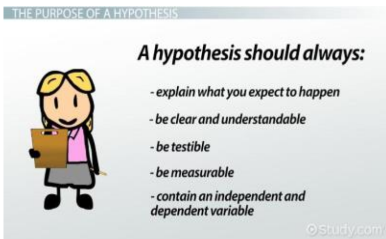
Lecture 1 WHAT THE WORLD GETS WRONG ABOUT SCIENCE Week 1 Summer June 3 2020,

Science is a glorious and powerful intellectual endeavor. It teaches us truths, but we must always be open to a newer and better understanding.

WHAT IS SCIENCE (7:07) ←(NOTE: ()This is where we are in the Computer. If you get lost.)

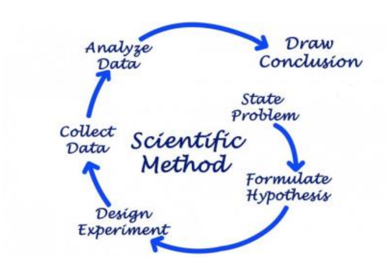
Many people would say that science is a collection of facts (7:25) —things like the Earth is 4.5 billion years old or the Egyptian pyramids were made by aliens using UFOs.(7:30) That last one isn't real, by the way, but it does lead us to the core essence of what science is: *Science isn't so much a series of facts, but rather a way of observing the world and generating testable hypotheses. Those hypotheses can be confirmed*, like the age of the Earth, or they can be falsified, like the UFO/pyramid connection.



Science isn't so much a series of facts, but rather a way of observing the world and generating testable hypotheses. (7:47)
Those hypotheses can be confirmed, Once the hypotheses are confirmed, they can be taken as facts. (8:02).
But facts in science can be soft things. They're not facts like saying that **George Washington was the first president of the United States**.(Or was he?)**** (8:08) (***Is This A Fact?)**** Or is this a distorted representation of history.
Science may be more malleable than History, say like **Newton's law of gravity**, which is still a good enough scientific theory that we can use it to calculate orbital parameters and rocket trajectories and accurately send a probe to Pluto. But when Newton's theory of gravity was proven to be incomplete, it was **replaced by Einstein's Theory of general relativity.(** 8:24) But **facts themselves aren't science** either. Science certainly does include determining facts, but it also includes seeing how those facts can be woven together into a tapestry that tells a bigger story.
Scientific facts and ideas can change as new information comes in. That way of thinking about facts is discomfiting to those who want an unchanging worldview, but **it's the flexibility of science that gives it such power.**
Ideas work as long as they work and to a needed level of accuracy, but they can be discarded when new information comes in or a higher level of accuracy is needed. (8:50)
Correlation: two things that happen together..(9:18) correlation isn't causation. (9:21) one item may not cause the other.
Science is a really big thing. 10:36Science is a methodology and a way to accept or reject facts. (10:41).Science is powerful tool. (10:54)
Ideas "work" than a=can be found to be wrong as the data changes. .(12:06)
new data will means that our picture of the world will change (12:29)
Science is about the process (12:37) Science is about learning processing and synthesizing new information. Then repeat this process over and over getting better. (12:57)

THE SCIENTIFIC METHOD (13:31)

Most people encounter a description of the scientific method in elementary school or in middle school at the latest. That introductory description is based on a recursive method that starts with an observation of some phenomenon—for example, a person sees bumblebees landing on flowers. From this, the person forms a hypothesis, which is that the flowers are a source of food for the bees. A hypothesis is described as an educated guess. (14:15)



Then, the person does an experiment, which tests the idea. If the experiment fails to support the hypothesis, it is rejected. If it succeeds, then the person can elevate the hypothesis to the level of a theory, (14:30) which might be called a tested hypothesis. Finally, if the person tests the theory over and over again and it is always supported by the data, then the idea can be elevated to being a law, (14:42) which is the highest-possible status in science. But scientific research is never that simple. The process is considerably messier, with many more twists and turns and revisions and surprises. There are dead ends and false alleys and puzzled looks. Science is much more interesting

SCIENTIFIC TERMINOLOGY

HYPOTHESIS - An educated guess or a motivated explanation for something. (16:20)

THEORY - A tested hypothesis— something that is well supported. (16:41)

LAW - A well-tested hypothesis; the highest-possible status in science. 19:15

MODEL - Like a theory, but often implies a more calculation like aspect than an explanatory one. (20:47)

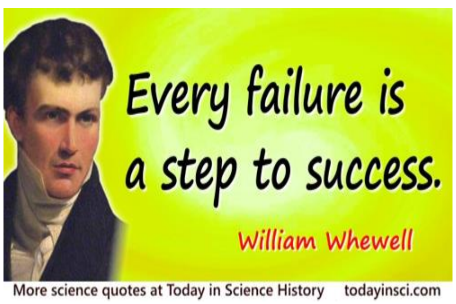
Most data aren't conclusive. They might support or contradict your idea. You might observe something wholly unexpected, or the data might be inconclusive. You to modify your hypothesis or change your experiment. (22:05)

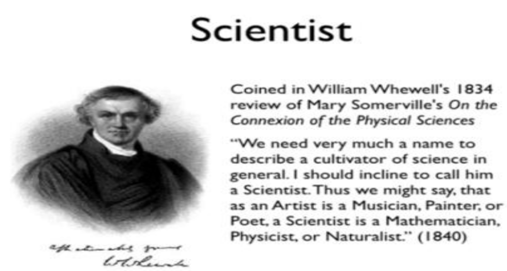
Even once you've done your experiment, you need to see if other people can replicate it. You need to have others criticize it., You need to have everything vetted by the most critical process possible. (22:25)

(22:48)Mind you, it's not that your colleagues are being mean; on the contrary, they are trying to help. The goal of scientists isn't to win an argument— it's to be right. If you can do that, you might be on to something. (22:48)

SCIENCE AND PHILOSOPHY (22:52)

Long before the word scientist was coined—in 1833, by British philosopher William Whewell (23:21) — the term used for those who studied science was natural philosopher, implying that they learned about the philosophy of the natural world.(23:27) Whewell also coined the term physicist to mean one who studies physics. (24:11)





There are those in the philosophical community who regard philosophy as the "queen" of intellectual disciplines. (24:19)

However, some then imply that philosophers are somehow superior to other pursuers of knowledge, such as scientists. (24:32)

Alternatively, the disciplines of science and philosophy can be viewed in the manner of evolution. For example, it appears true that the original form of semi-complex animal was a sea sponge(.24:33) Over millions of years, other forms of animals evolved, including the phylum Chordata, which includes mammals and humans. (24:53)

And even though our ancestral organism might have been a sponge, that doesn't mean that modern day sponges can do calculus. It's more of a schism that occurred early on, and the divergences have made the 2 organisms very different. In the same way, philosophy allowed science to arise, but the 2 disciplines are now quite distinct (25:14)

There are 2 core ideas of philosophy you must be aware of to understand science: metaphysics and epistemology. (25:38)

Metaphysics is the study of existence. (25:42) Metaphysics might, very broadly, be described as being concerned with 2 questions: What exists? and What is it like? (25:51)

Metaphysics is recognizably related to physics, but there are some very deep questions one might ask about existence. For example, we could ask whether there is an objective reality that exists without us. (26:03) **Most scientists would come down firmly on the position that there is a reality out there and that it would continue to exist even if we didn't.**

Other philosophers say that there is no reality other than what exists in our perception.(26:26)

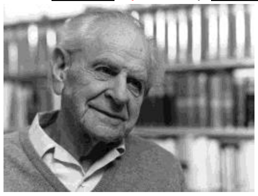
This implies that the existence is in the perceiving. And that leads to questions like whether 2 people see the color red the same way. Obviously, we can't know the answer to that in detail, which means that the conversation will continue.(26:40)

Epistemology, which might be called the philosophy of knowledge, is concerned with questions of whether we can know anything for sure and what it means to rationally believe in something.(27:07) This is an important consideration for scientists because theories and models are built on the basis of observations. If the observations are somehow flawed, then the theories will also be flawed. (27:21)

At the very deepest and most philosophical level, this could mean that we can never be sure of our science. Bad Observation → Bad Theory

If humans are actually held in a giant vat, with all of our sensory information fed to us, then we wouldn't actually know anything at all, and, in fact, our science could be totally wrong. Where is Kiana Reeves and the Matrix? (27:38)
But this doesn't stop us in our quest for what science is. We can make great progress in our understanding of the universe. (27:58) But it's important to realize that we are actually taking a leap of faith. And this faith involves believing that our senses are a mostly accurate representation of reality and that there is no evil demon or laboratory master that is deceiving us.(28:15) "Seeing" is believing.

There are those who then say that science is like religion, because it rests on faith. (28:24) But faith is a far more integral component in religion. But it's important for those who really want to scientifically understand the universe to be honest and understand the fundamental limitations and weaknesses of the discipline of science.(28:40) If we assume that there is an objective reality and that our senses are a good approximation of the world around us, there is the question of what science can prove. (28:56) Can the scientific method prove that a theory is true? (29:11)



Another important aspect of science—one that takes some getting used to—is the idea that science doesn't actually prove that anything is true. This idea originated most famously in the fertile mind of Austrian philosopher **Karl Popper**, (29:42) one of the most influential philosophers of science in the 20th century, who wrote extensively on scientific epistemology. It was his contention that the scientific method could not prove that something was true. This is because one could have a scientific theory that is right for the wrong reason.(29:57)
Consider Newton's theory of gravity, which worked very well for hundreds of years of observations but was replaced by Einstein's theory of general relativity31":13 when Newton's theory couldn't reproduce measurements of the movement of Mercury.
This is Popper's core idea: Scientific theories can't be proven, only disproven.(31:23)
Does this invalidate the scientific method? No. But it does remind us that **science is a method** more than **a body of knowledge**. The scientific method generates the body of knowledge. It gives us a model of how the world works. (31:46) But the result isn't static. Things can change; indeed, things are guaranteed to change. **Our understanding is always incomplete**. (31:55)

READINGS Ben-Ari, Just a Theory. Moreno, "Teaching Science in the 21st Century." Popper, The Logic of Scientific Discovery. Sagan, The Demon-Haunted World.

Lecture 2 Summer session June 3 2020

BENJAMIN FRANKLIN AND HIS KITE and Other Electrifying Myths 00:12

Imagine a world without electricity, then imagine how electricity effects you……

In June of 1752, American inventor Benjamin Franklin supposedly headed out in a thunderstorm with a kite and a key. (2:19) The kite was made with 2 light strips of cedar wood big enough to span a large silken handkerchief. (2:37) It was then tied to a hemp string, which was tied to a key. A metal rod was extended from the top of the kite to attract electricity. That addition was the progenitor for the idea of a lightning rod, which Franklin is credited with inventing. (2:44) Finally, a silk ribbon was tied to the string. Franklin supposedly stood under cover, keeping himself and the silk ribbon dry. This was important to keep electricity from conducting through the silk and into his hand.

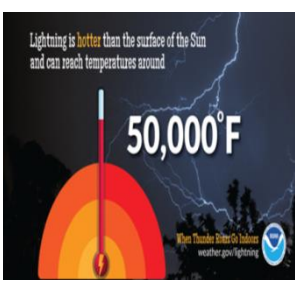
According to what might be considered the plausible legend, Franklin flew the kite into a thundercloud, but before the rain started, he supposedly moved his hand near the key and a spark jumped from the key to his knuckle. Furthermore, the little strands on the twine “stood up,” like the hair on your arm might if you take off a fuzzy sweater. Those things might have happened. ..

However, the largely believed legend is that the kite was struck by lightning and a lightning bolt came down the string, jumped off the key, and was collected in a glass and metal contraption called a Leyden jar, which was used at the time to store electricity. (3:22)

The first written account of Benjamin Franklin’s kite experiment was published in The Pennsylvania Gazette in October of 1752. The first “scientific” description didn’t occur until 1767, when British polymath and writer Joseph Priestly wrote down Franklin’s account of the episode.

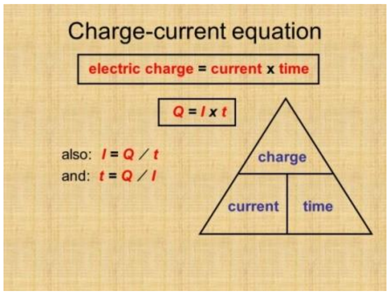
One real problem with this story is that a kite of the type Franklin described is actually very small, and it’s hard to imagine that it would really fly. (3:46) But maybe it’s possible that his description of a large handkerchief is just too small; maybe it was more like a woman’s shoulder scarf. So, let’s give him that one. The bigger problem is what would happen if lightning actually did strike the kite as the story is told: That amount of electrical energy would have simply killed Franklin. (440) A Baltic-German physicist named Georg Wilhelm Richmann died performing the experiment that Franklin is supposed to have conducted. The lightning jumped to his head and blew his shoes off. (4:51) It’s certainly possible that Ben Franklin had electrified his string before the storm struck. But it is beyond belief that he might have had the lightning bolt hit his kite. He would have been killed.

Lightning doesn’t just flow down a string and stop.(5:09) Electricity has to flow from place to place, and the lightning would have tried somehow to get from the string to the Earth, and the easiest path would have been through the silk ribbon and, ultimately, Ben Franklin.(5:21) So, the story as you probably learned it just isn’t true. However, Franklin did advance the technology of lightning rods, which are pointy pieces of metal that lightning prefers to hit rather than a house. Thus, elements of the science in the story are true— but not true enough. (542)

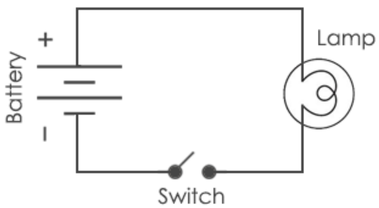


The safest place to ride out a lightning storm is in the family car.(650) The reason you might have been told that the car was safe was because it sat on tires, which are made of rubber, which is a good insulator. (7:04) The idea is that any electricity from the lightning strike couldn’t go farther, so the electricity couldn’t flow through you, and you were therefore safe(7:14) While it’s true that rubber is an insulator and it will keep you safe for reasonable voltages, if the voltage is high enough— like in a lightning bolt— rubber loses its ability to insulate. (7:55) In truth, the only kind of cars that offer significant protection are metal automobiles. Metal is a much better conductor than, say, you. If lightning strikes the car, the metal tends to conduct the electricity through it and down into the ground. (9:14) The Faraday cage effect helps with your safety. (9:45) The Boston Museum of Science has a fascinating lightning show(10:51) in which lightning bolts as thick as your arm are made right in front of you. The bolts hit a metal cage surrounding a person—and the person turns out just fine. It’s only scary if you don’t know your science. (11:05)

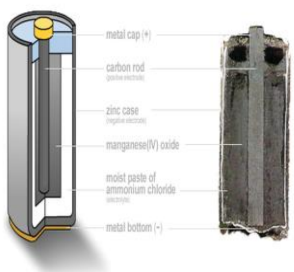
.CHARGE, VOLTAGE, AND CURRENT (11:27)

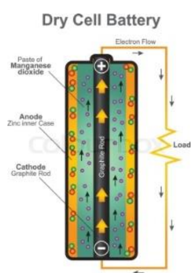


Electricity is the science of electrical charges and how they move(11:48)
You might have played with circuits as a kid. Take a battery, a few wires, and a light bulb and you have a flashlight, probably the simplest of circuits. If you disconnect one of the wires, the light bulb doesn't light. You do that in a flashlight by way of a simple switch.
People often don't have the foggiest notion of what electricity is. You've likely heard that electricity is the motion of charge through a circuit. So, maybe your mental image of what is going on in a circuit is that the battery is full of charge, which comes out of the positive side of the battery and flows through the circuit to the light bulb and then back to the bottom of the battery. (12:55)

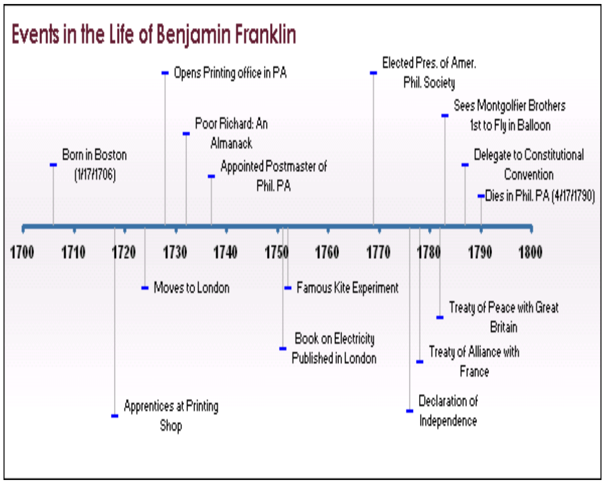


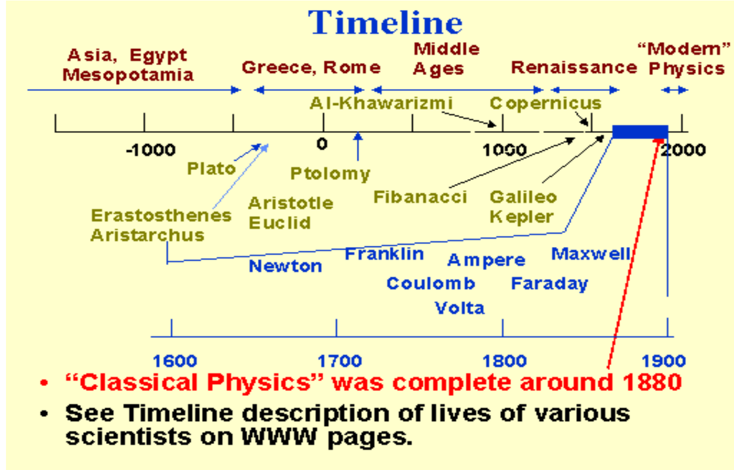
Basically, the mental image of electricity is something like water moving in pipes. But there is a lot wrong with that image.
To begin with, it's not really right to think of the battery as a charge holder. If a battery actually had a bunch of charge, it would be more like static charge,(13:21) in which you can store charge in a place. Then, when you touch something, the charge moves. If that idea were right, then when you reached for a battery, the charge in the battery would jump off and zap you.(13:41) You'd get a shock when you picked up a battery. But you don't.
Actually, in a battery, there is no net charge. You probably know that there are 2 kinds of charge, called positive and negative, and we have Ben Franklin and others to thank for those names.(14:03) Thinking in a more modern and atomic way, we have the nuclei of atoms—which are positive, and the nuclei get their charge from protons—and the electrons, which are negative. The battery consists of equal numbers of protons and electrons. Because one is positive and one is negative, the battery actually has no net charge at all. (14:24)



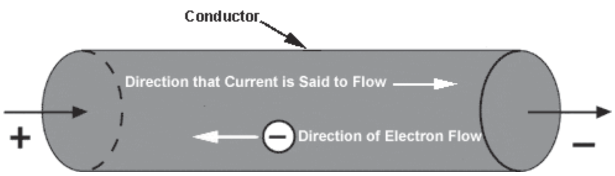


But batteries clearly work, so how do they do that without any net charge? It's because of the chemistry inside batteries. The chemistry pushes the negative electrons to one side of the battery, called the negative side, and away from the other side. (14:43) Because the atomic nuclei can't move easily and the nuclei are positive, once a lot of electrons slosh over to the negative side of the battery, that means that there aren't as many over on the positive side. And because the negative electrons are missing, what remains is positive. (14:55)
So, batteries are electrically neutral. In a battery, the charges get separated, and only the negative charges move. The positive ones don't move much. (15:09)
It turns out that the electrochemistry is a bit more complicated than this. Basically, the charge moves through the circuit, and as it does, a chemical reaction occurs inside the battery that makes the tendency of the battery to separate charges weaker and weaker. Eventually, enough chemical reaction occurs that there is no remaining tendency to separate, and that's what happens when we say the battery is dead (15:43)
In the mental image of a battery where the charge comes out of the positive part of the battery and moves around the circuit, the positive side of the battery can be thought of as the place where positive charges leave the battery and then zoom around to the negative side. This is called electrical current—the motion of positive charges. And the direction of electrical current is just direction of the motion of positive charges.(16:20) The positive charges then flow easily through the metal and less easily through the filament of the lamp, and the filament heats up and glows— and you have a light bulb(16:35)
But none of this happens. This is not what's going on inside the wires and the circuit. We have Benjamin Franklin to thank for this explanation. (16:45) However, in his defense, he imagined positive charges moving in a current before the United States was even a country, and it's been less than a century since we understood atoms. (17:2)





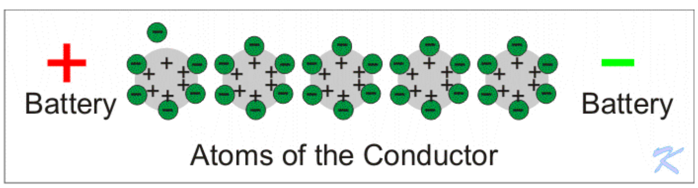
What's really going on? It turns out that positive particles don't move in circuits.(17:35) Remember that the positively charged parts of the battery were the nuclei of atoms that had somehow lost an electron. The nuclei of atoms are thousands, or tens of thousands, of times heavier than electrons. The nuclei don't move; the electrons do (17:52)

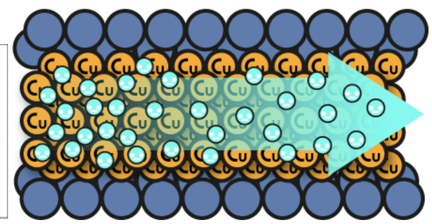


Electrons leave the negative side of the battery and then zoom around the circuit over to the positive side. Thus, the reality is exactly the opposite of what most people think is happening. (18:04)

Moving negative charges away from the negative terminal of a battery is entirely equivalent to moving positive charges away from the positive terminal. (19:09) Both things will effectively reduce the amount of positive charge on the top of the battery and the negative charge on the bottom. And in a real battery, the electrons leave the negative end of the battery and zoom around to the positive side.(19:25)

Most people are certain that the charges must move quickly. Their reasoning is that the light turns on seemingly instantly when a switch is flipped. But this vision is enormously wrong. (20:08)

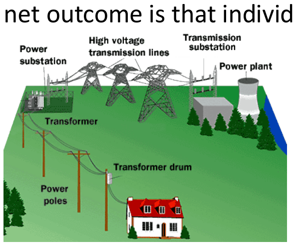




It turns out that electrons moving through wire have a tough time of it. It's not like they are sprinters running a 100-yard dash. They are more like intrepid explorers of yesteryear, hacking their way through a jungle, looking for a lost city full of gold. (20:26)

A wire is just a bunch of copper (a common wire material) atoms more or less unmoving in space, with some electrons on the outside of atoms that can move from atom to atom pretty freely. Those are the electrons that can move to conduct electricity. (20:48)

But when they are made to move by putting a battery on the circuit, they have to move through that jungle of atoms. They move, bounce into an atom, get knocked off in some direction, move forward again, get deflected again, and so on. (21:06) The net outcome is that individual electrons have a very small net motion. (21:11)



Electrons move less than a tenth of a millimeter per second- Drift Velocity of Electrons

How do the atoms in the wire and the atoms in the battery work together. (22:34) The wire obviously consists of atoms, with electrons that are negative and nuclei that are positive. When the first electron leaves the battery, it runs into the first electron it sees in the wire and pushes it out of the way. Then, the electron in the wire has to go somewhere, so it pushes the next electron up the chain. And that one pushes another, etc., (23:06) all the way around the circuit, through the light bulb, and then back into the battery. (23:18)

Similar to the way a train moves, the battery pushes the first electron outside the battery, but that electron pushes the rest all the way up the line until electrons start slowly moving through the light bulb and cause it to heat up and glow. (24:26)

There is one more surprising thing about electricity. The electricity that your house uses is different from the electricity of a battery. In the battery situation, the battery is always pushing electrons out of the negative side. (24:47) For your house, batteries supply direct current,(24:52) which means that they push electrons in one direction only. But houses, and basically all commercial power, run on alternating current,(25:00) which means that the electricity is first pushed and then pulled, over and over again. Thus, for the power from the power plant, the situation looks different from a battery. The copper nuclei of in the wire still don't change location, but the electrons move back and forth—in and out atoms. (25:33)

And they don't move very far. And this has a very interesting consequence: When you turn the lights on in your house, the electrons don't actually move through the house. They just sit in place, jiggling back and forth.(26:13)

This is true even for large factories, which consume an enormous amount of electrical energy to run—yet no electrical charge ever moves into or out of the buildings.(26:32) The electrons that were in the wires when the wires were installed have stayed in those wires and not moved

In the US, electricity is pushed and pulled into your house 60 times a second. In Europe, it's 50 times a second. Everywhere else in the world uses either the European or the American standard.

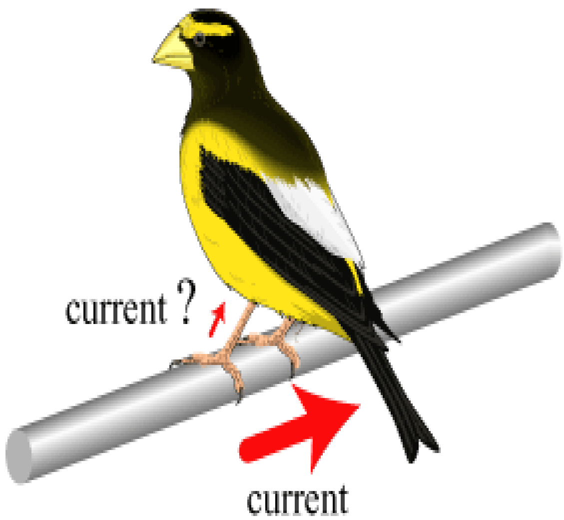
**** **Footnotes:** **All of the First Presidents.**

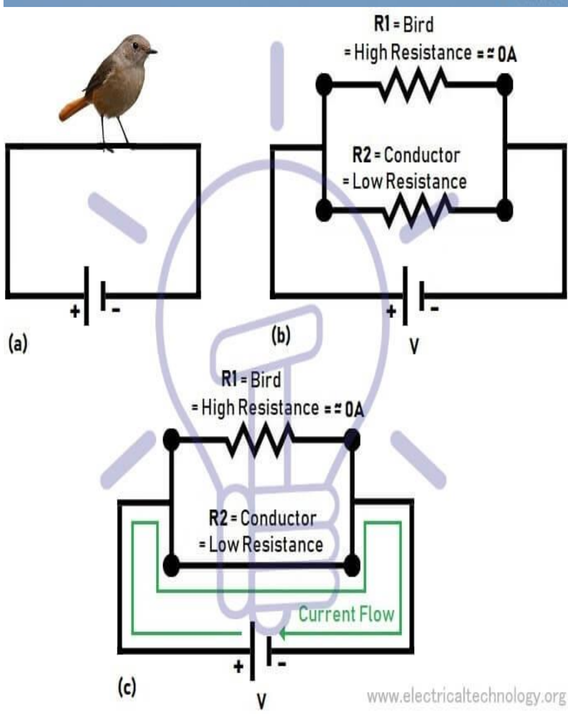
Peyton Randolph (1) is known as the first President of the Continental Congress, or Continental President. He was given this title in September 1774 when everyone in Congress voted for him to be so. However, in October 1774, **Henry Middleton** (2) became the second Continental President for about a week, after which **Peyton Randolph** took over again, this time for a little under a month due to poor health. Once Randolph resigned a second-time due to his health and headed back to Virginia to be with his family, one of the most famous Founding Fathers took over, **John Hancock** (3). Hancock stayed on as president until October 1777.John Hancock did not even step down as Continental President when **Peyton Randolph** (4) he came back for a period of time, though many felt Hancock should have in order to let Randolph assume his responsibilities. Unfortunately, all this debate ended when Peyton Randolph passed away suddenly of a stroke in October 1775. This means that **John Hancock was the first President of the Continental Congress to preside under the US after the Revolutionary War broke out and after independence was declared.** **Henry Laurens** (5) was the fifth Continental President and served from the time Hancock stepped down until December 1778.Laurens was succeeded by **John Jay**, (6) who served until September 28, 1779. The seventh Continental Congress President was **Samuel Huntington**, (7) who served from the date John Jay stepped down until a couple months after the Articles of Confederation were ratified in 1781. Once the Articles of Confederation were ratified by all of America's 13 states, the responsibilities of the Presidents of the Continental Congress began to extend. **Thomas McKean** (8) was the first Continental President to hold his full term under the Articles of Confederation, lasting from July 1781 to November of that year. **John Hanson** (9) was the ninth and lasted a year in office, from November 5, 1781 to November 4, 1782. Then it was the turn of **Elias Boudinot** (10) from New Jersey, who was in place until November 3, 1783. The eleventh Continental President was **Thomas Mifflin**, (11) who served as president until June 1784. Unfortunately for Mifflin, he had a tough short term as Continental President as General George Washington resigned in December 1783 and then Mifflin had the challenge of trying to get enough delegates from the states so Congress could ratify the Treaty of Paris. **Richard Henry Lee** (12) of Virginia was the twelfth and resided in office from November 30, 1784 to November 4, 1785. The thirteenth was once again **John Hancock**, (13) who filled the position from November 1785 to June 1786. After Hancock's second term as Continental President, **Nathaniel Gorham** (14) took over from June 6, 1786 until November of that same year. The last two Continental Presidents were **Arthur St. Clair**, (15) who was in office from February to November 1787, and **Cyrus Griffin** (16) who was president until November 1788.In November 1781, **John Hanson** (17) became the first President of the United States in Congress Assembled, under the Articles of Confederation. **George Washington** (18) was President from 1789 to 1797.Many people have argued that John Hanson, and not George Washington, was the first President of the United States. "Maybe History is not an exact science"….

EXTREMELY DANGEROUS!
This is a warning sign that charged particles from the earth are reaching their way up towards the sky in response to a precursor to a lightning strike called a stepped leader. These charges are climbing up your body and accumulating causing positive charge to accumulate and
repel each other, thereby making the hairs stand on end.
The picture attached shows this very phenomenon, unfortunately just
before lighting did strike her and her friends.

Dangerous Myths about Electrical Safety

https://www.machinedesign.com/automation-iiot/cables-connectors-enclosures/article/21832273/6-dangerous-myths-about-electrical-safety


current ?
current


R1 = Bird
= High Resistance = ≈ 0A
R2 = Conductor
= Low Resistance
(a)
(b)
V
R1 = Bird
= High Resistance = ≈ 0A
R2 = Conductor
= Low Resistance
Current Flow
(c)
V
www.electricaltechnology.org


shutterstock.com • 1394548883