Light Bulb Lesson

Title: How A Light Bulb Works Lab

Principles Investigated: This activity demonstrates how electrical energy is used in light bulbs as radiant and thermal energy. This activity can be used to demonstrate the following:

- The differences between various types of light bulbs.
- Concept of exciting electrons causing them to shift to a higher energy level and thus, producing energy.
- Methods of energy conservation.

Situating the Lesson:
Students should have some knowledge of atoms. This lesson followed one in which the various forms of energy were explored.

Materials:

- Lamp (3)
- Halogen Bulb
- Fluorescent Bulb
- Incandescent Bulb
- Nichrome Wire
- Insulated Copper Wire
- D Batteries
- Nails
- Clear Cups
- Modeling Clay
- Trays
- Lab Write Up

Procedure:

- This lesson is geared towards English Language Learners.
- This lesson is divided up into three parts:
  - Part 1 – Exploring Different Types of Light Bulbs
    - Have students observe the following kinds of bulbs (turned on): incandescent, fluorescent, halogen.
    - They should rank the temperature (they can feel the heat being emitted, but should not touch it), rank the brightness, and draw a picture of the bulb including the inside.
    - Discuss what the students observed using this as a lead in to part 2.
  - Part 2 – Building A Light Bulb
    - Explain to students that they will build a light bulb, but do not tell them what kind.
    - Go through the procedure on the lab write-up step by step (using visuals and modeling).
    - Students should complete the circuit one battery at a time. They should make observations including temperature and what the nichrome wire looks like (i.e. glowing).
    - After students have answered the discussion questions go over what they saw. Ask students to share their drawing of “How a light Bulb works” with two other groups. Using a diagram reinforce students’ correct answers/clarify wrong ones.
  - Part 3 – Light Bulb and Electricity Information Walk Around
    - Rather than have students sit and read I prefer to complete this task using walk around activities.
    - Place pieces of information re: light bulbs around the room and have students rotate from one station to another. They should fill in the blanks on their lab write up.
    - Afterwards, students should answer the discussion questions.
    - Discuss the issues covered through this activity.

- At the end of the lesson I give each student (13 in total) a fluorescent bulb, which I have received from the Energy Coalition, to use at home.

Explanation:

I have included information from the "How Stuff Works" website - http://howstuffworks.lycoszone.com/fluorescent-lamp7.htm. Information that is discussed includes the following:

- How Light Bulbs Work
- Fluorescent Bulbs
- Halogen Bulbs

** Please note that I do not go into great detail with my English Language Learners. More detailed explanations as well as a more complex lab write up (i.e. use of more vocabulary/in depth discussion questions) should be used in mainstream and higher level classes.

Applications to Everyday Life:

- **Choosing the Right Light Bulb:** Understanding how each type of light bulb works is important in choosing which is best for your home. This activity makes students aware of the advantages/disadvantages of using various types of bulbs (i.e. pollution, energy consumption, cost, etc).
- **Being Energy Efficient:** Students can apply the idea of conserving energy to other appliances in their home. This activity could be used to spur a discussion about other high energy consuming devices, various sources of energy, and methods to conserve our resources.

**** These ideas can be reinforced by performing an experiment at home. Students can log their current energy usage, come up with an idea of how to change their behavior or device to conserve energy, and log how this change affects their electricity bill.**

References:

Energy Coalition - http://www.energycoalition.org
Energy Star - http://www.energystar.gov
How Stuff Works - http://howstuffworks.lycoszone.com/fluorescent-lamp7.htm

Light Bulb Lab

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Disclaimer

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SDAIE

- Oftentimes teachers lack pictures and diagrams in their lessons. English Language Learners (ELL) have a difficult time understanding and keeping up in the mainstream environment due to this.
- This lesson was designed for my SDAIE (Specially Designed Academic Instruction in English) science class (grade level 6th thru 8th).

Principles Investigated

- This activity demonstrates the following:
  - The differences between various types of light bulbs.
  - Concept of exciting electrons causing them to shift to a higher energy level and thus, producing energy.
  - Methods of energy conservation.

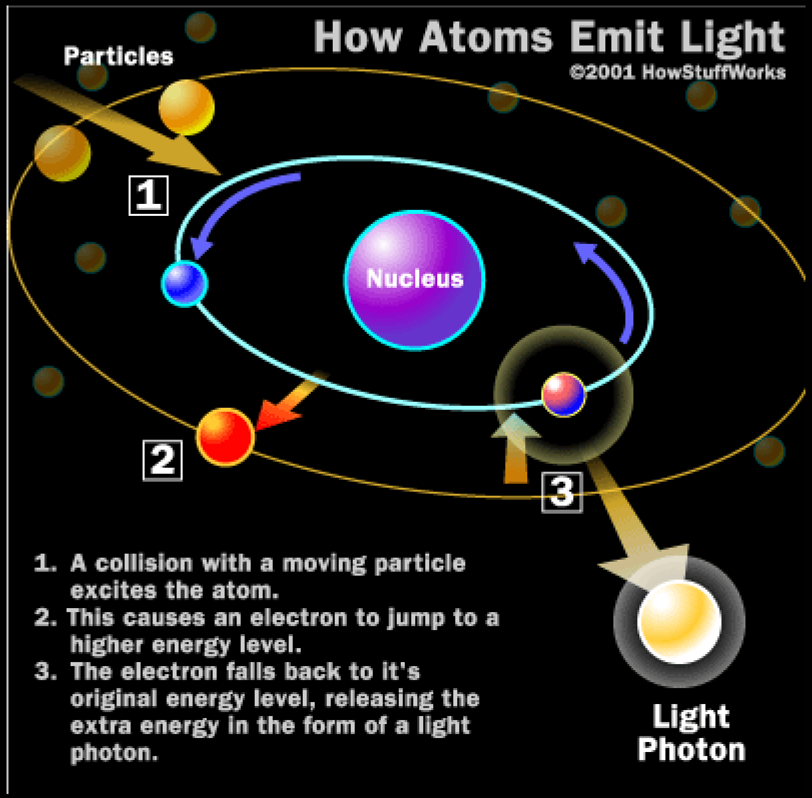
www.onesourcelighting.com/../ default.asp (3/7/2004)

www.buylighting.com/ capsylite-light-bulbs.htm (3/7/2004)

http://www.alliantenergy.com/ stellent/groups/public/documents/pub/res_ia_cs_phn_010349.hcsp (3/7/2004)

Prior Knowledge

- Students should have some knowledge of atoms.
- This lesson followed one in which the various forms of energy were explored.



http://howstuffworks.lycoszone.com (3/7/2004)

3 Part Lab Activity

- Part 1
  - Exploring Different Kinds of Light Bulbs
- Part 2
  - Building A Light Bulb
- Part 3
  - Light Bulb and Electricity Information Walk Around

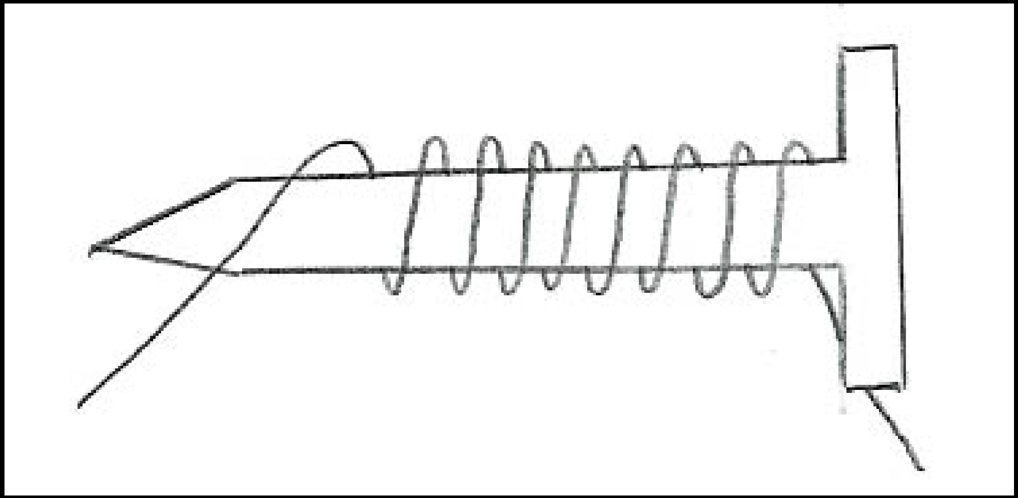
** Due to lack of time we will focus on part 2. Please peruse part 1 and 3 on your own in order to see the big picture.

Building A Light Bulb

- You should have the following in your box:
  - 10cm Nichrome Wire (pre-cut)
  - 15cm Insulated Copper Wire (2) – pre-cut
  - Nails (2)
  - Clear Plastic Cup
  - Modeling Clay
  - Tray
  - D Batteries (4)

Preparing Filament

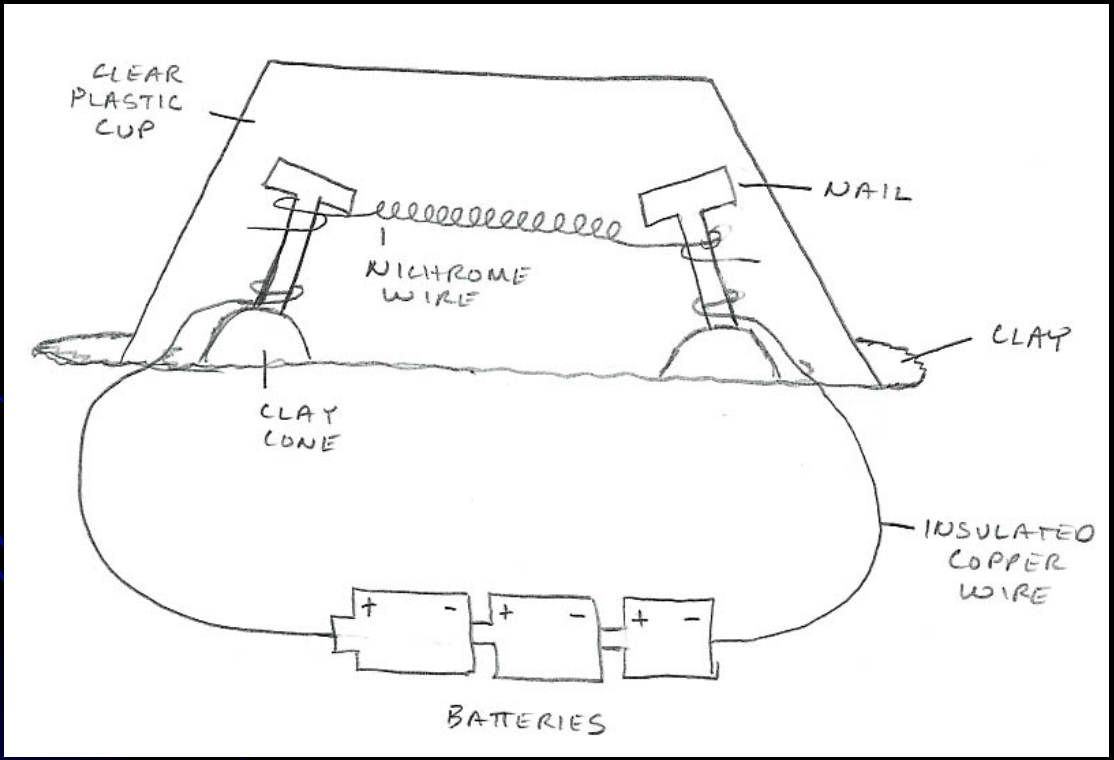
- Wrap the Nichrome Wire around one of the nails. Leave about 2cm of wire at each end.



- Once you are finished slide the coiled wire off the nail.

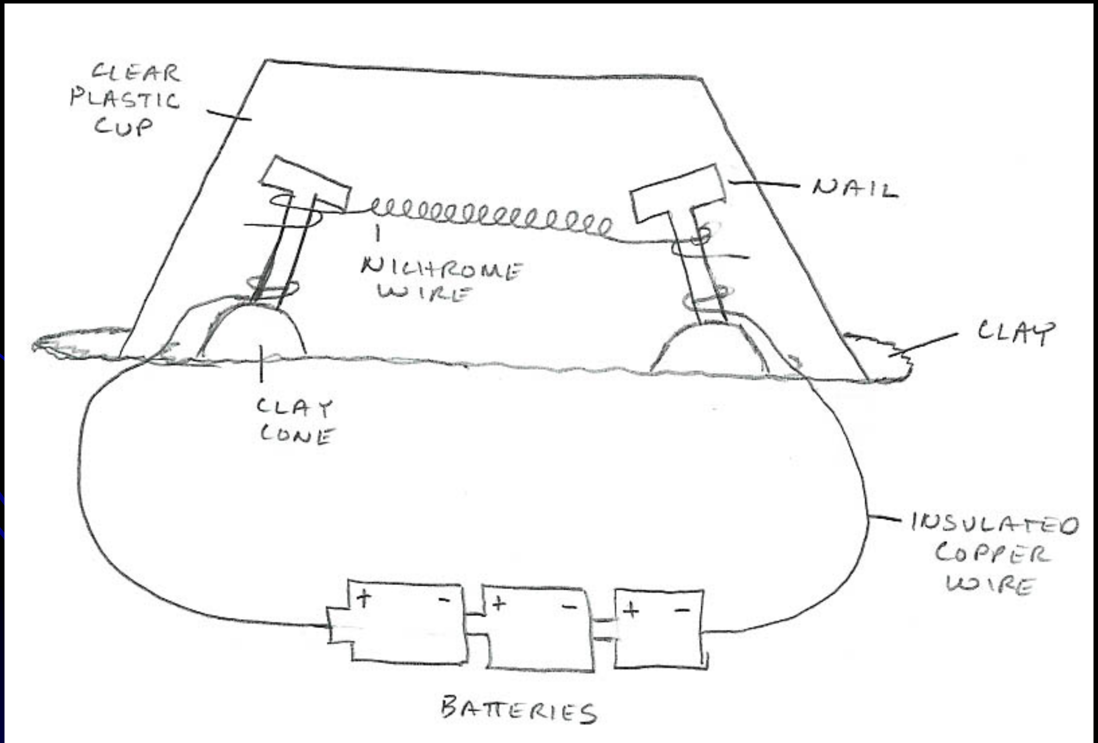
Preparing the Base

- Flatten a piece of clay like a pancake.
- Make two cones using the clay so the nails can stand up in the clay.



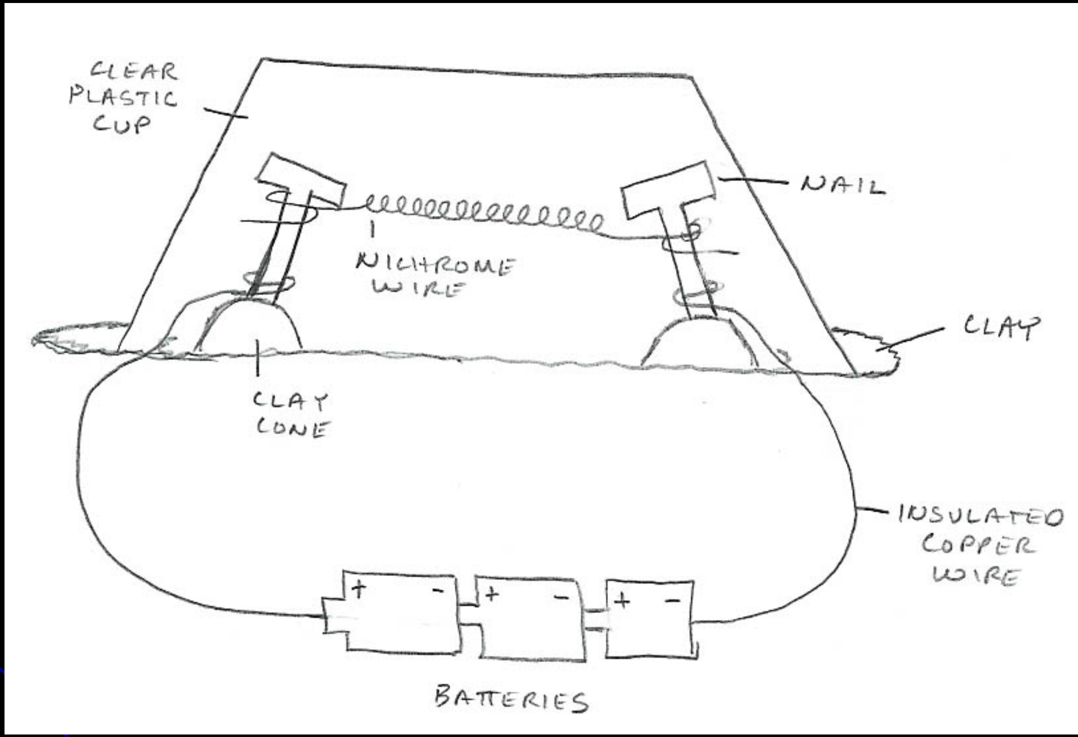
Setting Up the Bulb

- Stick the two nails in the clay cones slanting them slightly toward the middle.
- Attach the Nichrome Wire filament to the two nails.
- Attach the Insulated Copper Wire to the base of the nails.



Connecting the Circuit

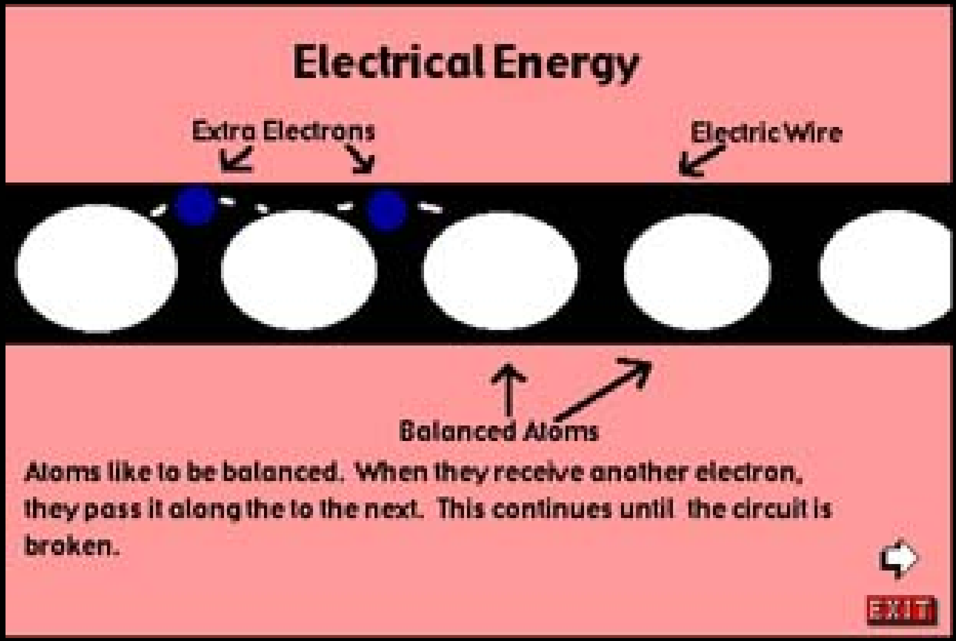
- Place the cup over your light bulb.



- Connect one battery to the circuit and record your observations. Keep adding batteries until you see the Nichrome Wire give off light.

Explanation

- Why was the Nichrome wire able to give off light?
  - Movement of electrons.
    - Atoms lose and gain electrons making them positive or negative = unbalanced.
    - Atoms want to be neutral.
    - Positive atom will attract electrons and the negative atom will push away electrons.
    - This flow of electrons creates electrical energy.



http://www.coe.ufl.edu/courses/edtech/support/teacher/TRL/Andy/hyperstudio.htm (3/7/2004)

Application

- The overall theme of this activity is energy conservation.
- This activity can spur discussions re:
  - **Choosing the Right Light Bulb**
    - Understanding how each type of light bulb works is important in choosing which is best for your home. This activity makes students aware of the advantages/disadvantages of using various types of bulbs (i.e. pollution, energy consumption, cost, etc).

Application Continued

- **Being Energy Efficient:**
  - Students can apply the idea of conserving energy to other appliances in their home. This activity could be used to spur a discussion about other high energy consuming devices, various sources of energy, and methods to conserve our resources.

Reinforcement

These ideas can be reinforced by performing an experiment at home.

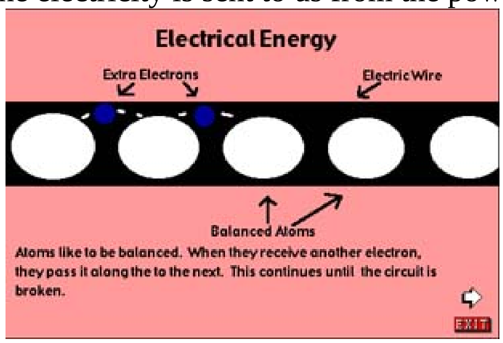
Students can log their current energy usage, come up with an idea of how to change their behavior or device to conserve energy, and log how this change affects their electricity bill.

SDAIE Science

How A Light Bulb Works Lab

Background:

How do we get our electricity? You might say it comes from a power plant. How does the power plant make electricity? Electricity wouldn't be around if it weren't for those atoms that we talk so much about. Remember atoms are made of protons, neutrons, and electrons. Protons are positive and electrons are negative. Atoms like to have the same amount of protons and electrons so it can stay balanced. We learned in our last unit that atoms can lose electrons and they can gain electrons. When one electron leaves an atom that atom becomes positive. The electron that was lost moved to another atom making it negative. Both atoms are now out of balance. These atoms want to get balanced. The positive atom will attract an electron from another atom. The negative atom will push away the electron it gained. Then it happens again and again and again….making ELECTRICITY! The electricity is sent to us from the power plant using electric wire.



http://www.coe.ufl.edu/courses/edtech/support/teacher/TRL/Andy/hyperstudio.htm (3/7/2004)

There are three kinds of light bulbs humans use: **incandescent, halogen,** and **fluorescent.** We will talk more about these later.

Part 1: Exploring Different Kinds of Light Bulbs

Procedure:

1. Check out the different kinds of light bulbs at Ms. Steinmetz's lab station.
2. In the chart below make your observations – rank the temperature of each bulb (how hot it feels. You may put your hand close to it, but do NOT touch it), rank how bright each bulb is, and draw a picture of the bulb (including what you see inside). Rank bulbs from 1-3. 1 is the brightest or hottest. 3 is the dimmest or the coolest.

Observations:

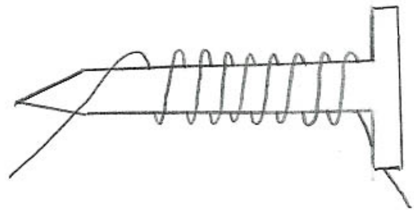
Bulb Type	Temperature Rank	Brightness Rank	Picture
Incandescent			
Fluorescent			
Halogen			

<u>Part 2:</u> Building A Light Bulb

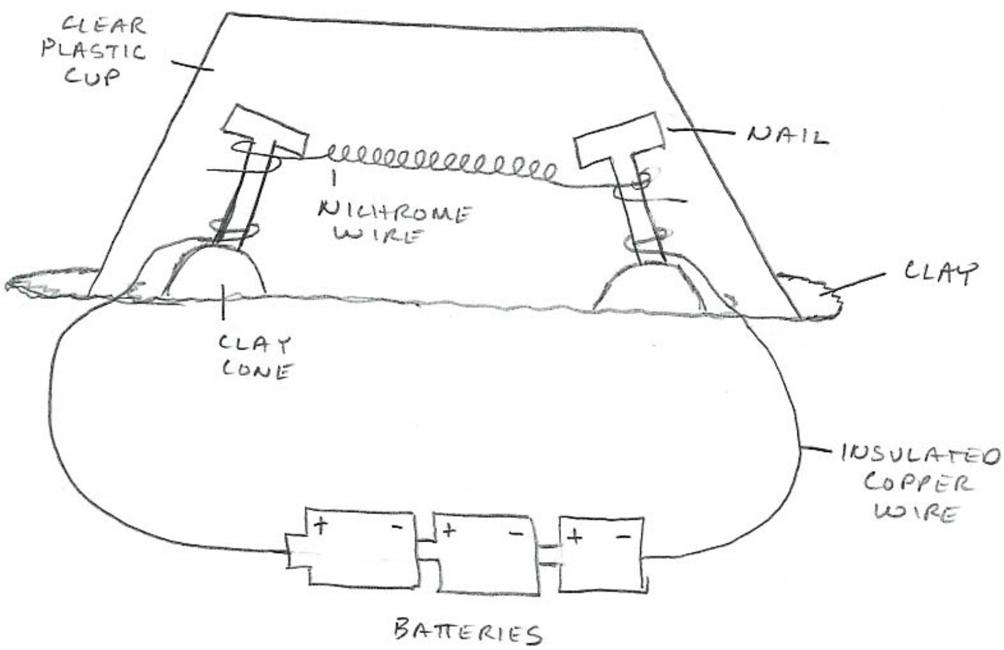
Materials: 10cm Nichrome Wire, 15cm Insulated Copper Wire (2), Batteries (4), Nails (2), Clear Cup, Modeling Clay

Procedure:

1. Wrap the Nichrome Wire around one of the nails. Make sure the coils are close together, but not touching. Leave about 2cm of wire at each end. See picture below.



2. Slide the coil off the nail.
3. Flatten a piece of modeling clay on your tray (like a pancake). Make two little cones using the clay so the nails can stand up in the clay. See picture below.
4. Stick the two nails in the cones and slant them slightly towards the middle.
5. Connect the coil Nichrome Wire to the top of the two nails and connect the metal part of the Insulated Copper Wires to the bottom of the nails. See picture below.
6. Place the cup over your light bulb. See picture below.



7. Connect your wires to one battery and watch for about 10-15 seconds. Record your observations in the data table below (Is the cup hot? Is the Nichrome Wire glowing?)
8. Repeat step #7 adding one battery at a time until the filament wire begins to glow. If it takes more than four batteries pair up with another group and share one light bulb. Do not connect more than 8 batteries.

Observation Table:

# Batteries	Temperature	Nichrome Wire
1		
2		

# Batteries	Temperature	Nichrome Wire
3		
4		
5		
6		
7		
8		

Discussion Questions:

1. How many batteries did it take to see the Nichrome Wire glow? __

2. How many batteries do you think it would take to make this light bulb bright enough to read a book? __

3. What type of light bulb do you think we made? ____

4. Using what you learned in the "Background", draw a picture showing how this light bulb works. Make sure you label your drawing.

5. What happened to the electrons when you disconnected the wire from the battery?

6. Which did you observe first? Heat or light? ____________

7. Which do you think there was more of? Heat or light? ____________

<u>Part 3</u>: Light Bulb and Electricity Information Walk Around

Station #1: What type of light bulb do most people use in their homes? ___________________________________

Station #2: How much of the energy used by incandescent light bulbs is turned into light? ____%. The other ____% is turned into __________ energy.

Station #3: How hot can halogen light bulbs get? _________ degrees Farenheit. This can cause ____.

Station #4: Incandescent bulbs create _____________ by running _______________ through a ________ _____________________ until it ____________ with ______________.

Station #5: Halogen bulbs work the same way as _______________________ bulbs except they are filled with _______________ ________, which makes more ______________.

Station #6: Fluorescent bulbs have __________________ on the glass inside and are filled with __________ that _________ and give off _________ when they are _____________ by electricity.

Station #7: Fluorescent bulbs use approximately ________ the amount of energy needed to make an incandescent bulb work.

Station #8: Fluorescent bulbs last _____ to _____ times longer than incandescent bulbs.

Station #9: One compact fluorescent light bulb can save you approximately __________ dollars!

Station #10: The main way we get electricity is by _________________ _____________ __________. Burning ______________ ____________ ________________ the air and causes __________________ _______________________.

Station #11: When you use less energy everyday ________ fossil fuels are being ___________.

Station #12: If ______ room in every home used a compact fluorescent light bulb, it would keep ______________________ out of the air. This is the same as keeping _____________________ cars off the road! Wow…if we did this we would have cleaner air to ________________.

Station #13: An incandescent bulb only lasts about ____________ hours while a fluorescent light bulb can last up to _______________ hours.

Discussion Questions:

1. Which light bulb would you use in your home? _________________________. Why?

2. What kind of light bulb do you use most in your home? ____________________________

3. What kind of light bulb would be best to use in your home? _________________________ Why?

Part 3: **Light Bulb and Electricity Information Walk Around**

Station #1: Most people use incandescent light bulbs in their home.

Station #2: Approximately 90% of the energy used by incandescent bulbs is used to create HEAT and only. The other 10% is turned into light energy.

Station #3: Halogen bulbs burn at temperatures as high as 1, 000 degrees. This can cause fires to start in people's homes.

Station #4: Incandescent bulbs create light by running electricity through a filament wire until it glows with heat.

Station #5: Halogen bulbs work the same way as incandescent bulbs except they are filled with halogen gas, which makes more light.

Station #6: Fluorescent bulbs have chemicals on the glass inside and are filled with gases that react and give off light when they are excited by electricity.

Station #7: Fluorescent bulbs use approximately ¼ the amount of energy needed to make an incandescent bulb work.

Station #8: Fluorescent bulbs last 10 to 20 times longer than incandescent bulbs.

Station #9: One compact fluorescent light bulb can save approximately 108 dollars!

Station #10: The main way we get electricity is by burning fossil fuels. Burning fossil fuels pollutes the air and causes global warming.

Station #11: When you use less energy everyday less fossil fuel are being burned.

Station #12: If one room in every home used a compact fluorescent light bulb, it would keep greenhouse gases out of the air. This is the same as keeping one million cars off the road! Wow…if we did this we would have cleaner air to breathe.

Station #13: An incandescent bulb only lasts about 1,000 hours while a fluorescent light bulb can last up to 10,000 hours.

How Light Bulbs Work

by Tom Harris

Before the invention of the light bulb, illuminating the world after the sun went down was a messy, arduous, hazardous task. It took a bunch of candles or torches to fully light up a good-sized room, and oil lamps, while fairly effective, tended to leave a residue of soot on anything in their general vicinity.

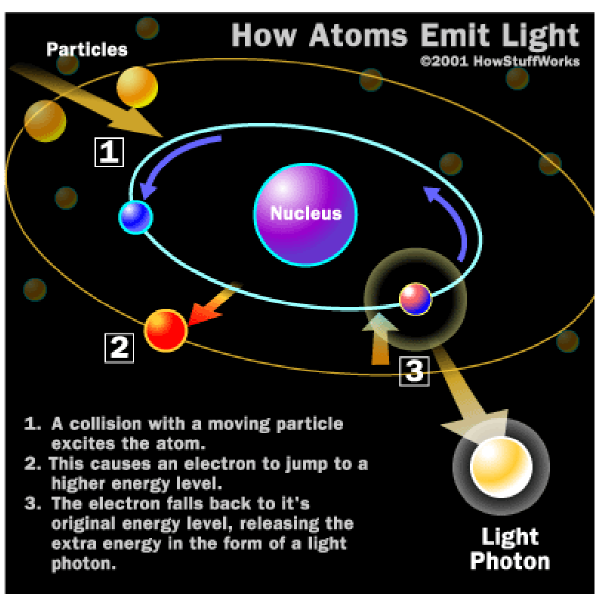
When the science of electricity really got going in the mid 1800s, inventors everywhere were clamoring to devise a practical, affordable electrical home lighting device. Englishman Sir Joseph Swan and American Thomas Edison both got it right around the same time (in 1878 and 1879, respectively), and within 25 years, millions of people around the world had installed electrical lighting in their homes. The easy-to-use technology was such an improvement over the old ways that the world never looked back.

The amazing thing about this historical turn of events is that the light bulb itself could hardly be simpler. The modern light bulb, which hasn't changed drastically since Edison's model, is made up of only a handful of parts. In this edition of **HowStuffWorks** , we'll see how these parts come together to produce bright light for hours on end.

Light Basics

Light is a form of energy that can be released by an atom. It is made up of many small particle-like packets that have energy and momentum but no mass. These particles, called light **photons**, are the most basic units of light. (For more information, see How Light Works.)

Atoms release light photons when their **electrons** become excited. If you've read How Atoms Work, then you know that electrons are the negatively charged particles that move around an atom's nucleus (which has a net positive charge). An atom's electrons have different levels of energy, depending on several factors, including their speed and distance from the nucleus. Electrons of different energy levels occupy different orbitals. Generally speaking, electrons with greater energy move in orbitals farther away from the nucleus. When an atom gains or loses energy, the change is expressed by the movement of electrons. When something passes energy on to an atom, an electron may be temporarily boosted to a higher orbital (farther away from the nucleus). The electron only holds this position for a tiny fraction of a second; almost immediately, it is drawn back toward the nucleus, to its original orbital. As it returns to its original orbital, the electron releases the extra energy in the form of a photon, in some cases a light photon.

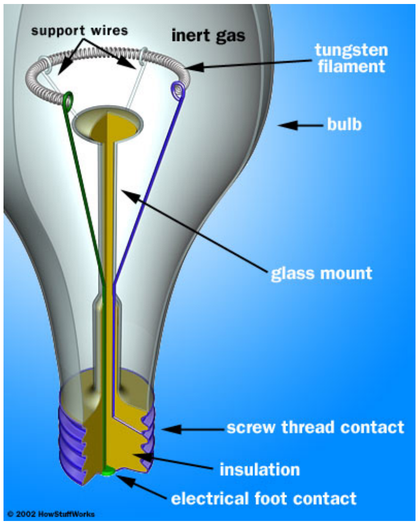


The **wavelength** of the emitted light (which determines its color) depends on how much energy is released, which depends on the particular position of the electron. Consequently, different sorts of atoms will release different sorts of light photons. In other words, the color of the light is determined by what kind of atom is excited.

This is the basic mechanism at work in nearly all light sources. The main difference between these sources is the process of exciting the atoms. In the next section, we'll see how atoms are excited in a light bulb.

The Bulb

Light bulbs have a very simple structure. At the base, they have two metal contacts, which connect to the ends of an electrical circuit. The metal contacts are attached to two stiff wires, which are attached to a thin metal **filament**. The filament sits in the middle of the bulb, held up by a **glass mount**. The wires and the filament are housed in a glass bulb, which is filled with an **inert gas**, such as **argon**.



When the bulb is hooked up to a power supply, an **electric current** flows from one contact to the other, through the wires and the filament. Electric current in a solid conductor is the mass movement of **free electrons** (electrons that are not tightly bound to an atom) from a negatively charged area to a positively charged area.

As the electrons zip along through the filament, they are constantly bumping into the atoms that make up the filament. The energy of each impact **vibrates** an atom -- in other words, the current **heats** the atoms up. A thinner conductor heats up more easily than a thicker conductor because it is more resistant to the movement of electrons.

Bound electrons in the vibrating atoms may be boosted temporarily to a higher energy level. When they fall back to their normal levels, the electrons release the extra energy in the form of photons. Metal atoms release mostly **infrared** light photons, which are invisible to the human eye. But if they are heated to a high enough level -- around 4,000 degrees Fahrenheit (2,200 degrees C) in the case of a light bulb -- they will emit a good deal of **visible light**.

The filament in a light bulb is made of a long, incredibly thin length of **tungsten** metal. In a typical 60-watt bulb, the tungsten filament is about 6.5 feet (2 meters) long but only one-hundredth of an inch thick. The tungsten is arranged in a **double coil** in order to fit it all in a small space. That is, the filament is wound up to make one coil, and then this coil is wound to make a larger coil. In a 60-watt bulb, the coil is less than an inch long.

Tungsten is used in nearly all incandescent light bulbs because it is an ideal filament material. In the next section, we'll find out why this is, and we'll examine the role of the glass bulb and inert gas.

The Right Materials

As we saw in the last section, a metal must be heated to extreme temperatures before it will emit a useful amount of visible light. Most metals will actually **melt** before reaching such extreme temperatures -- the vibration will break apart the rigid structural bonds between the atoms so that the material becomes a liquid. Light bulbs are manufactured with tungsten filaments because tungsten has an abnormally high **melting temperature**.

But tungsten *will* catch on fire at such high temperatures, if the conditions are right. **Combustion** is caused by a reaction between two chemicals, which is set off when one of the chemicals has reached its **ignition** temperature. On Earth, combustion is usually a reaction between **oxygen** in the atmosphere and some heated material, but other combinations of chemicals will combust as well.

The filament in a light bulb is housed in a sealed, oxygen-free chamber to prevent combustion. In the first light bulbs, all the air was sucked out of the bulb to create a near **vacuum** -- an area with no matter in it. Since there wasn't any gaseous matter present (or hardly any), the material could not combust.

The problem with this approach was the **evaporation** of the tungsten atoms. At such extreme temperatures, the occasional tungsten atom vibrates enough to detach from the atoms around it and flies into the air. In a vacuum bulb, free tungsten atoms shoot out in a straight line and collect on the inside of the glass. As more and more atoms evaporate, the filament starts to disintegrate, and the glass starts to get darker. This reduces the life of the bulb considerably.

In a modern light bulb, **inert gases**, typically argon, greatly reduce this loss of tungsten. When a tungsten atom evaporates, chances are it will collide with an argon atom and bounce right back toward the filament, where it will rejoin the solid structure. Since inert gases normally don't react with other elements, there is no chance of the elements combining in a combustion reaction.

Cheap, effective and easy-to-use, the light bulb has proved a monstrous success. It is still the most popular method of bringing light indoors and extending the day after sundown. But by all indications, it will eventually give way to more advanced technologies, because it isn't very efficient.

Incandescent light bulbs give off most of their energy in the form of heat-carrying infrared light photons -- only about 10 percent of the light produced is in the visible spectrum. This wastes a lot of electricity. **Cool light sources**, such as fluorescent lamps and LEDs, don't waste a lot of energy generating heat -- they give off mostly visible light. For this reason, they are slowly edging out the old reliable light bulb.

Bright, Brighter, Brightest

Light bulbs are ranked by their **power** -- the amount of light they put out in a certain period of time (measured in **watts**). Higher-watt bulbs have a bigger filament, so they produce more light.

A three-way bulb has two filaments of different wattage -- typically a 50-watt filament and a 100-watt filament. The filaments are wired to separate circuits, which can be closed initially using a special three-way socket.

The switch in the three-way socket lets you choose from three different light levels. On the lowest level, the switch closes only the circuit for the 50-watt filament. For the medium light level, the switch closes the circuit for the 100-watt filament. For the brightest level, the switch closes the circuits for both filaments, so the bulb operates at 150 watts.

Are fluorescent bulbs really more efficient than normal light bulbs?

A "normal light bulb" is also known as an **incandescent light bulb**. These bulbs have a very thin tungsten filament that is housed inside a glass sphere. They typically come in sizes like "60 watt," "75 watt," "100 watt" and so on.

The basic idea behind these bulbs is simple. Electricity runs through the filament. Because the filament is so thin, it offers a good bit of resistance to the electricity, and this resistance turns electrical energy into **heat**. The heat is enough to make the filament white hot, and the "white" part is light. The filament glows because of the heat -- it incandesces.

The problem with incandescent light bulbs is that the heat wastes a lot of electricity. Heat is not light, and the purpose of the light bulb is light, so all of the energy spent creating heat is a waste. Incandescent bulbs are therefore very inefficient. They produce perhaps **15 lumens per watt** of input power.

A **fluorescent bulb** uses a completely different method to produce light. There are electrodes at both ends of a fluorescent tube, and a gas containing argon and mercury vapor is inside the tube. A stream of electrons flows through the gas from one electrode to the other (in a manner similar to the stream of electrons in a cathode ray tube). These electrons bump into the mercury atoms and excite them. As the mercury atoms move from the excited state back to the unexcited state, they give off **ultraviolet photons**. These photons hit the phosphor coating the inside of the fluorescent tube, and this phosphor creates visible light. It sounds complicated, so lets go through it again in slow motion:

- There is a stream of electrons flowing between the electrodes at both ends of the fluorescent bulb.
- The electrons interact with mercury vapor atoms floating inside the bulb.
- The mercury atoms become excited, and when they return to an unexcited state they release photons of light in the ultraviolet region of the spectrum.
- These ultraviolet photons collide with the phosphor coating the inside of the bulb, and the phosphor creates visible light.

The phosphor **fluoresces** to produce light.

A fluorescent bulb produces less heat, so it is much more efficient. A fluorescent bulb can produce **between 50 and 100 lumens per watt**. This makes fluorescent bulbs **four to six times more efficient** than incandescent bulbs. That's why you can buy a 15-watt fluorescent bulb that produces the same amount of light as a 60-watt incandescent bulb.

How does a halogen light bulb work?

Let's start with a normal electric light bulb like you see in any normal household lamp. A normal light bulb is made up of a fairly large, thin, frosted glass envelope. Inside the glass is a gas such as argon and/or nitrogen. At the center of the lamp is a tungsten filament. Electricity heats this filament up to about 4,500 degrees F (2,500 degrees Celsius). Just like any hot metal, the tungsten gets "white hot" at that heat and emits a great deal of visible light in a process called **incandescence**. See How Gas Lanterns Work for more information on incandescence.

A normal light bulb is not very efficient, and it only lasts about 750 to 1,000 hours in normal use. It's not very efficient because, in the process of radiating light, it also radiates a huge amount of infrared heat -- far more heat than light. Since the purpose of a light bulb is to generate light, the heat is wasted energy. It doesn't last very long because the tungsten in the filament evaporates and deposits on the glass. Eventually, a thin spot in the filament causes the filament to break, and the bulb "burns out."

A **halogen lamp** also uses a tungsten filament, but it is encased inside a much smaller **quartz envelope**. Because the envelope is so close to the filament, it would melt if it were made from glass. The gas inside the envelope is also different -- it consists of a gas from the **halogen group**. These gases have a very interesting property: They combine with tungsten vapor! If the temperature is high enough, the halogen gas will combine with tungsten atoms as they evaporate and redeposit them on the filament. This **recycling** process lets the filament last a lot longer. In addition, it is now possible to run the filament hotter, meaning you get more light per unit of energy. You still get a lot of heat, though; and because the quartz envelope is so close to the filament, it is EXTREMELY hot compared to a normal light bulb.