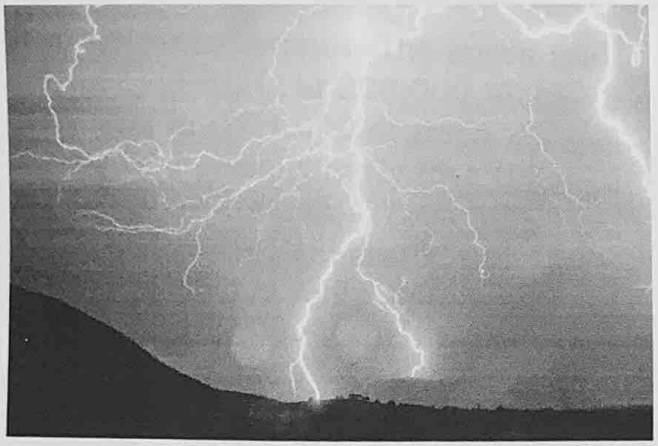
THE SCIENCE OF LIGHTNING 1



We have all seen those ominous dark clouds that suddenly flash a bright bolt of lightning through the sky, with a loud clap of thunder trailing close by. Thunderstorms are a common occurrence on our planet, thousands happening any given minute, but much information is yet to be discovered about this mysterious light show. Scientists continue to have unanswered questions about lightning because the process is so complex. It involves an in depth knowledge of both physics and chemistry. (1)

Lightning is an electric current that originates inside of a cloud, caused by rapidly rising and falling air currents. Ice and water droplets move around inside the cloud, forming collisions and friction that cause the cloud to fill with both positive and negative charges, each at opposite ends of the cloud. To generate a bolt of lightning, the negative charges must gain enough power and pull towards the positive charges on the ground. The negative charge from the cloud will send out a feeler, best known as a *stepped leader*, which is a series of negative charges. As the stepped leader approaches the ground, a *positive streamer* will extend up for it creating a *channel* and then a flash of light is created from the return stroke running from the ground to the clouds. (2)

Bolts of lightning do not always flash vertically. Most of the electrical energy created from a thunderstorm is dissipated within the clouds. Lightning may flash horizontally towards the positive particles of another nearby cloud, hopping back and forth between the positive and negative charges. (3)

As the air surrounding the lightning bolt is heated, it causes the air to expand faster than the speed of sound, squeezing the air and forming a shock wave that we know as thunder. Since lightning bolts can create many short bursts, multiple shock waves at various altitudes are made, which reach your ears at different times, making a rumbling sound. (4)

Light travels at 186,291 miles per second, which is much faster than sound at 1,088 feet per second. This explains why we always see a bolt of lightning before we hear a rumble of thunder. If you want an estimate as to how many miles away the lightning struck, simply count the seconds between the flash of light and the rumble of thunder and divide by 5. (5)

THE SCIENCE OF LIGHTNING

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Do not underestimate the speed and heat of lightning at 220,000 miles per hour and 54,000 degrees Fahrenheit, respectively (five times hotter than the sun). The total electrical energy generated in a large thunderstorm is more than an atomic bomb! When the negative charges from the clouds make a connection with the positive charges from the ground, the amount of light generated is enough to temporarily blind a camera lens. (6)

Studying lightning is not easy, and it can be very dangerous. In 2015, lightning took the lives of 27 people. During a thunderstorm, it is best to remain indoors and stay off the roads, if possible. People on the road should remain in their cars and seek shelter away from trees or other tall objects, which are known to be good conductors of electricity. (7)

1. Why do scientists continue to have so many unanswered questions about lightning?

2. Explain what is lightning and how does it happen.

3. Why do we see lightning before we hear thunder?

4. How can we estimate the distance from where a bolt of lightning struck?

5. What makes the rumbling sound of thunder?

6. Why is studying lightning so dangerous?

7. What should you do to remain safe during a thunderstorm?

PLANTS FOR THE FUTURE

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At the University of Illinois, scientists have found a way to hack into the genes of plants and manipulate them to use sunlight more quickly and efficiently in order to increase the production of plants and food around the world. (1)

Plants are autotrophs that make their own food (glucose) by using sunlight, carbon dioxide and water to perform the process of photosynthesis. In their study, scientists measured the process of photosynthesis and found it to be very slow, whereby plants are only using a very small amount of energy available to them. By hacking into the plant's genes within its protective system, scientists were able to increase the size of the plants up to 20 percent. (2)

When a plant is exposed to too much sunlight, it senses the light, disposes of extra energy via its protective system and grows more leaves. This system would be turned off if the plant were in the shade and growth would occur at a much slower rate. (3)

Just like sunglasses that adjust by getting darker or lighter depending on the amount of sunlight exposure, a plant's protective system does the same, but it can take a plant anywhere from 10-60 minutes to adjust, making it more difficult for plants to get the sunlight and energy they need to perform photosynthesis to make food. (4)

By manipulating the plant's genes, scientists can control a plant's protective system and turn it on faster to allow for an increase in leaf growth. Scientists have studied tobacco plants because their genes are easy to modify. On average, hacked plants grew 20 percent larger than normal, which is considered a breakthrough. (5)

The world's population is steadily growing, and is expected to reach 8.5 billion by 2030. This population increase will also give rise to an increase in the demand for food around the world. Using this technology, scientists could adjust crops such as rice, corn and other seed-oriented foods on a much larger scale and increase the world's food by many millions of tons. (6)

Scientists have also found ways to manipulate a plants genes to make them more tolerant to drought. Plants produce a hormone called abscisic acid (ABA) when they are deprived of water. ABA closes the plant's stomata, preventing water loss. (7)

PLANTS FOR THE FUTURE

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It would be logical to simply spray plants with ABA, but this technique is not cost effective and the hormone is very fragile. Instead, scientists genetically modified plants to respond to mandripropamid, a fungicide, in a similar way it would respond to ABA. (8)

One concern is that this technique will have an affect on plant temperatures and that a plant's nitrogen use should be modulated instead (9).

Researchers are full of ideas on how to make plants more tolerant to drought and how to make their natural processes more efficient. Many people oppose GMO research, and there is substantial evidence that plants bred naturally are doing a fine job, but with an increase in population and drought looming in the future, we should not dismiss scientists' ideas that may potentially solve many of the problems our world faces today. (10)

1. What are two reasons why scientists would want to hack into a plant's genes?

2. Why did scientists use the tobacco plant for their study?

3. Based on what we know about plants, why do we call classify them as autotrophs?

4. Explain how a plant's protective system works.

5. Why is it important for scientists to come up with new ideas to increase or maintain plant growth?

6. Why do scientists use mandripropamid instead of ABA?

7. What is one concern about using mandripropamid? What could we do instead?

TURN DOWN THE HEAT

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Greenhouse gases are at an all-time high. These harmful gases, which consist primarily of water vapor, carbon dioxide, methane, nitrous oxide, and ozone, are trapped in Earth's atmosphere and making it a warmer planet. Greenhouse gases are produced from things we do daily, such as using electricity, turning on the heater, or driving a car, but the bulk of these gases come from factories and farms. (1)

Carbon is one of the most abundant elements on Earth and in every living organism. Oxygen is an element in the air we breathe. When these two elements combine via a chemical bond, they produce carbon dioxide. Carbon dioxide is an invisible gas that when released into the atmosphere in large quantities (more than 400 ppm) can cause long-term climate changes, such as heat waves and floods. (2)

This common gas can remain in Earth's atmosphere for hundreds of years and in the oceans for much longer, which poses a problem for the future of Earth's environment. Plants, soil, coal deposits, oil, and natural gas also store large amounts of carbon. (3)

Carbon naturally circulates from one part of the Earth to another through the carbon cycle. By burning fossil fuels such as coal, oil and natural gas, people are adding more carbon to the atmosphere which can combine with oxygen to form carbon dioxide. (4)

As water is heated and evaporates, it can take on the form of an invisible gas called water vapor, which is present naturally in Earth's atmosphere. As the planet gets warmer, more water evaporates from Earth's surface and gets trapped as water vapor in the atmosphere, which can lead to more warming. This is an example of a positive feedback loop. (5)

Greenhouse gases circulate throughout Earth's atmosphere as more are added. The air moves these gases around the world, globally mixing them so that the levels of carbon dioxide are roughly the same no matter where you measure it. (6)

China is the main source of greenhouse gas emissions due to the amount of coal they are currently burning. The Chinese government officials are working on ways to cut their country's carbon dioxide emissions by more than half. Billions of dollars have been invested on renewable energy sources, such as wind and solar power. (7)

TURN DOWN THE HEAT

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If not for greenhouse gases, the Earth would be a much colder planet. These gases keep the Earth warm by a process called the greenhouse effect. This happens by Earth capturing and absorbing solar energy from the sun and heating up. As the Earth cools down at night it gives off infrared radiation, but before this radiation can leave Earth and venture into outer space, greenhouse gases that are trapped in the atmosphere absorb some of it. This warms the atmosphere and makes the Earth's surface warmer too. (8)

One person may not be able to stop climate change, but the collective effort of millions of people can by switching to cleaner energy sources, using less energy, making smarter traveling choices, reducing water usage, planting more trees, and buying locally grown food. (9)

1. Where do the greenhouse gases in Earth's atmosphere come from?

2. Why is it important that we keep Earth's atmosphere's carbon dioxide levels under 400 ppm?

3. What are four ways humans have contributed to the overabundance of carbon dioxide in Earth's atmosphere?

4. Using evidence from the article, give an example of a positive feedback loop.

5. How can the levels of carbon dioxide be roughly the same no matter where you measure it?

6. How are the Chinese government officials working to cut their country's carbon dioxide emissions?

7. How would Earth be different without greenhouse gases?

8. Explain the greenhouse effect.

9. What can we do to help combat climate change?

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