

# Ohmic Heating & Electrocution



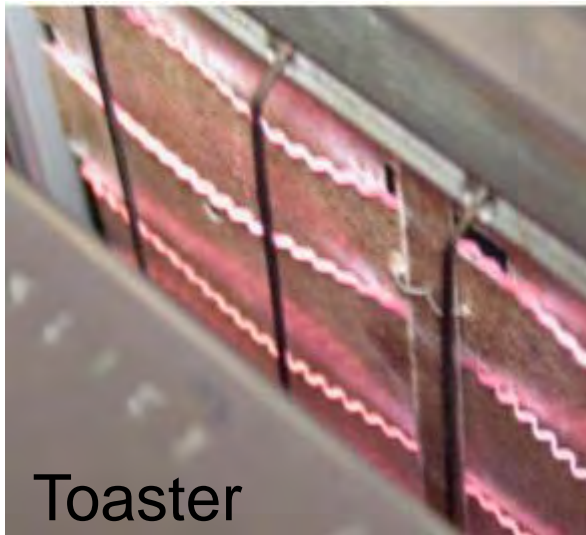
National Science Foundation  
WHERE DISCOVERIES BEGIN

# Ohmic Heating

Flowing electrons strike atoms in a conductor, heating the material.



Georg Ohm



Toaster



Hellboy (2004)

# Rate of Heating (Power)

The rate at which an electric current delivers energy during ohmic heating is

$$\text{Electric Power} = \frac{(\text{Voltage})^2}{\text{Resistance}}$$

Hold Fixed	Change	Result
Voltage	Resistance ↓	Power ↑
Resistance	Voltage ↑	Power ↑↑

# Ohmic Cooking

An electric current running through a hot dog generates enough heat to cook it (poorly).



# Electric Pickle

Strange light show  
when using a pickle  
in place of hot dog.  
Similar to sodium  
lamp discharge.

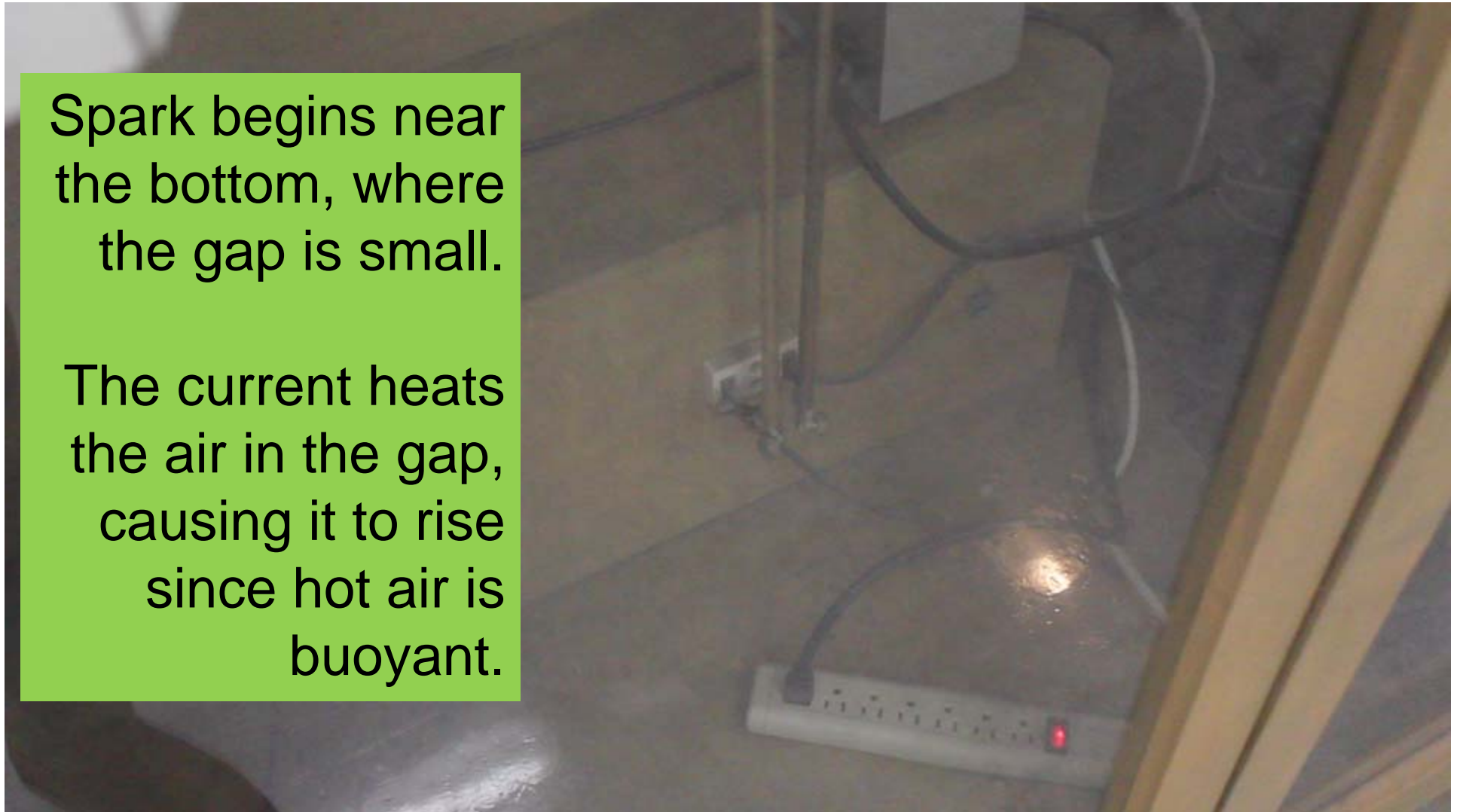


# Jacob's Ladder

Outside Science Bldg.  
Room 258 at SJSU

Spark begins near the bottom, where the gap is small.

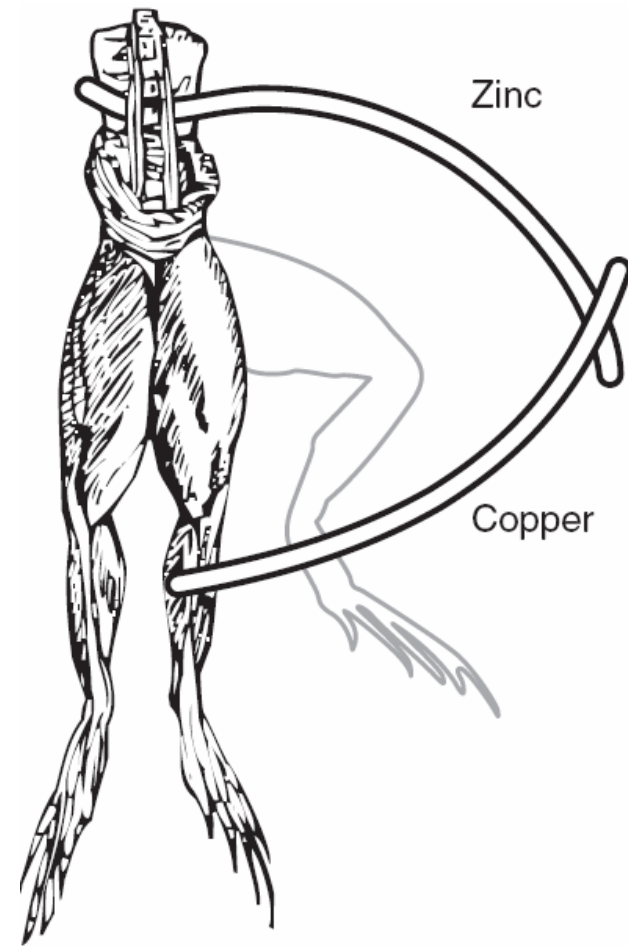
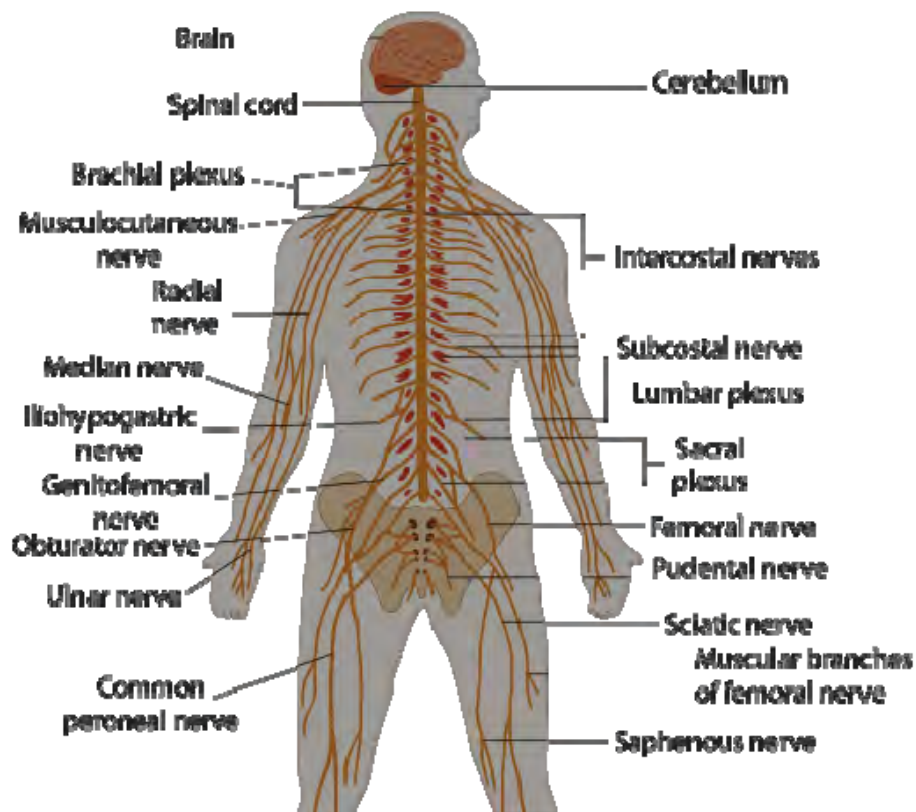
The current heats the air in the gap, causing it to rise since hot air is buoyant.





# Nervous System

Nervous systems in animals use electrical currents to signal the contraction and relaxation of muscles.



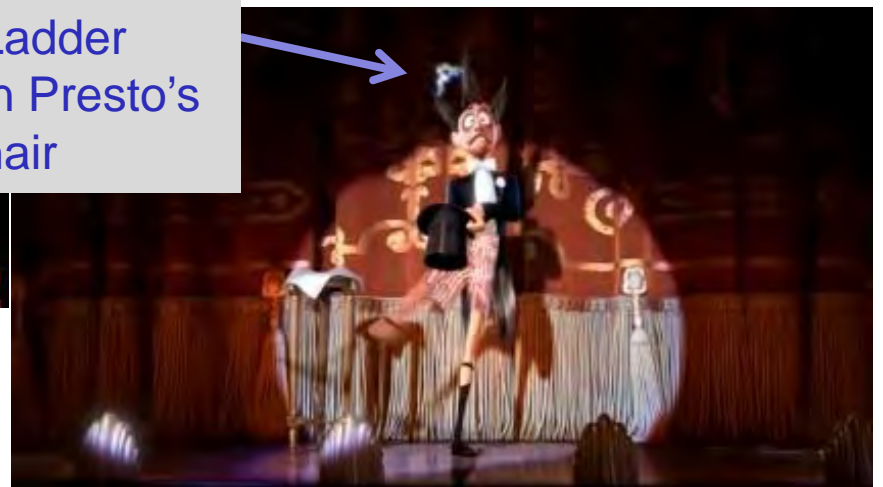
Alessandro Volta found that a frog leg jumps when electrical current passes through it.

# Presto (2008)

Common visual gag is the uncontrollable twitching of a person's muscles.



Notice Jacob's Ladder in Presto's hair



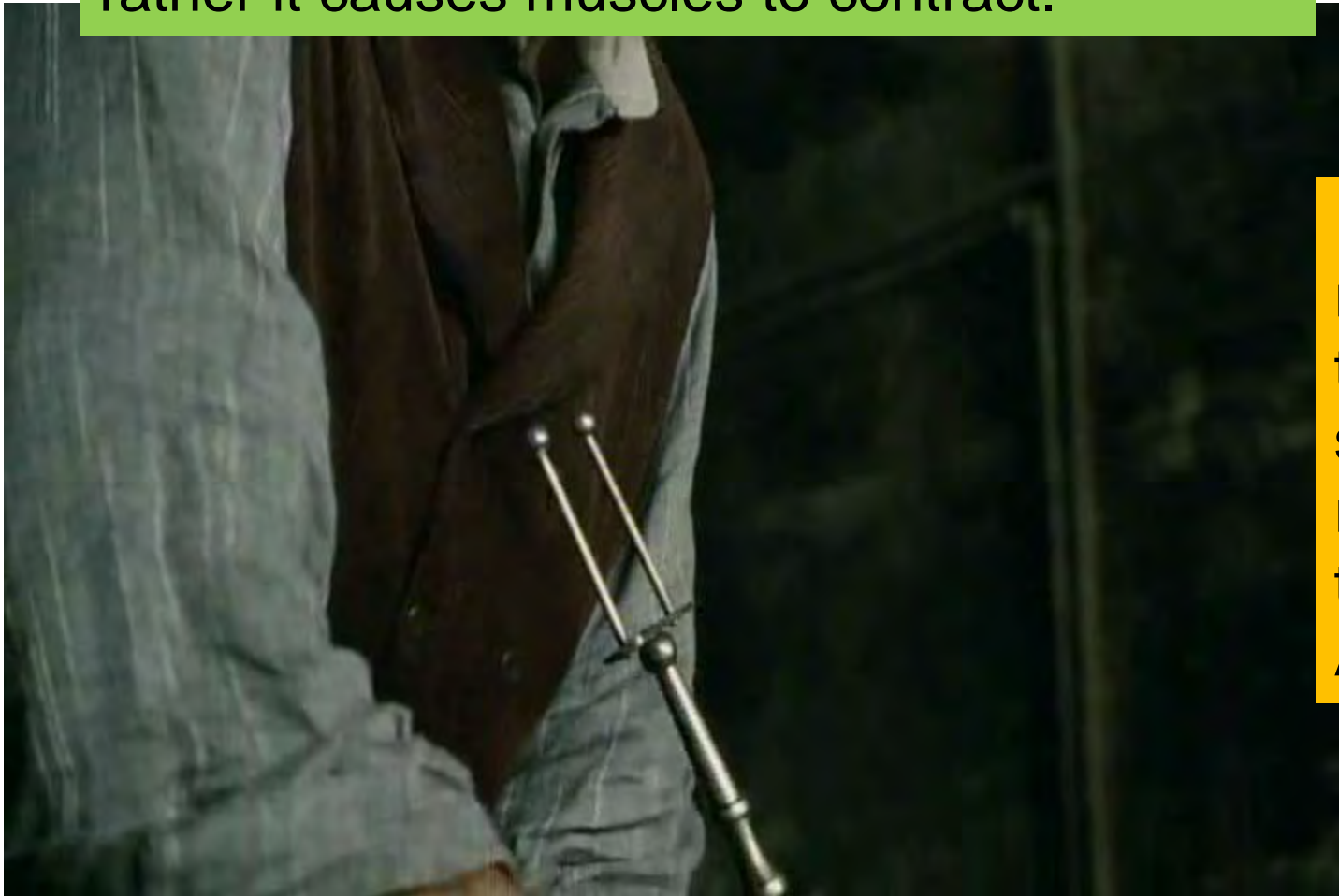


# Sherlock Holmes (2009)

The electric shock does *not* exert a force, rather it causes muscles to contract.



If there *was* repulsion force then there should be a recoil due to the principle of Action/Reaction



# Electrocution

Electrocution (death by electric shock) is typically not due to ohmic heating.

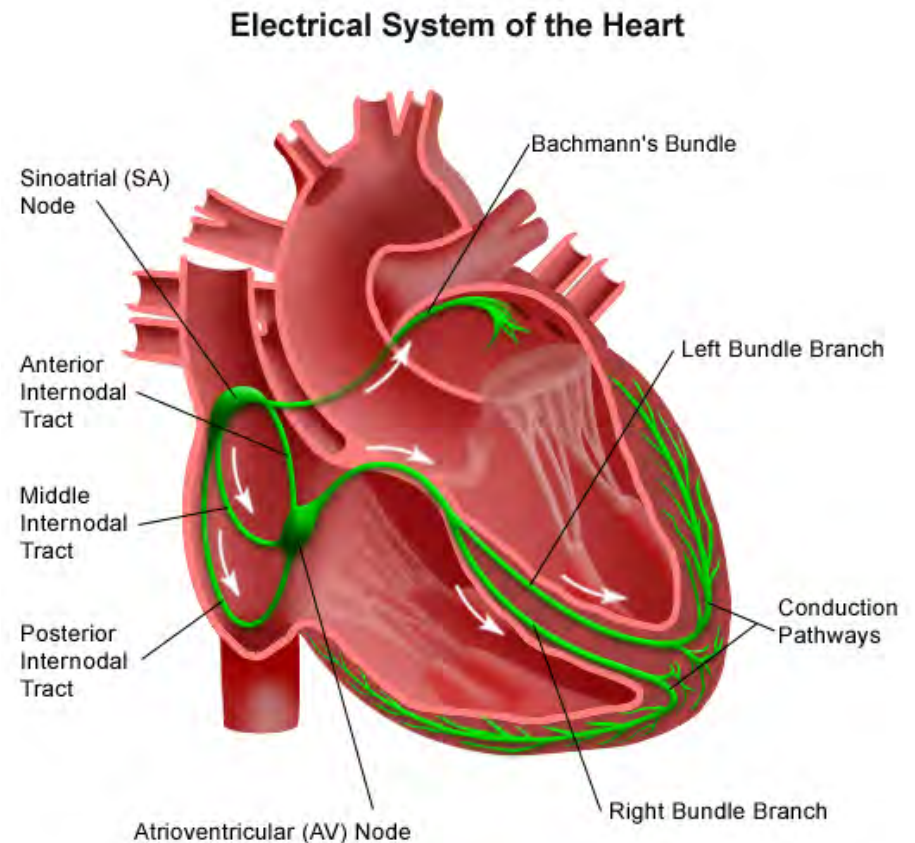
Electric current usually kills due to a disruption of the body's electrical nervous system.



# Conduction in the Human Heart

The most important electrical signal in our body is the periodic signal that contracts and relaxes our heart muscle to pump blood.

Without a constant flow of blood the brain suffers permanent damage.



# Electric Shock

Damaging effects of electric shock are the result of current passing through the body.

Current depends on the voltage *and* on electrical resistance.

Dry skin has a high resistance but the resistance drops by x1000 when wet.

Effects of Electric Shock on Human Body

<b><i>Current (A)</i></b>	<b><i>Effect</i></b>
0.001	Can be felt
0.005	Is painful
0.010	Causes involuntary muscle contractions (spasms)
0.015	Causes loss of muscle control
0.070	If through the heart, serious disruption; probably fatal if current lasts for more than 1 s

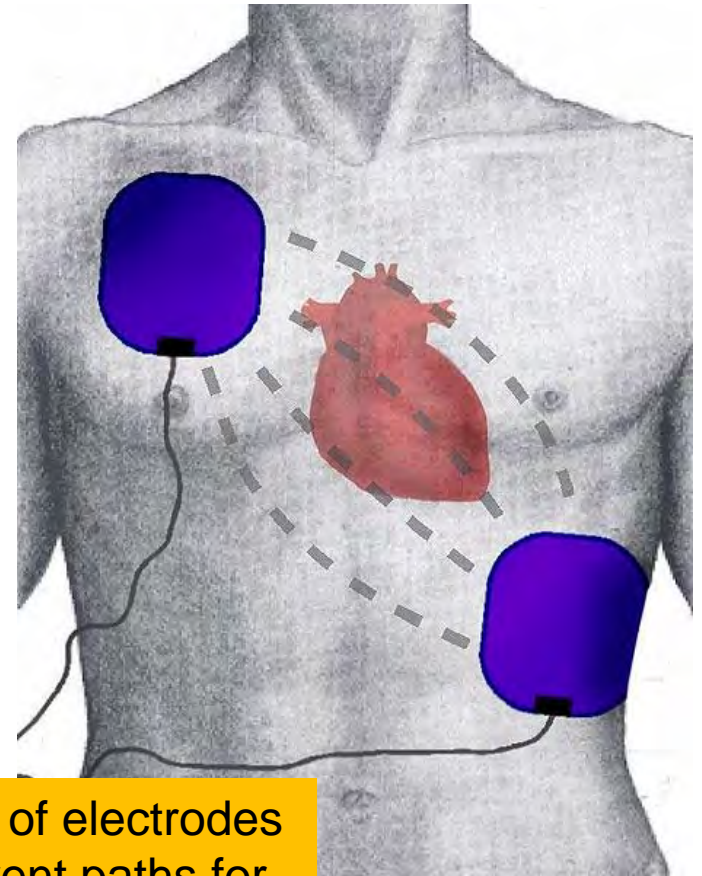


# Defibrillation

Ventricular fibrillation is an uncoordinated contraction of the cardiac (heart) muscle.

This can degenerate into a state of no cardiac electrical activity ("flatline") and death within minutes.

Defibrillators deliver electrical energy to the heart that allows normal rhythm to be reestablished by the body's natural pacemaker.



Position of electrodes and current paths for a paddle defibrillator





# Frankenstein (1931)

Electricity brings Frankenstein's monster to life in the 1931 horror classic yet it's not mentioned in the original book, written in 1818 and defibrillators were not invented until 1947.



Bolts for  
electrical  
contact



# Summary

- Electrical current produces ohmic heating.
- Rate at which energy is delivered (power) in ohmic heating increases as voltage goes up and as resistance goes down.
- The nervous system uses electrical signals to activate muscles, including the heart.
- Electrocution typically occurs due to a fatal disruption of the body's nervous system caused by a large current.
- Electric current can also restart the heart's pacemaker circuit (defibrillation).