Chapter 27:
Electric Currents, Resistance

"Now, with the *new* math . . ."
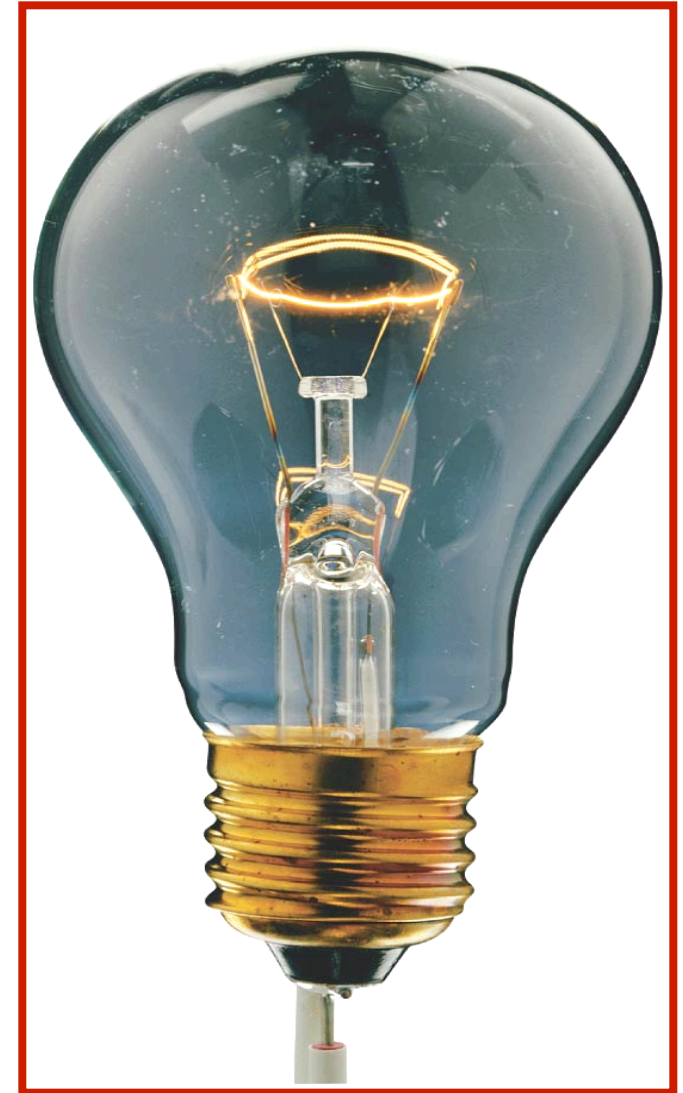
Chapter Outline

- The Electric **Battery**
- Electric **Current**

Ohm's *"Law"*
Resistance, Resistors, Resistivity

- Electric **Power**. **Power** in Household Circuits
Alternating Current
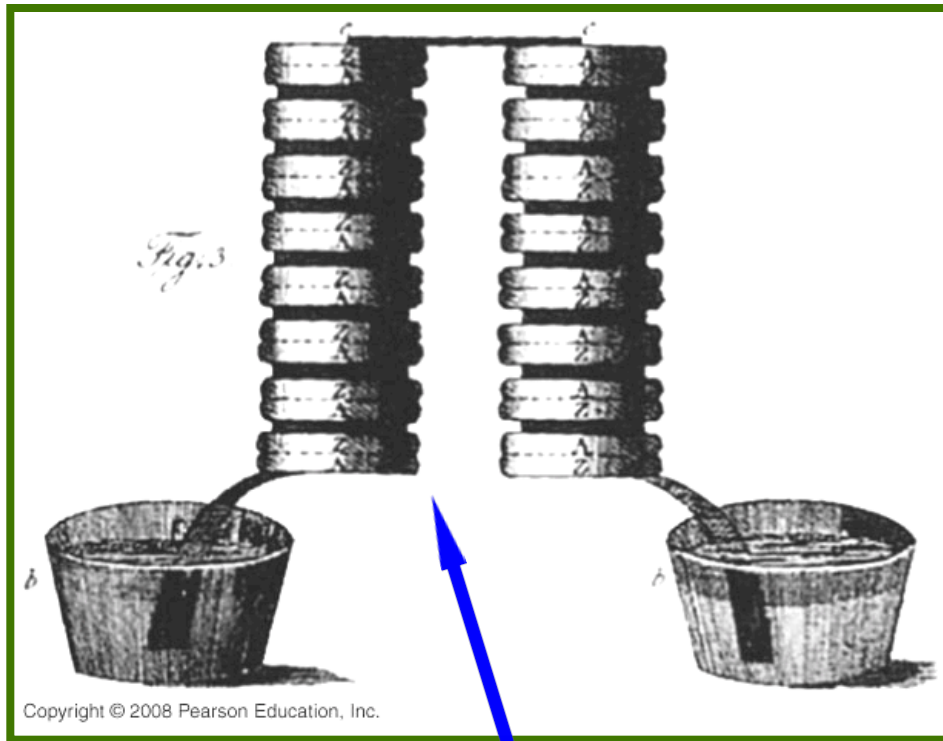
- Microscopic View of **Electric Current:**

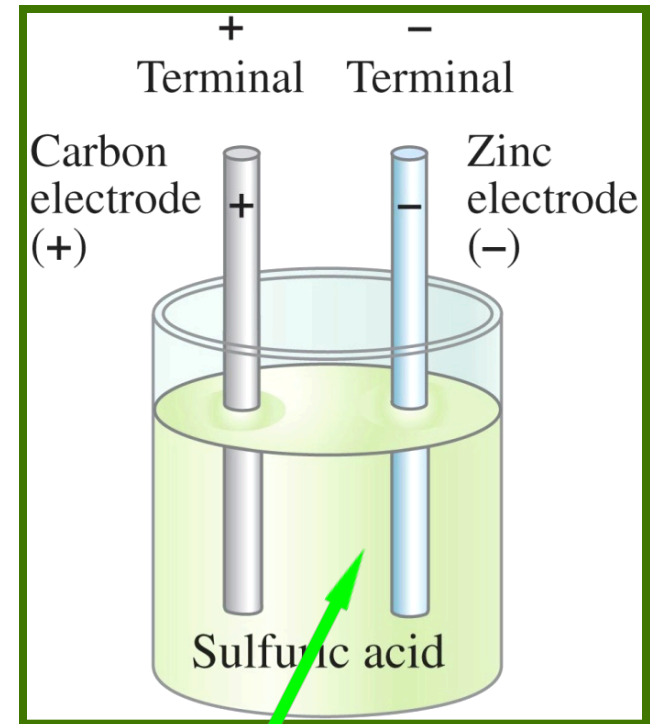Current Density & Drift Velocity
*Superconductivity***??**

- Electrical Conduction in the **Nervous System??**

The Electric Battery

• In 1801, **Alessandro Volta** discovered that electricity could be created if dissimilar metals were connected by a conductive solution called ***an electrolyte***. This is a simple ***Electric Cell.***

Volta's Original *Electric Cell*

A modern *Electric Cell*

Count Alessandro Giuseppe Antonio Anastasio *Volta*

Alessandro Volta
February 18, 1745 - March 5, 1827

Volta demonstrating his battery to Emperor Napoleon

Alessandro Volta (1745 – 1827). Italian physicist
•Known for pioneering work in electricity. Born in Como & educated in public schools. By 1800, he had developed the so called *voltaic pile,* **a forerunner of the** *electric battery*, which produced a steady stream of electricity. For his work in electricity, **the SI electrical unit known as** *the volt* **was named in his honor.** Also to honor him for this work, Napoleon made him a Count in 1801.

Luigi Galvani: (Sept. 9, 1737 - Dec. 4, 1798)

Luigi Galvani, Italian

Experimenting on frog legs!

Physiologist/anatomist/biologist. Founder of **electrochemistry**.

- Should be called a founder of **biophysics** also. Educated & taught anatomy in Bologna. Made early discoveries that advanced the study of electricity. His work with frogs led to his 1781discovery of **galvanic** or **voltaic electricity**. He made the muscles of a dead frog twitch when touched them with different metals current from an electric generator. Incorrectly thought fluid in the frog's body was the electric source. Later, **Volta** proved that the source of the electricity was a reaction caused by the animal's body fluids being touched by two different types of metal.
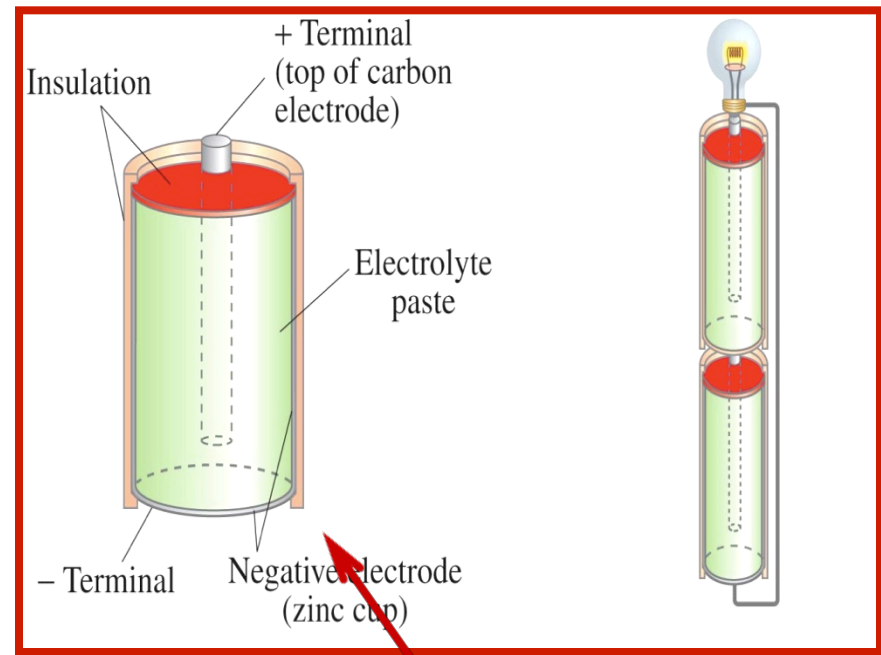
- Through **chemical reactions**, a battery transforms it's internal chemical energy into *Electrical Energy*.

- The chemical reactions within the cell create a *Potential Difference* between the terminals by slowly dissolving them. This **Potential Difference** can be maintained even if a current is kept flowing, until one or the other terminal is completely dissolved.

Insulation

+ Terminal (top of carbon electrode)

Electrolyte paste
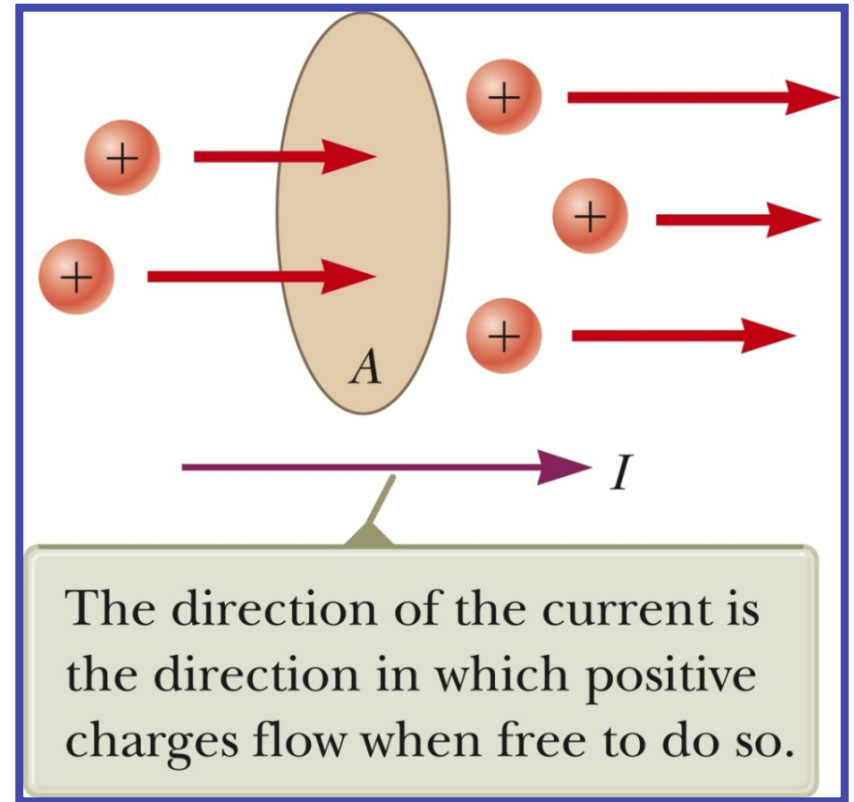
− Terminal

Negative electrode (zinc cup)

Common Household Battery

Technically, several cells connected together make a battery. Modern usage is to refer to a single cell as a battery also.

Average Electric Current

- Assume charges are moving perpendicular to a surface of area **A**.
- If **ΔQ** is the amount of charge that passes through **A** in time **Δt**, the average current is:

$$I_{avg} = \frac{\Delta Q}{\Delta t}$$

The direction of the current is the direction in which positive charges flow when free to do so.

Electric Current

- *Electric Current* is the rate of flow of charge through a conductor. *Average Current*:

$$I_{avg} = \frac{\Delta Q}{\Delta t}$$

- The *Instantaneous Current* is given by:

$$I = \frac{dQ}{dt}.$$

The SI unit of electric current is **The Ampère, A: 1 A = 1 C/s.**

André-Marie Ampère

André-Marie Ampère, **Jan. 22, 1775 - June 10, 1836**

- French physicist. *A Founder of Electromagnetism*. Prodigy who mastered all known mathematics by age 12! (?) Professor of physics, chemistry, & mathematics. Formulated a law of electromagnetism, called

Ampère's Law, that describes the magnetic force between two electric currents. An instrument he devised to measure the flow of electricity was later refined as the galvanometer. Chief published work: (1827):

Memoir on Mathematical Theory of Electrodynamic Phenomena

SI unit of electric current, the Ampere (A) named for him.

- A ***complete circuit*** is one where current can flow all the way around. Note that the schematic drawing doesn't look much like the physical circuit!
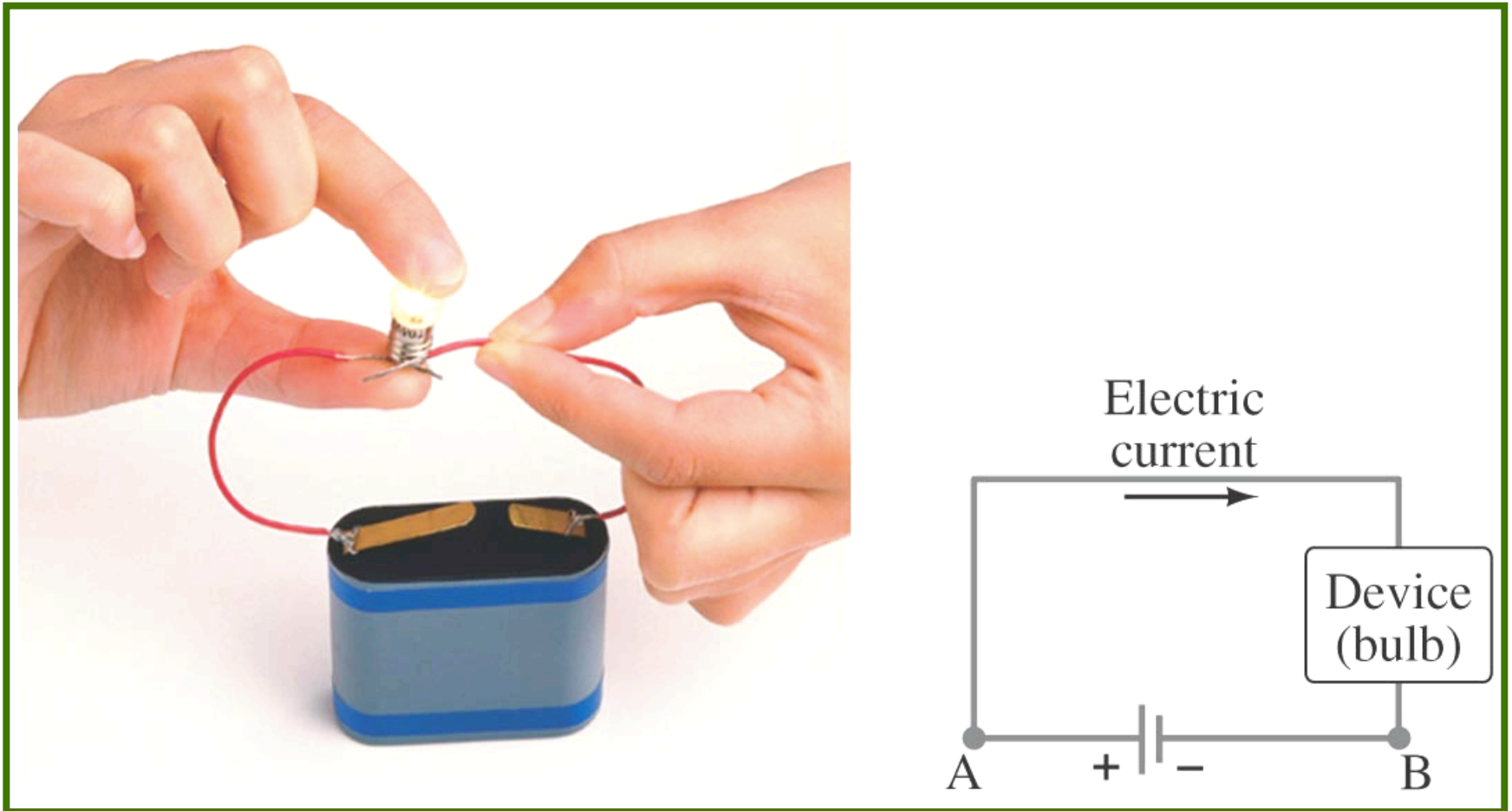
Example: Current - The Flow of Charge.

A steady current of **2.5 A** exists in a wire for **4.0 min**.

(a) Calculate the total charge which passes by a given point in the circuit during those **4.0 min**.

(b) How many electrons is this?

$$I_{avg} = \frac{\Delta Q}{\Delta t}$$

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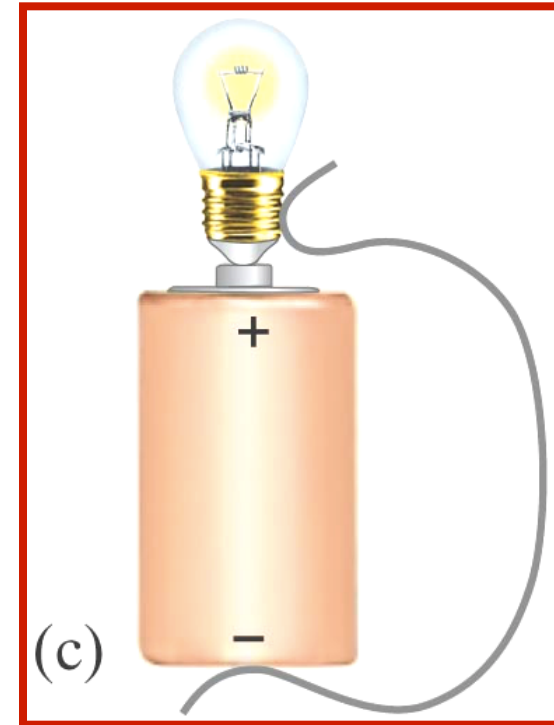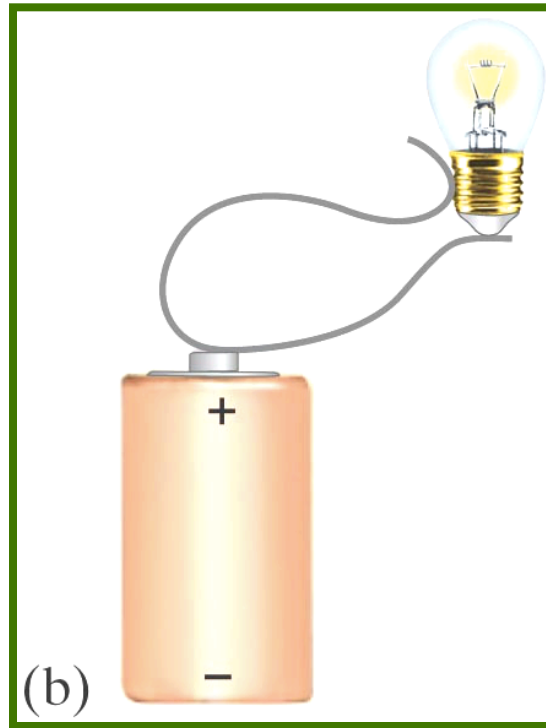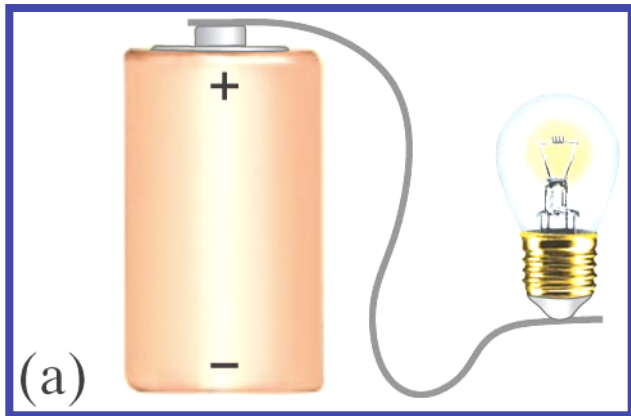
$$\Delta Q = (2.5 \text{ C/s})(240 \text{ s})$$

$$\Delta Q = 600 \text{ C}$$

$$\Delta Q = 3.75 \times 10^{21} \text{ electrons}$$

Conceptual Example
How to connect a battery.

What is wrong with each of the schemes shown for lighting a flashlight bulb with a flashlight battery and a single wire?

By convention, ***current is DEFINED*** as flowing ***from + to -.*** Electrons actually flow in the opposite direction, but not all currents consist of electrons.