



SCIENCE DISSECTED

Electric Current *Model-Evidence Link Diagram (MEL)*

Electric current can be described as a rate of movement or flow of electric charges through a conductor. Some resources only mention electrons as the source of that charge. Others argue that ions or atoms can also produce electric currents.

Electricity, on the other hand, has been described as a form of energy or a flow of electric power and charge. Is electric current a flow of charges between atoms and a flow of energy? Herein lies the debate. This issue of Science Dissected provides an instructional resource for teachers to present students with the opportunity to examine common misconceptions about electric current and electricity and to evaluate two competing models of electric current;

Model A: Electric current is a flow of charge.

Model B: Electric current is a flow of charge and energy.

Evidence #1: Batteries do not store electric charge or electrons. They have the ability to make charges move in a circuit. Batteries run out of energy.

Evidence #2: Electric current is a flow of charge, not energy. Charge and energy are different.

Evidence #3: Electric charge and electric energy flow along wires.

Evidence #4: Electricity is not only a flow of electrons. Electric currents can be caused by moving atoms or ions.

Evidence #5 Electricity is a flow of charge around a circuit. It carries energy throughout the circuit.

The following is a suggestion for using this MEL with students:

1. Hand out the Electric Current Model Evidence Link Diagram (page 1). Instruct students to read the directions, descriptions of Model A and Model B, and the five evidence texts presented.
2. Handout the five evidence text pages (pages 3-10).
3. Instruct students to carefully review the Evidence #1 text page (page 3), then construct two lines from Evidence #1; one to Model A and one to Model B. Remind students that the shape of the arrow they draw indicates their plausibility judgment (potential truthfulness) connection to the model.
4. Repeat for Evidence #2-5 (pages 4-10).
5. Handout page 2 for the students to critically evaluate their links and construct understanding.

Once students have completed page 2, they can then engage in collaborative argumentation as they compare their links and explanations with that of their peers. Students should be given the opportunity to make revisions during the collaborative argumentation exercise. If time permits, have students reflect on their understanding of electrical current and create questions that they might explore in the future. This can be a great KWL exercise for this unit.

Name: _____ Period: _____

Directions: draw two arrows from each evidence box. One to each model. You will draw a total of 10 arrows.

Key:

	The evidence supports the model
	The evidence STRONGLY supports the model
	The evidence contradicts the model (shows its wrong)
	The evidence has nothing to do with the model

Standard:

CCSS Mathematics- SMP3

CCSS ELA –RL.8.1

SCIENCE: P.8.C.6

Evidence #1
Batteries do not store charge /electrons.

Evidence #2
Electric current is a flowing motion of charged particles; and the particles do not carry energy with them as they move.

Model A
Electric current is a flow of charge.

Model B
Electric current is a flow of charge and energy.

Evidence #3
Two things flow along wires- electric charge and electric energy.

Evidence #4
Electricity is not made up of a flow of only electrons .

Evidence #5
Electricity is the flow of charge around a circuit carrying energy to the load(s).

Provide a reason for three of the arrows you have drawn. **Write your reasons for the three most interesting or important arrows.**

- A. Write the number of the evidence you are writing about.
- B. Circle the appropriate descriptor (**strongly supports** | **supports** | **contradicts** | **has nothing to do with**).
- C. Write the letter of the model you are writing about.
- D. Then write your reason.

1. Evidence # ____ **strongly supports** | **supports** | **contradicts** | **has nothing to do with** Model ____ because:

2. Evidence # ____ **strongly supports** | **supports** | **contradicts** | **has nothing to do with** Model ____ because:

3. Evidence # ____ **strongly supports** | **supports** | **contradicts** | **has nothing to do with** Model ____ because:

4. Circle the plausibility of each model. [Make two circles. One for each model.]

	Greatly implausible (or even impossible)										Highly Plausible
Model A	1	2	3	4	5	6	7	8	9	10	
Model B	1	2	3	4	5	6	7	8	9	10	

5. Circle the model which you think is correct. [Only circle one choice below.]

Very certain that Model A is correct	Somewhat certain that Model A is correct	Uncertain if Model A or B is correct	Somewhat certain that Model B is correct	Very certain that Model B is correct
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Evidence #1: Batteries do not store charge/ electrons.

Because we talk about 'charging' a battery, it's a common misconception that batteries store electric charge or electrons.

This is tied up with another incorrect idea that an electric current is the flow of electrons [through initially empty wires](#).

For every electron that leaves a battery at one terminal another one enters at the other, so batteries never run out of charge. What they run out of is the ability to make the charges everywhere in the circuit move. This is essentially because the chemicals that [make the battery work](#) have all reacted.



[Animation](#) showing a simplified

model of how a battery works.

It's useful to think of batteries running out of [energy](#).

Source----- <http://www.furryelephant.com/content/electricity/teaching-learning/misconceptions/>

Evidence #2: Electric current is a flowing motion of charged particles; and the particles do not carry energy with them as they move.

An electric current is a flowing motion of charged particles, and the particles do not carry energy along with them as they move. A current is defined as a flow of charge by $I=Q/T$; amperes are coulombs of charge flowing per unit time. The term "Electric Current" means the same thing as "charge flow." Electric current is a very [slow](#) flow of charges.

On the other hand, electric energy is different than charge. The energy travelling across an electric current is made up of waves in electromagnetic fields and it moves VERY rapidly. Electric energy moves at a completely different speed than electric current, and obviously they are two different things flowing in wires at the same time. Unless we realize that two different things are flowing, we won't understand how circuits work. Indeed, we will have little grasp of basic electrical science.

In an electric circuit, the path of the electric charges is circular, while the path of the energy is not. A battery can send electric energy to a light bulb, and the bulb changes electrical energy into light. The energy does *not* flow back to the battery again. At the same time, the electric current is different; it is a very slow circular flow, and the electric charges flow through the light bulb filament and all of them return to the battery.

Electric energy can even flow in a direction *opposite* to that of the electric current. In a single wire, electric energy can move continuously forward while the direction of the electric current is alternating back and forth at high frequency. The charges wiggle, while the energy flows forward; electric current is not energy flow.

Here's one way to clarify the muddled concepts: if electric current is like wind, then electrical energy is like some sound waves, and electrons are like the molecules of the air. For example, sound can travel through a pipe if the pipe is full of air molecules, and electrical energy can flow along a wire because the wire is full of movable charges. Sound moves much faster than wind, correct? And electrical energy moves much faster than electric current for much the same reason. Air in a pipe can flow fast or slow, while sound waves always move at the same very high speed. Charges in a wire can flow fast or slow, while electrical energy always flows along the wire at a single incredibly high speed. Whenever sound is flowing through a pipe, the air molecules in that pipe are vibrating back and forth. When waves of AC electrical energy are flowing along a wire, the electrons in that wire are vibrating back and forth 60 times per second.

Suppose that we were all taught that sound and wind are the same thing? This would prevent us from understanding wind or sound. Where electricity is concerned, K-6 textbooks teach us that "sound" and "wind" are the same. They say that electric currents are a flow of energy, as if wind were really sound. It completely prevents us from understanding both electric current and energy flow.

Be careful, since my description of the above pipes are just an analogy, and sound waves aren't *exactly* like electrical energy. For example, sound can flow inside an air-filled tube, while electrical energy always flows in the space outside of the wires, and does not travel along within the metal wires. However, electrical energy is coupled with compression waves in the electrons of the wire. Electron-waves travel inside the wires, yet the energy they carry is in the invisible fields surrounding the wires.

Is it important for us to realize that wind is not sound? Obviously yes! School books would cause harm if they taught us that wind is sound. And if we want to understand circuits, we need a clear view of electric charge-flow, and of electric energy flow. Students need to be totally certain that they are two different things, and our textbooks teach us the exact opposite.

Source= <http://amasci.com/miscon/eleca.html#current>

Evidence #3: Two things flow along wires- electric charge and electric energy.

What is electricity?

Here is the simple answer. There are TWO main things that flow along wires:

- Electric Charge
- Electric Energy

There are several other things that flow as well, but to keep it simple, we'll ignore them.

Because there are TWO things flowing, we cannot call them by the name "electricity." For this reason, we cannot ask "what is electricity?" Instead we have to ask more specific questions like these:

1. What is the stuff that flows **through** a light bulb and comes back out again through the other wire?
2. What is the stuff that flows **into** a light bulb and gets changed entirely into light and heat?

The answer to question #1 is **ELECTRIC CHARGE**. Charge is a "stuff" that flows through light bulbs, and it flows *around* a circuit. Normally no charge is lost during the operation of a circuit, and no charge is gained. Also, charge flows very slowly, and it can even stop flowing and just sit there inside the wires. In an AC circuit, charge does not flow forwards at all, instead it sits in one place and wiggles forwards and back.

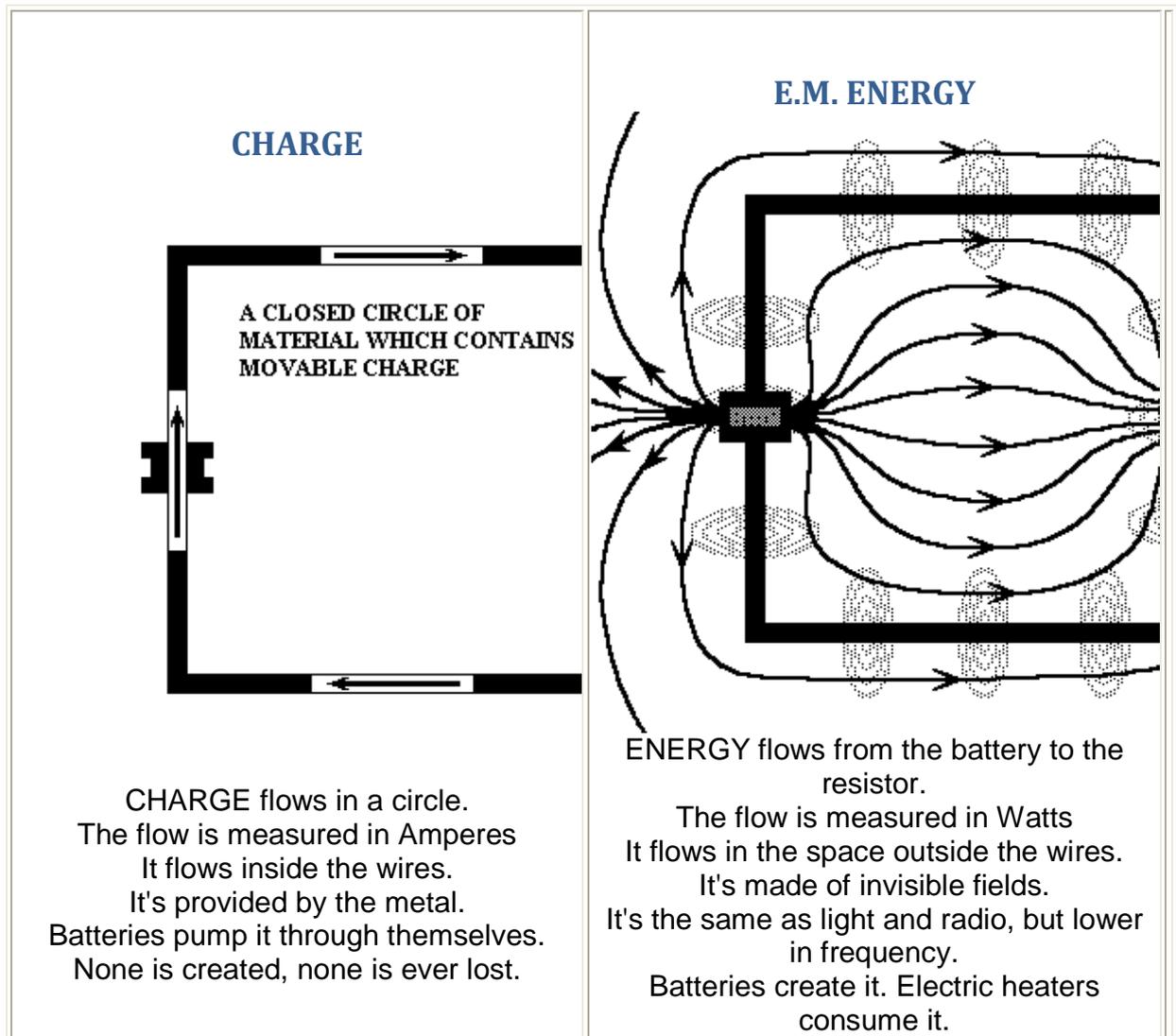
The answer to question #2 is **ELECTRICAL ENERGY**. It's also called "electromagnetic energy". This energy is also like "stuff" and it can flow from place to place. It always flows very fast; almost at the speed of light. It can be gained and lost from circuits, such as when a light bulb changes the flow of electrical energy into a flow of light and heat.

Here is a list of differences of these two kinds of "stuff":

ELECTRIC CHARGE	---	E.M. ENERGY
Flows very slowly, and can even stop.	-----	Always flows incredibly fast, almost at the speed of light.
The flow is called "electric current," measured in Amps.	-----	The flow is called "electric power," measured in Watts.
Flows through light bulbs	---	Consumed by light bulbs (and converted into light)
In AC cables, it wiggles back and forth	---	In AC cables, it flows continuously forwards
Supplied by metals (and by all other conductors)	---	Supplied by generators, batteries, etc.
It's a component of matter	---	A form of energy
Doesn't usually leave a circuit.	---	A "Source" injects it into a circuit, while a "load" removes it again.
Composed of movable charges from conductor atoms	---	Composed of electromagnetic fields
Electrons and protons are particles of CHARGE	---	Photons are particles of E.M. energy
Flows inside of wires	---	Flows in the space adjacent to wires
Generators pump it through themselves	---	Generators create it
Circular flow. It flows around and around the circuit, and never leaves it.	---	One-way flow, from a "source" to a "load".
VISIBLE: it is the silvery part of a metal	---	INVISIBLE: the EM energy can only be seen if you use iron filings, etc.
Measured in units called Coulombs	---	Measured in units called Joules
Occurs naturally	---	Produced and sold by electric companies
Scientists of old called it "electricity."	---	Today, electric companies call it

	"electricity."
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Perhaps some pictures would help? Here are two diagrams below. More can be found at [Where does the Energy flow?](#)



Electric charge flows along wires. So does electromagnetic energy. If you ask "what is electricity", the answer is WHICH ONE?

<http://amasci.com/elect/elefaq1.html#ae>

Evidence #4: Electricity is not made up of a flow of only electrons.

Electricity is not made up of only electrons.

Other things flow besides electrons. It's true that electric current *in metals* is a flow of electrons. But there are many other conductors besides metals, and in many of them the currents are not caused by moving electrons. Electric currents can also appear in electrolytes or in plasma. When an electric current creates the glowing plasma within a neon sign, electrons flow in one direction, while positively charged *atoms* flow in the other. Yes, there is an electron flow in the glowing gas, but part of the total electric current is also made of moving positive atoms which flow the other way.

Also there can be electric currents where no electrons flow at all. The currents in electrolytes (such as wet dirt and human flesh) are entirely composed of flows of ions: electrified atoms. Bare electrons can't exist in salt water. In electrolytes, half of the atoms have more protons than electrons, and the other half has more electrons than protons. During a current, the opposite-charged atoms move in opposite directions. For example, when an electric current is passing through the inside of a battery, it is not made of moving electrons, it is made of moving electrolyte atoms (ions), and each atom carries a charge imbalance. The positive atoms flow one way, and the negative atoms flow the other.

The same thing happens when an electric current passes through the damp earth, or through the ocean, or through your body. All are non-electron currents. If you receive an electric shock, no electrons flowed inside you. These electric currents are flows of atoms. All the electric currents in your brain and nerves are composed of moving sodium and potassium atoms. No electrons.

Source= <http://amasci.com/miscon/eleca.html#current>

Evidence #5: Electricity is the flow of charge around a circuit carrying energy to the load(s).

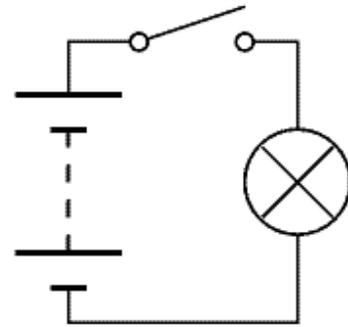
Electricity and the Electron

What is electricity?

Electricity is the **flow of charge** around a circuit **carrying energy** from the battery (or power supply) to components such as lamps and motors.

Electricity can flow only if there is a **complete circuit** from the battery through wires to components and back to the battery again.

The diagram shows a simple circuit of a battery, wires, a switch and a lamp. The switch works by breaking the circuit.



With the **switch open** the circuit is broken - so electricity cannot flow and the lamp is off.

With the **switch closed** the circuit is complete - allowing electricity to flow and the lamp is on. The electricity is carrying energy from the battery to the lamp.

Source= <http://www.kpsec.freeuk.com/electron.htm>