

L 24 Electricity & Magnetism [2]

- static electricity
 - the van de Graff generator
 - electrostatic shielding
- lightning
- batteries and frogs legs



review – electric charge

- Matter (stuff) has two basic properties
 - mass → gravitational force
 - charge → electric and magnetic forces
 - positive charge
 - negative charge
- electric forces
 - like charges repel $+/+$ or $-/-$
 - unlike charges attract $+/-$
- charge is measured in **Coulombs [C]**



Where is the charge?

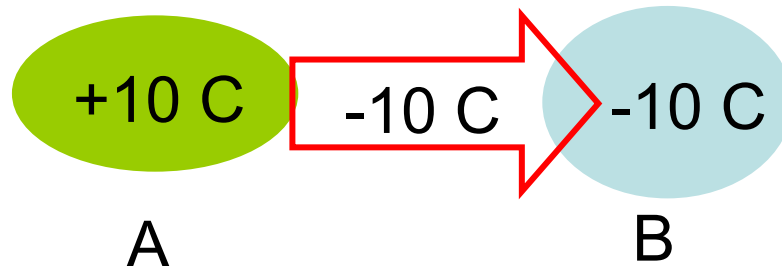
- the charge is in atoms
 - positive → protons
 - negative → electrons
- matter is usually electrically neutral → it has the same amount of positive and negative charge
- electrons can be transferred from one object to another by rubbing (friction)

The charging process

- an object is charged positive (has a net positive charge) if electrons are removed from it
- an object is charged negative (has a net negative charge) if electrons are transferred to it
- charges can be transferred from conductors or non-conductors but they can only move through conductors.

Example

- 10 Coulombs of negative charge are transferred from object A to object B. What is the net charge on each object?
- **ANSWER:**
 - object A has a net charge of +10 C
 - object B has a net charge of -10 C.



One Coulomb is a HUGE charge

- To get a charge of one Coulomb on an object we would have to remove

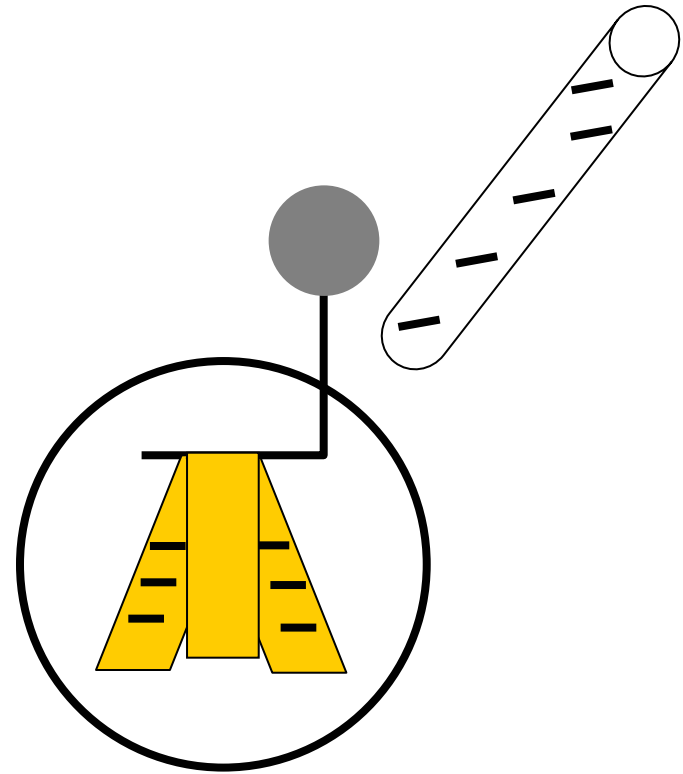
6,250,000,000,000,000,000

electrons from it!

- In the capacitor discharge demo, only 0.01 C of charge were involved.

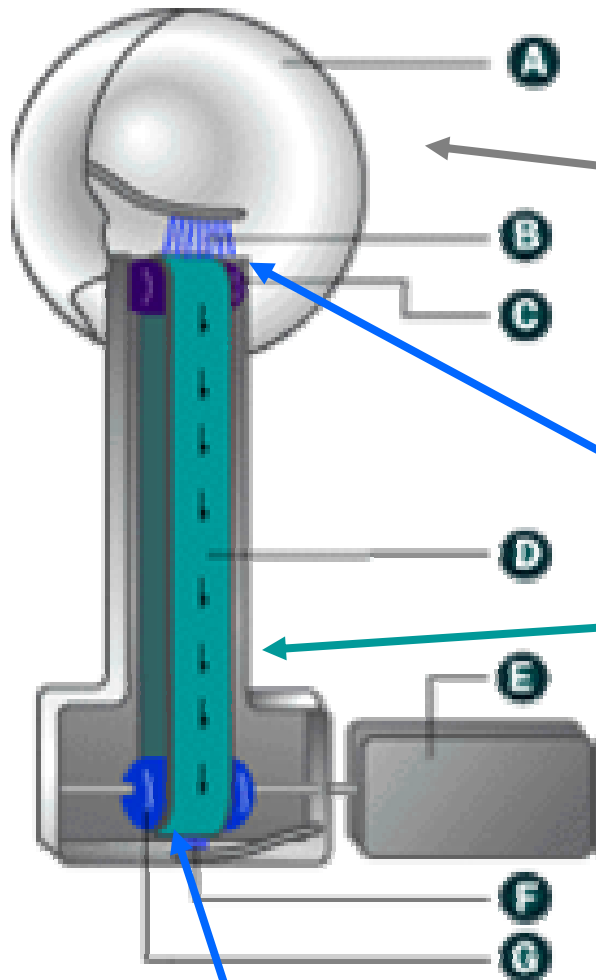
Seeing the effects of charge: the electroscope

- the electroscope is a simple device for observing the presence of electric charge
- it consists of a small piece of metal foil (gold if possible) suspended from a rod with a metal ball at its top



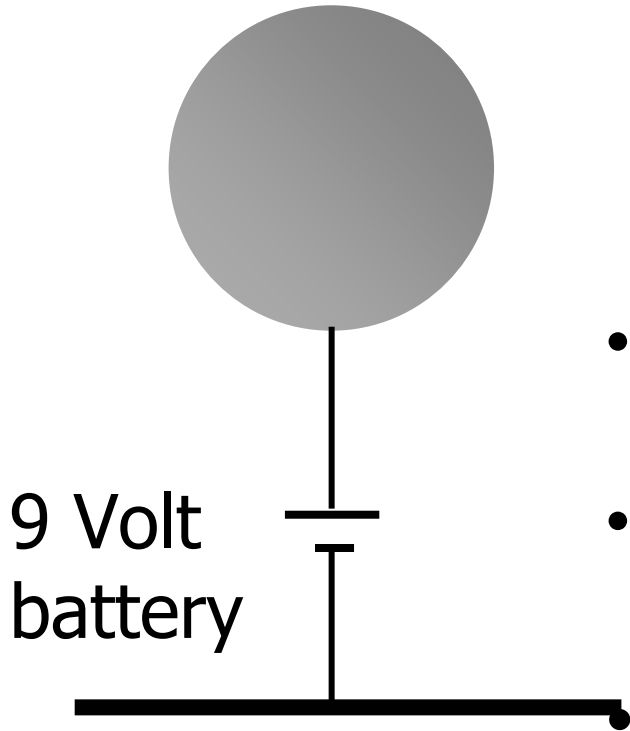
- If a negatively charged rod is placed near the ball, the electrons move away because of the repulsion. The two sides of the metal foil then separate.

Making Sparks: The Van de Graaff Generator



- The van de Graff generator is a device for building up a large electrical charge on a metal sphere.
- The charge is generated by friction between a rubber belt and a roller.
- the charge on the belt is transferred to the sphere by a brush.

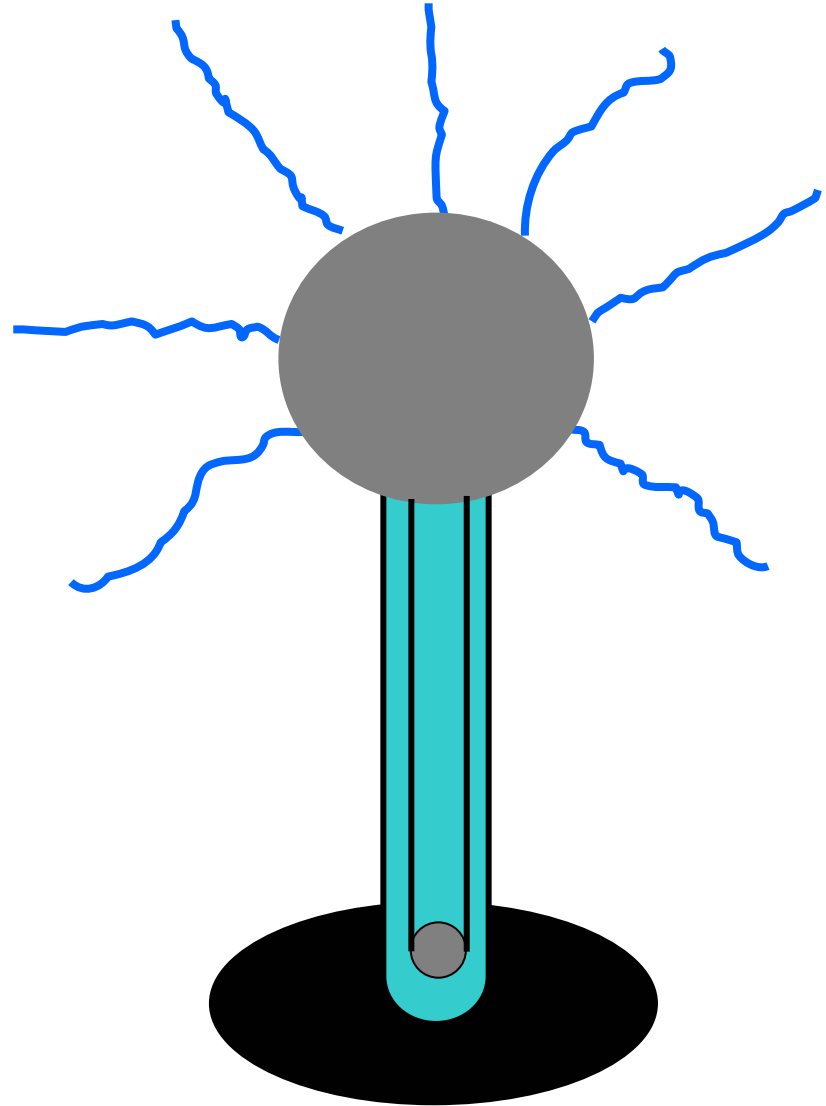
Electric Potential → voltage



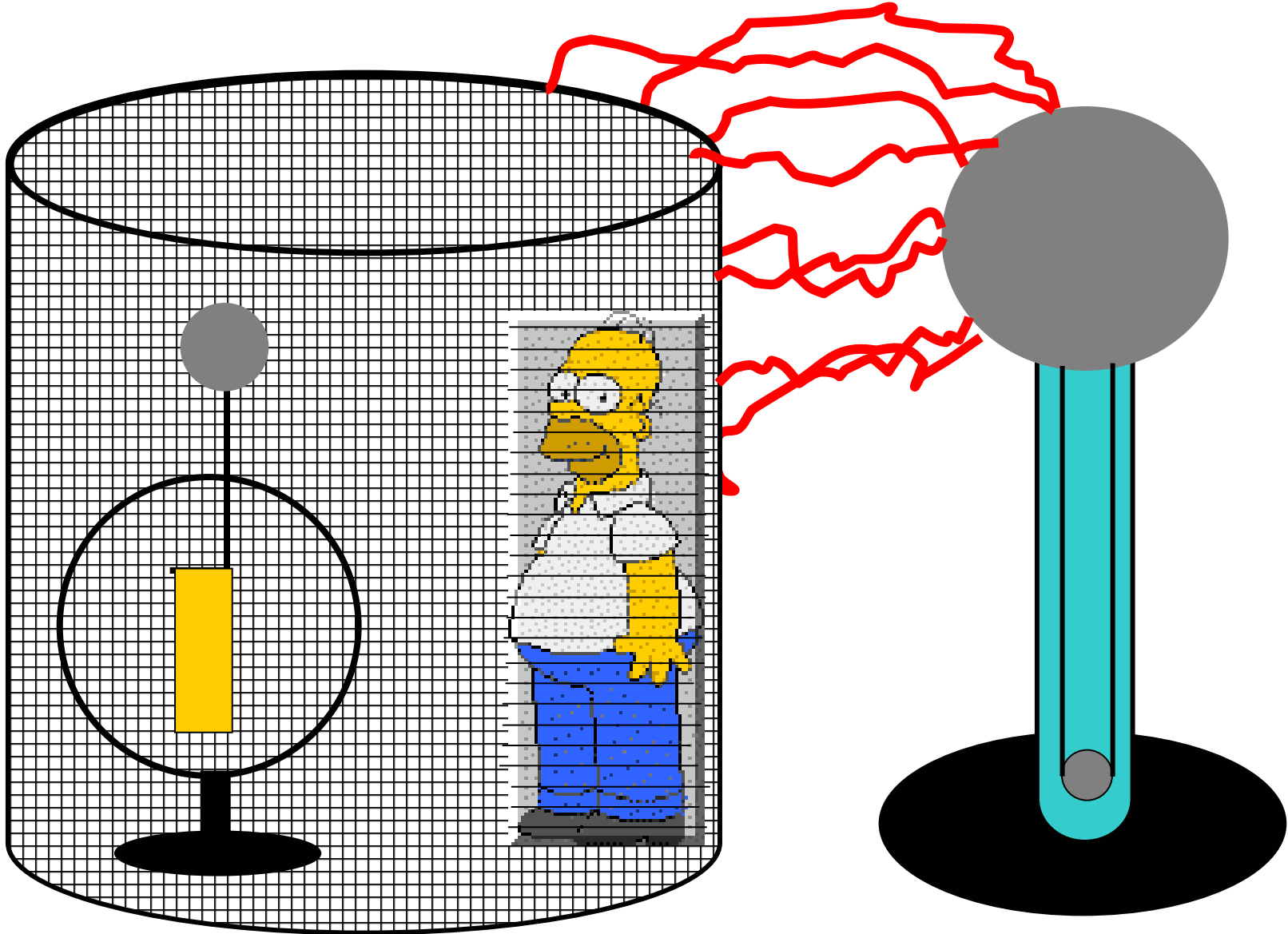
- The amount of charge on a charged sphere can be measured in terms of its electric potential or voltage
 - the more charge that is on the sphere, the higher its voltage
 - electric potential is measured in VOLTS
- if I connect a 9 V battery to the sphere and the ground, it will have a potential of 9 V

Danger High Voltage !

- The van de Graaff can charge the sphere to 50,000 volts!
- This is enough to cause discharges to the surrounding air
- The sparks excite air molecules which give off light



Electrostatic shielding



Electrostatic shielding

- The effect of the high voltage on the van de Graff generator stops on the outside of the metal cage → Homer is SAFE!
- Being inside your car during a lightning storm offers you some protection
- radio signals cannot penetrate through a metal enclosure
- the metal bars (rebar) that reinforce the concrete in walls can interfere also

Lightning- outdoor spark



- causes 80 million dollars in damage each year in the US
- On average, kills 85 people a year in the US
- over in a thousandth of a second
- carries up to 200,000 A
- causes the thunder!

development of a lightning bolt

charge
separation

stepped
leader

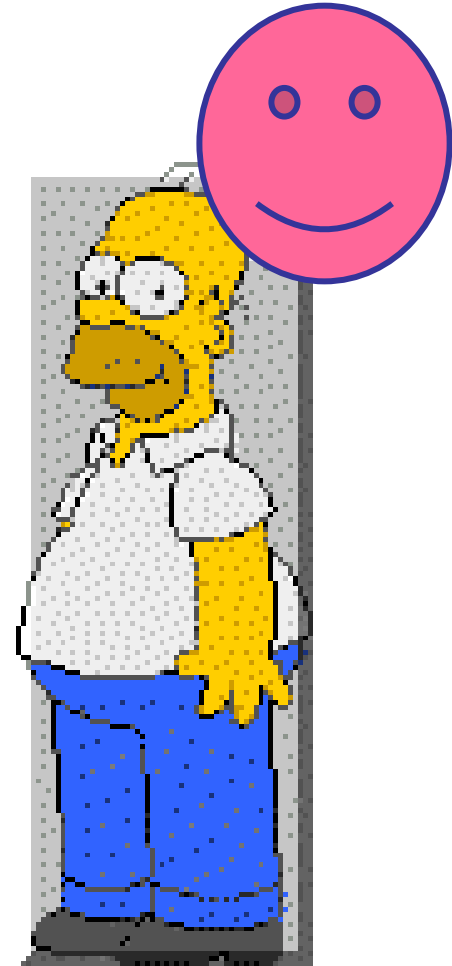
leader &
streamer

leader meets
streamer

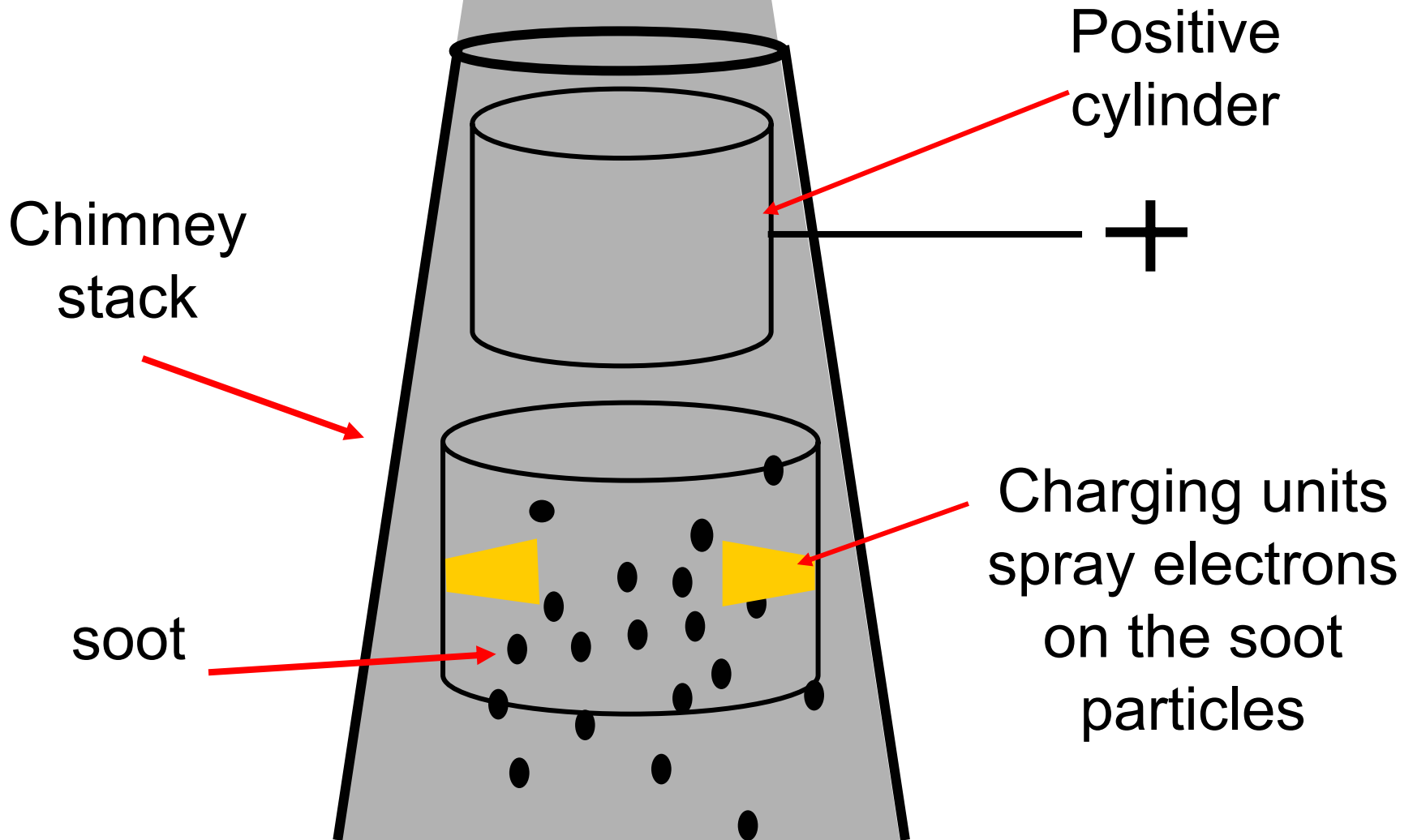
lightning
bolt

applications of electrostatics

- Xerox copiers use electrostatic attraction to put the ink droplets on the paper
- electrostatic precipitators use the attraction of charged dust to remove dust particles from smoke.
- can be used to hold balloons on your head



Removing soot particles

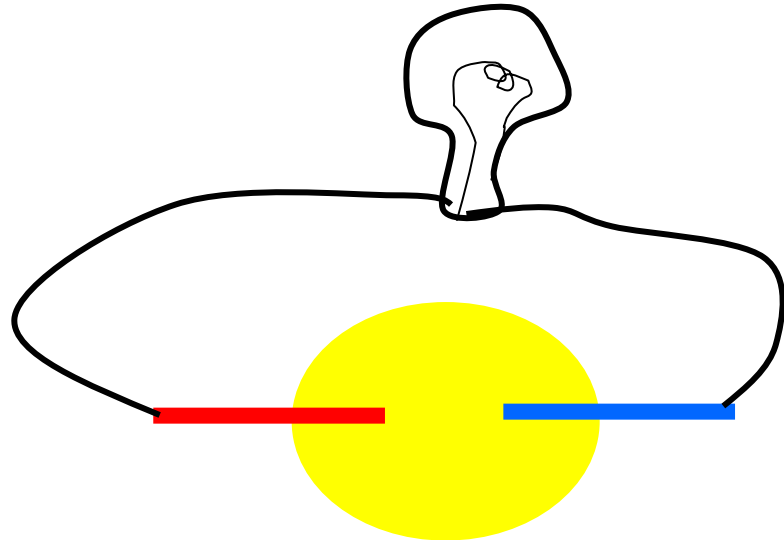


Frog's leg Batteries

- in 18th century Luigi Galvani a professor of anatomy at the University of Bologna found that a freshly dissected frog leg hung on a copper hook twitched when touched by an iron scalpel.
- The two metals had to be different.
- Galvani thought that he had discovered the secret life force

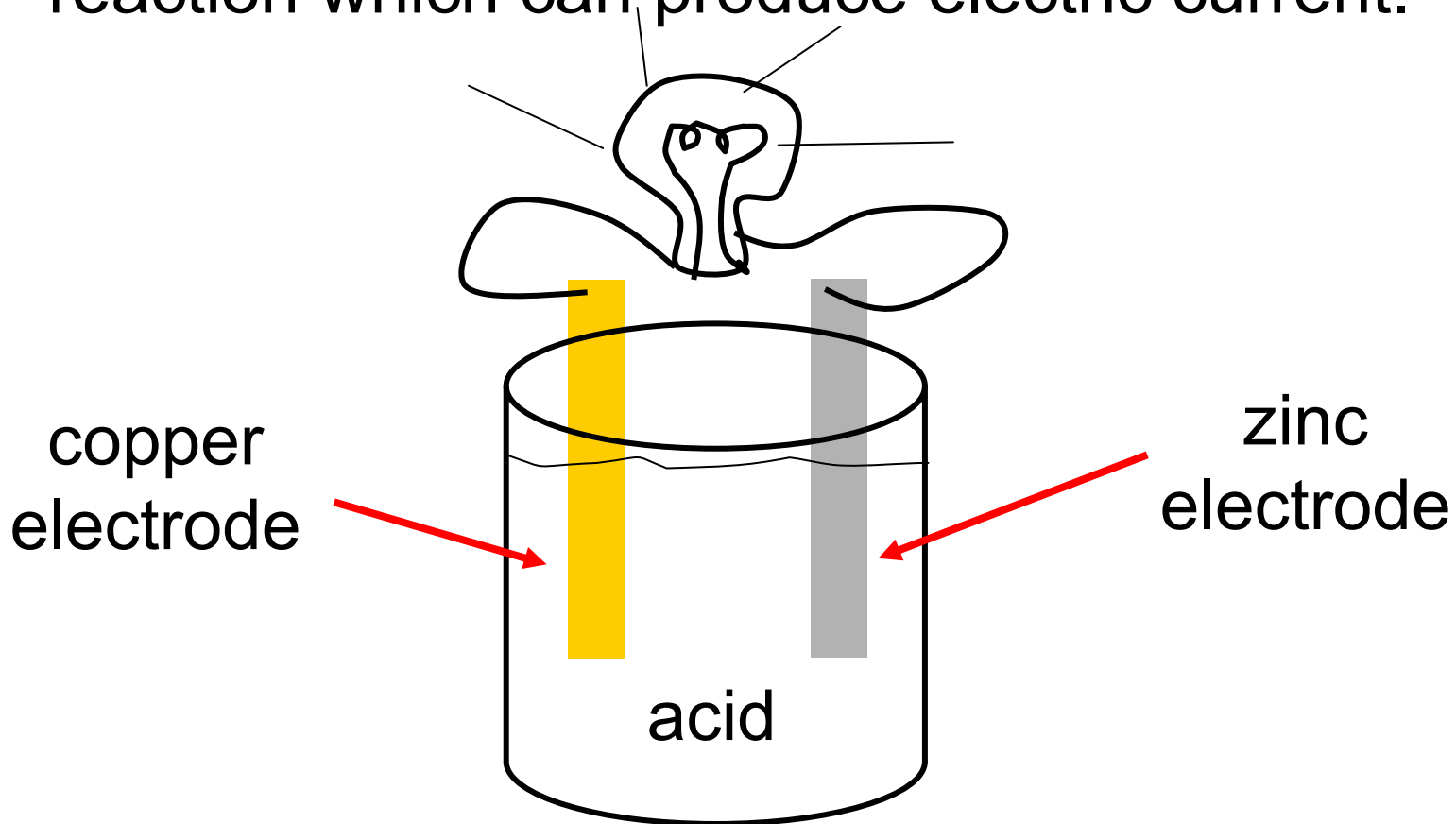
Alessandro Volta

- Professor of Physics at the University of Pavia realized that the electricity was not in the frog's leg but the twitching was the result of touching it with two different metals
- Volta had discovered the first battery.
- Lemon battery



Batteries → use chemical energy to produce electricity

- two dissimilar metals immersed in a conducting fluid (like an acid for example) cause a chemical reaction which can produce electric current.



Inside a Duracell 1.5 Volt battery

