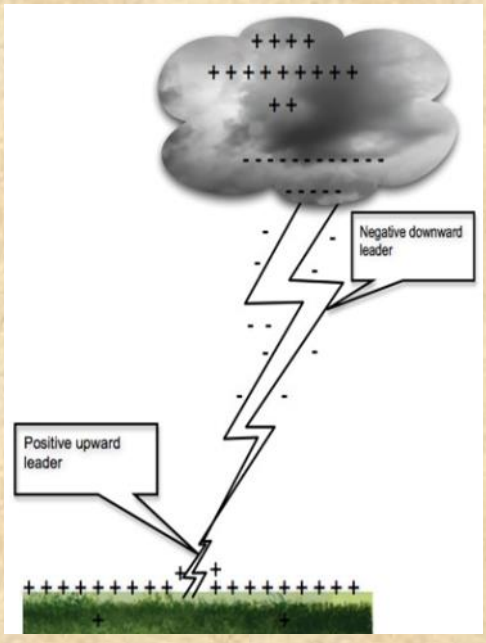
In Africa, lightning is a force of nature that causes harm to people, animals and property. Rural people who work outdoors tending the land or herding animals are particularly vulnerable to lightning strikes. Many of rural houses are structurally too unsound to protect inhabitants adequately against lightning

Basic Physics of Lightning:

The very basic physics of lightning can be described as follows:

-A thundercloud forms when positively charged icy bits are separated from negatively charged water droplets within a cloud;



-The cloud's negative charge attracts positive charges on earth;

-They attract each other and streams of charge start moving towards each other, the positive upward leader moving upwards from the earth and the negative downward leader moving down from the cloud;

-When the upward and downward leaders meet, an electric current rushes from the cloud to the earth and we see a lightning flash.

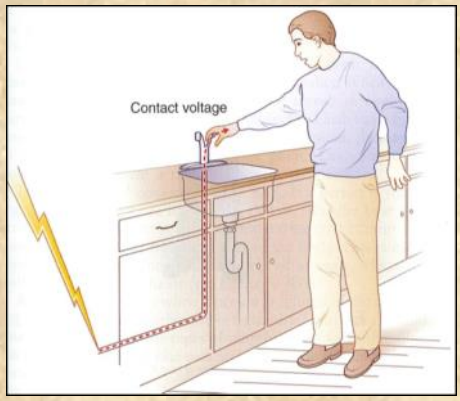
There are currently five generally accepted mechanisms of lightning death and injury, namely a direct strike, a touch voltage, a side flash, a step potential and upward streamers.

DIRECT STRIKE:

Death or injury due to a direct strike, occurs when a lightning stroke connects directly with a person. Due to the potential difference between the point where lightning strikes the person and his/her feet, current flows through the body into the earth. Although one might imagine that this would be the greatest cause, it only accounts for 3 – 5% of lightning injuries (Cooper, 2010).

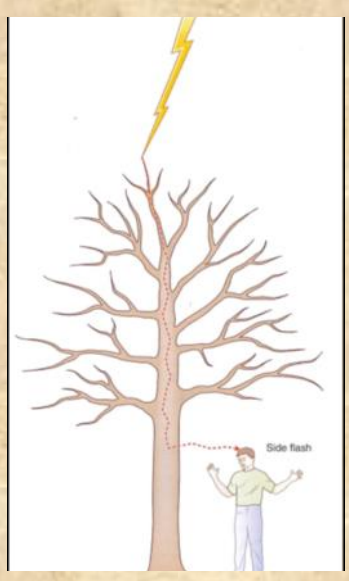
TOUCH VOLTAGE:

A touch or contact voltage, occurs when a person is touching an object when it is struck by lightning, also called a touch potential or contact potential. If lightning strikes something like a telephone wire or an electrical conductor, a person can be injured even if the lightning strikes quite far away but s(he) is touching something connected to the point of strike, for example a landline telephone or an electrical appliance.



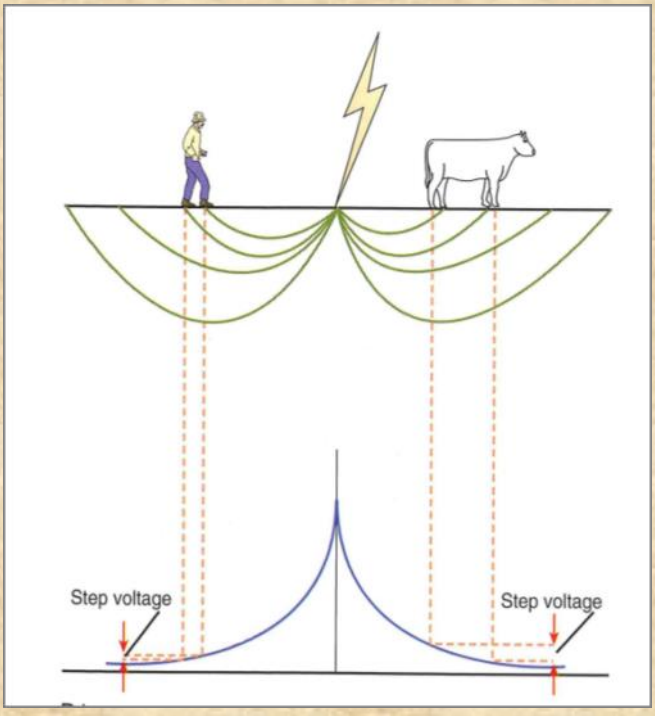
SIDE FLASH:

A side flash can harm somebody standing close to an object that is struck by lightning. Part of the lightning flash will keep traveling down to the ground along that object, but part of it jumps to the nearby person and travels to ground through the person.



STEP POTENTIAL:

When lightning strikes an object, for example a tree, the lightning current goes into the earth. As the current spreads out through the earth, from a higher to a lower concentration of negative charge, it could happen that a person has one foot is standing in an



area of higher charge than the other foot.
If the person's body constitutes a path with lower resistance than the ground, the lightning will travel through that body. This also happens to animals, for example cattle and sheep – with lightning current traveling through their bodies between their forelegs and hind legs.

UPWARD LEADER:

During thunderstorm conditions, upward leaders start to form from points on the ground, attracted by the opposing charge of the cloud. A lightning flash occurs when the downward leader and the upward leader connect and form a channel for the lightning discharge. An upward leader could form from a person's body, typically from the top of the head of somebody standing upright. Even if the upward and downward leaders never connect to complete a full lightning strike, the upward leader can be so strong that a person could still be hurt. That is what happened during a football match in 1998 between Moroka Swallows and Jomo Cosmos in Johannesburg (Anderson, 2002) - lightning struck nearby and several players were injured by upward leaders

USABLE ELECTRICITY FROM LIGHTNING??

One may wonder if the enormous amount of energy in lightning flashes can be harnessed for domestic or industrial use. Well, according to **Prof. V. A. Rakov**, it is impractical to utilize such energy. Here's why:

Each cloud-to-ground lightning flash involves an energy of the order of 10^9 J. This is approximately equal to the energy required to operate five 100-W light bulbs continuously for one month:
5 x 100 W x 3600 s x 24 x 30 = 1.3 x 10^9 J or about 360 kilowatt-hours (1 kWhr = 3.6 x 10^6 J), probably comparable to the monthly energy consumption of an average household. Even if it were possible to capture all flash's energy (the bulk of this energy is not delivered to the strike point since it is lost to heating the air and producing thunder, light, and radio waves), one would need to attract 12 flashes to the energy storage facility in order to operate these five light bulbs for one year. The probability of lightning strike to a given point on ground is very low. For example, a 1 m^2 area in Florida is struck by lightning, on average, once in 10^5 years. A grounded structure protruding above earth's surface is more likely to be struck by lightning. A 60-m tower located in Florida is expected to be struck by lightning once every other year. Thus, one needs 24 such towers covering a large area of 1 km^2 or so to operate five 100-W light bulbs, which appears rather impractical. Most of the U.S. experiences a factor of 2 to 3 lower lightning activity than in Florida. As a result, the number of lightning capturing towers needed to operate only five 100-W bulbs in areas of moderate lightning activity would be 48 to 72. Thus the two main problems with the utilization of lightning energy can be formulated as follows:
1) The power associated with a lightning flash is very high, but it is released in pulses of short duration (of the order of 10^{-4}-10^{-5} s). As a result, lightning energy, the integral of high power over a short period of time, is rather moderate, comparable to the monthly energy consumption by a typical household (the integral of relatively low power over a long period of time). This energy is equivalent to that released in the burning of 20 to 30 kg of oil.
(2) The capturing of lightning strikes would require the use of a large number of tall towers, which is rather impractical.
Additionally, as noted above, not all the lightning energy is delivered to the strike point.

MYTH...or FACT??

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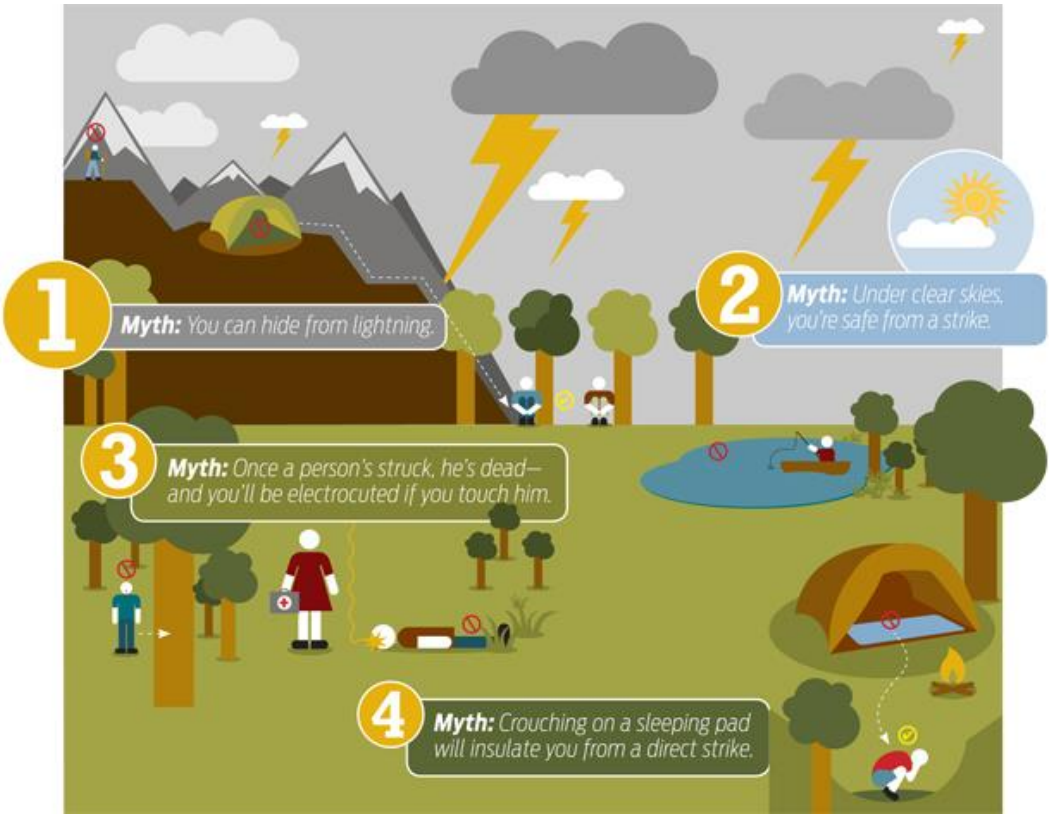
Chandima Gomes, Associate Professor (Electrical Engineering), Head, centre for Electromagnetic and Lightning Protection Research , University Putra Malaysia, Malaysia



In extreme circumstances it may travel 80-100 km from a thundercloud. At least 10% of lightning hits when there is no rain or overhead cloud to blame!

Myth: If I am outside in a thunderstorm, it is OK to go under a tree to stay dry.

Truth: Being underneath trees is one of the most dangerous places to be because lightning likes to hit tall things.

FACT: Any time you hear thunder, you are in danger. Thunder can only be heard for about 15 km. By the time it is this close, you are in danger and should be thinking about where to go for safety.

Myth: Metal attracts lightning (or wearing jewelry, watches, or glasses attracts lightning.)

Truth: Lightning is more likely to hit things that are tall or isolated but the presence of metal makes virtually no difference on where lightning strikes. Mountains are made of stone and dirt but can be hit many times each year. Nothing 'attracts' lightning and it makes little sense to think that the huge power of lightning would search for a tiny piece of metal on someone's body. However, because metal can transmit lightning energy if it is hit, it is better to stay away from touching metal things in a thunderstorm. If they are hit, long metal things like wire fences and water pipes can conduct lightning electricity over a long distance (as much as 1-200 meters!) and injure or kill a person.

FACT: No place outside is safe when thunderstorms are in the area. This includes under trees, in open sided small buildings (like classrooms or shops.

Myth: If it is not raining or if I don't see a thundercloud overhead, I'm safe from lightning.

Truth: Most of the time you will see a thunderstorm coming but there are many times when lightning seems to come from a clear sky. This is because it can shoot out from the front, back, of sides of a cloud that is 15-20 km away from the person.

Myth: Cell phones attract lightning.

Truth: There is no evidence that the small amount of metal in a phone or iPod or the electromagnetic waves used for the communication distracts lightning from its path to intercept a cell phone. As we all know, talking on cell phones can be dangerous for other reasons such as distracting the user from paying attention to the truck that is about to run over them as well as ignoring an approaching storm and the warning thunder!

Myth: Wearing gold jewelry will prevent being struck by lightning.

Truth: Wearing gold doesn't affect whether a person will be injured by lightning or not. Neither does having a tyre on the roof of a building!

Myth: There are devices that can prevent lightning from striking an object

Truth: Just as there are no commercial products that can stop a hurricane, a monsoon, a tsunami or other natural disaster, there are no products that can prevent lightning from striking what it wants to. Although there are people who are happy to sell products that they claim will prevent, repel, or deflect lightning, none of these devices withstand scientific testing and none

are recognized by any standard in the world.
Most people are surprised to learn that lightning rods do not prevent a lightning strike. If properly installed as part of a lightning protection system (three essential parts: rod, 'down conductor', and grounding system), it takes the lightning that was going to hit the building and transmit it harmlessly around the building and down to a grounding system.

Myth: As soon as the rains stops falling, it is safe to continue what I was doing before the storm.

Truth: See above – lightning can come out of a thundercloud from any direction, including the back end of it after you think it has passed. It is not safe to start doing activities until at least 20-30 minutes from the last time you see lightning or hear thunder.

Myth: If I am in a building, I am safe from lightning.

Truth: Usually, the safest places to be are inside a substantial building or inside an all metal car with the windows closed. If the building is large enough to have plumbing and wiring inside the walls, it is usually much safer than staying outdoors in a thunderstorm. However, if the building has open sides, a thatch or ungrounded metal roof, or simple strings of lights instead of wires inside the walls, it is not safe. Dry thatch can even catch fire and fall onto people who are sleeping inside. .

Myth: Lightning doesn't affect person who is totally inside water

Truth: Lightning energy can travel through water and kill or temporarily paralyze anything in it. If the lightning energy doesn't kill the person directly, they may drown because of the paralysis.

Myth: Throwing a metal object out prevents lightning striking the house

Truth: There is no scientific reasoning for such act. Metal does not attract lightning

Myth: Mango trees are safe from lightning. Lightning prefers to strike palm and coconut trees.

Truth: Lightning favors hitting anything that is tall, including any kind of tree. It only appears that lightning prefers coconut or palm trees because they are much more likely to be killed by lightning. Lightning is more likely to run through the highly conductive living core of coconut and palm trees, killing them, but along the bark of mango trees leaving less signs of harm and less chance of being killed.

Myth: (cone of protection) Lightning won't strike within a cone of 45° of a tall isolated object, (fig 1) since it will attract lightning that close.

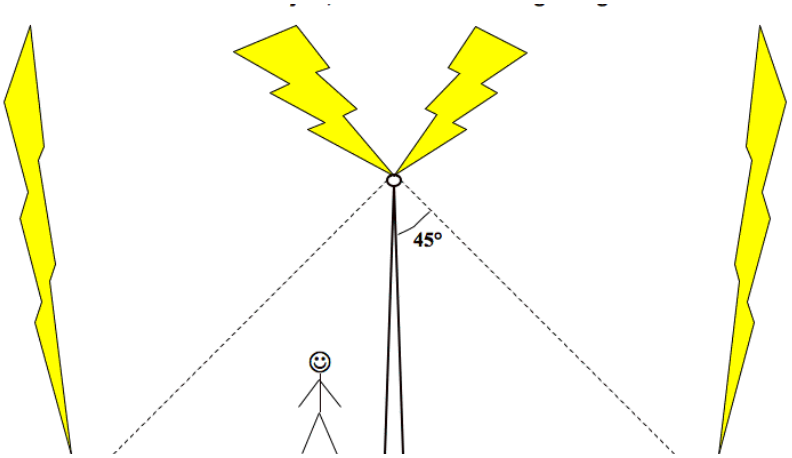


Fig 1- "cone of protection from Lightning"

Truth: Lightning will easily strike inside the so-called "cone of protection (fig 2)

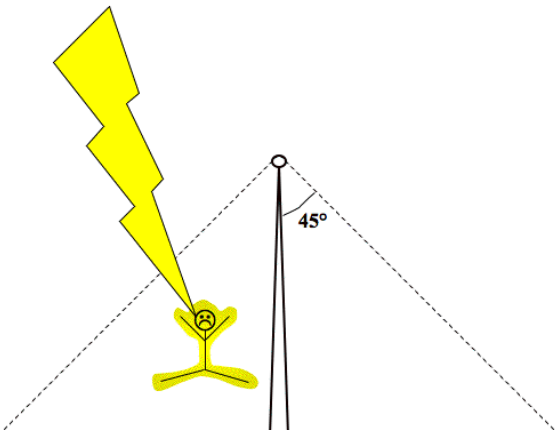


Fig 2– Lightning may not strike the tall object

Even if lightning strikes the object, you are still in danger as it dissipates along the ground or side flash. (fig 3)

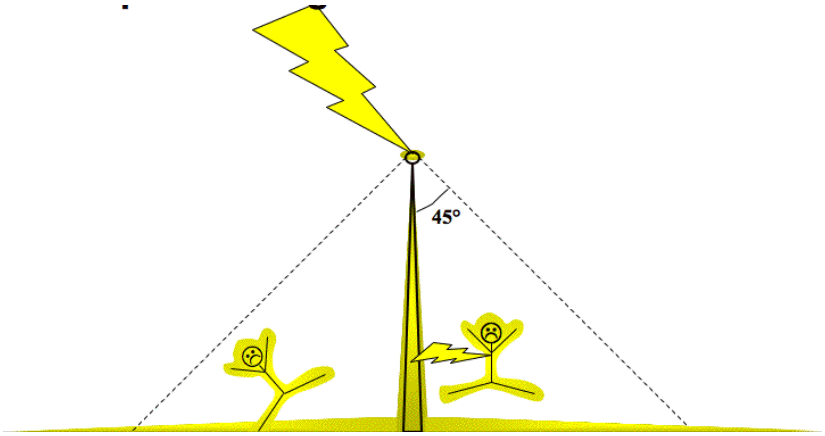


Fig 3– ground current or side flash will harm you in the "cone of protection"

Illustrations from: http://www.lightningsafety.com

HOW LIGHTNING KILLS AND INJURES

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We have all seen lightning, but hopefully few of us have seen what it does to the human body. Many people are surprised to learn that as many as 90% of people survive lightning injury. Unfortunately, many of those who survive will have permanent disabling problems afterwards. There are many ways someone can be injured by lightning. It is often difficult to tell which mechanism occurred.

Lightning can injure a person both directly and indirectly. An indirect injury could be when a tree that was hit by lightning falls on a person, when a thatched roof catches fire and falls on the people inside, or when a small building collapses on a family or a classroom of children.

It is important to remember that if a thunderstorm is still going on that everyone in the area is still in danger and could be injured. The injured person needs to be moved to a safer place for everyone, if one is available. Safer places include fully enclosed metal vehicles and substantial buildings (those with indoor plumbing and wiring in the walls).
Being close to a lightning strike can be like being close to an explosion. Ear drums can rupture or be burned and the person may show other signs of explosive injury. Some will have injury to their eyes with cataracts, damage to the retina or other parts of the eye. Involuntary contraction of the person's muscles, caused by the electricity, can cause them to be thrown several yards. Of course, when they land, they can have injuries to their head, back, spine, muscles, or internal organs from the fall.

There are all degrees of injury, from a simple little shock all the way to cardiac arrest where the heart stops beating. Table 1 shows some of the more serious injuries. If the person has a cardiac arrest, of course, bystanders need to call police numbers **112, 0800199099** or **0800199799** (Uganda Police toll free) for help, but in the mean time, they should start **cardiopulmonary resuscitation (CPR)** or use an Automatic External Defibrillator (AED) if one is available. This can make the difference in life and death.

Immediate	Short term or temporary	Long term or permanent
Cardiac arrest and death	Confusion, amnesia	Memory problems
Confusion, loss of consciousness, amnesia	Stomach upset, decreased appetite	Thinking problems
Temporary paralysis	Irritability	Difficulty organizing things
Burns	Muscle aches and pains	Irritability, rage, frustration
Blindness, deafness	Trouble sleeping	Trouble sleeping
Muscle or spine damage	Ruptured ear drums	Cataracts, eye damage
	Dizziness	Chronic pain, nerve pain

Table 1 – Most common lightning injuries

For injuries less severe than cardiac arrest, a person will usually be knocked to the ground. Most of the time, they will have loss of consciousness or at least confusion and sometimes amnesia for the event. They may be disoriented and not thinking clearly enough to get away from danger and may need to reach a safe place.

An additional problem that can happen is temporary paralysis of the legs and sometimes the arms, too. This can last for at least several minutes or a few hours and keep a person from moving to a safer place. If you think about the nervous system of a person being like a computer, it is almost like the nervous system locked up, had to be rebooted, and then takes a while for all of the parts to get started again. Even then, sometimes they have been damaged too much to work the way they used to.

When lightning injures someone, it only goes through them for a very brief time before it flashes over the outside of the person. If the person is covered with sweat or rainwater, the flashover may cause the water to turn to steam, blowing apart the clothing and shoes and sometimes causing steam burns to parts of the body. (Fig 1)

Fig 1- Dummy whose clothes were blown apart by Lightning

In developed areas, few people have serious burns and some may have no signs of burns or marks on their skin. Burns can be caused from heat of the steam when rainwater or sweat is turned into steam or when a metal belt buckle or necklace heats up and burns the skin underneath. (Fig 2). But in more remote areas where buildings have thatched roofs or other flammable materials, people who are inside may be burned much more seriously if they lose consciousness or have the temporary lightning paralysis that keeps them from escaping and if the burning roof falls down on them. Fig 3 shows a South African woman who lost several members of her family when the roof of their rondavel (hut) burned.

Fig 2- This man's necklace was burned into his skin when he had lightning injury while he was fishing

Fig 3- This woman lost several family members when the thatched roof caught fire from a lightning strike

After the strike, it is common for the person to have sore muscles and body aches, to be confused or irritable, and to have an upset stomach or even vomit once or twice. These symptoms are similar to those that a person has with a football (soccer) concussion and may last a few days. After that, some people will return to normal. Many others may notice that they do not think as well as they used to. They may have headaches, memory and learning problems, difficulty multitasking or organizing things, and they may be frustrated and become angry easily. All of these are due to brain injury. Some will not be able to return to the work they used to do before the injury. They may also have nerve or muscle and joint damage that cause pain in other parts of their bodies that lasts for months or years.

Sometimes these injuries will resolve over a few months or the person may learn to work around them. Other times, they last for the rest of a person's life. If the person has a cardiac arrest, they may have far more serious damage to the brain because of lack of blood flow and oxygen to the brain during the time the heart was stopped.

TEACH YOURSELF…..

CARDIOPULMONARY RESUSCITATION (CPR)

If the heart stops pumping, it is known as a **cardiac arrest**. Cardiopulmonary resuscitation (CPR) is a combination of mouth-to-mouth resuscitation and chest compressions that delivers oxygen and artificial blood circulation to a person who is in cardiac arrest. It **can be life-saving first aid**. When the blood stops circulating, the brain is starved of oxygen and the person quickly becomes unconscious and stops breathing. Without treatment the person will die.

Keep in mind these 3 things if you are to perform a successful CPR:

1. CALL:
Check the victim for unresponsiveness. If the person is not responsive and not breathing or not breathing normally, call or tell someone to call emergency service numbers **112, 0800199099 or 0800199799** (Uganda Police toll free) for help and return to the victim. This is because CPR alone is unlikely to restart the heart; its main purpose is to restore partial flow of oxygenated blood to the brain and heart. The objective is to delay tissue death and to extend the brief window of opportunity for a successful resuscitation without permanent brain damage. So you may still need an ambulance after.

2. PUMP:
If the victim is still not breathing normally, coughing or moving, begin chest compressions. Push down in the center of the chest 2 inches 30 times. Pump hard and fast at the rate of at least 100/minute, faster than once per second.

3. BLOW: Tilt the head back and lift the chin. Pinch nose and cover the mouth with yours and blow until you see the chest rise. Give 2 breaths. Each breath should take 1 second

CONTINUE WITH 30 PUMPS AND 2 BREATHS UNTIL HELP ARRIVES

PROTECTION FROM LIGHTNING

Prof V. A. Rakov and Dr. Estelle Trengove

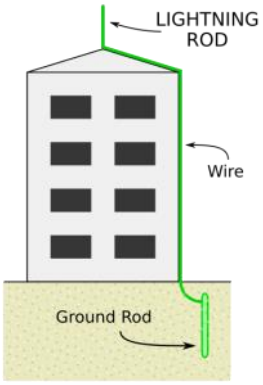
A group of lightning safety experts (Holle et al., 1999) has summarized their consensus views of personal safety from lightning as follows: "No place is absolutely safe from the lightning threat; however, some places are safer than others."

- **Large enclosed structures** (substantially constructed buildings) tend to be **much safer** than smaller or open structures. The risk for lightning injury depends on whether the structure incorporates lightning protection, construction materials used, and the size of the structure.
- In general, **fully enclosed metal vehicles** such as cars, trucks, buses, vans, fully enclosed farm vehicles, etc., with the windows rolled up **provide good shelter from lightning.** Avoid contact with metal or conducting surfaces outside or inside the vehicle.
- **Avoid** being in or near **high places** and **open fields,** isolated trees, unprotected gazebos, rain or picnic shelters, baseball dugouts, communications towers, flagpoles, light poles, bleachers (metal or wood), metal fences, convertibles, golf carts, and water (ocean, lakes, swimming pools, rivers, etc.)
- When inside a building **avoid** use of the telephone, taking a shower, washing your hands, doing dishes, or **any contact with conductive surfaces with exposure to the outside** such as metal door or window frames, electrical wiring, telephone wiring, cable TV wiring, plumbing, etc."
- Metallic rods (**called lightning rods**) that are installed on building tops and connected to buried metallic rods (called ground rods) help protect buildings from lightning damage. A lightning rod **intercepts lightning** that would otherwise attach to the building. The lightning electric charges then safely flow through wires connecting the lightning rods and ground rods to the ground.
- Remember that lightning can occur at the edges of clouds, so **do not wait until it starts raining** before you take safety precautions.
- If you are outdoors or if the only shelters are flimsy or temporary, **squat down or sit on the ground** to keep your height as small as possible. Make your contact with the ground as small as possible, so **do not lie down** on the ground.
- If you use a fire for cooking, **put it out**.

THE LIGHTNING ROD

How it works

Lightning rods were originally developed by **Benjamin Franklin**. A lightning rod is very simple -- it's a pointed metal rod attached to the roof of a building. The rod might be an inch (2 cm) in diameter. It connects to a huge piece of **copper or aluminum** wire that's also an inch or so in diameter. The wire is connected to a conductive grid or rod buried in the ground nearby. The purpose of lightning rods is often misunderstood. Many people believe that lightning rods "attract" lightning. It is better stated to say that lightning rods provide a low-resistance path to ground that can be used to conduct the enormous electrical currents when lightning strikes occur. If lightning strikes, the system attempts to carry the harmful electrical current away from the structure and safely to ground. The system has the ability to handle the enormous electrical current associated with the strike. If the strike contacts a material that is not a good conductor, the material will suffer massive heat damage. The lightning-rod system is an excellent conductor and thus allows the current to flow to ground without causing any heat damage. So clearly, the Lightning rod is not meant to attract lightning, but to provide a safe option for lightning to strike. Regardless of whether or not a lightning rod system is present, the strike will still occur.



Though the shapes of the different available rods may differ, they all work on the same protection principle of safely conducting electricity from lightning strikes to the ground, thereby protecting the structure onto which they are attached from damage.

NOTABLE LIGHTNING INCIDENTS IN WORLD HISTORY

1660's: In 1660, lightning ignited the gunpowder magazine at Osaka Castle, Japan; the resultant explosion set the castle on fire. In 1665, lightning again terminated on the main tower of the castle, igniting a fire which subsequently burned it to its foundation.

1789: A particularly deadly lightning incident occurred in Brescia, Italy. Lightning struck the Church of St. Nazaire, igniting the 90 tonnes of gunpowder in its vaults; the resulting explosion killed 3000 people and destroyed a sixth of the city. Gunpowder was stored in a church was because people felt that God would not strike his own building (church) and so they felt that churches were safe to store gunpowder and munitions. Churches, however, were very often hit because of their tall steeples and there was significant loss of life because of this and because the gunpowder and other items were stored in them

1902: A lightning strike damaged the upper section of the Eiffel Tower, requiring the reconstruction of its top.

July 12, 1970: The central mast of the Orlunda radio transmitter collapsed after a lightning strike destroyed its foundation insulator.

November 2, 1994: A lightning incident lead to the explosion of fuel tanks in Dronka, Egypt, causing 469 fatalities.

July 2007: A lightning incident killed up to 30 people when it struck a remote mountain village Ushari Dara in northwestern Pakistan.

February 2013: Nine South African children were hospitalized after a lightning incident occurred on a cricket field at their school, injuring five children on the pitch and four girls who were walking home.

November 14, 1969: Thirty-six-and-a-half seconds after lift-off, the Apollo 12 Mission's Saturn V rocket and its ionized exhaust plume became part of a lightning flash channel as it terminated on earth. Discharge occurred "through" vehicle, however it did not affect instrumentation or ignite the rocket's highly combustible fuel.

October 31, 2005: Sixty-eight dairy cows, all full of milk, died on a farm at Fernbrook on the Waterfall Way near Dorrigo, New South Wales after being involved in a lightning incident. Three others were temporarily paralyzed for several hours, later making a full recovery. The cows were sheltering near a tree when it was struck by lightning and the ground potential followed the path of least resistance through the animal's bodies.

March 26, 1987: Lightning was initiated by the Atlas-Centaur 67, a 137-foot, $78 million rocket carrying $83 million of military communication equipment. Spinning out of control 51 seconds after liftoff, the rocket had to be destroyed immediately to prevent any off-course veering that might have endangered populated areas along the Florida coast. The flaming wreckage fell into the Atlantic Ocean three miles from Cape Canaveral.

December 8, 1963: The worst lightning strike death toll occurred when lightning hit a Pan American Boeing 707 near Elkton, Maryland, killing all 81 on board.