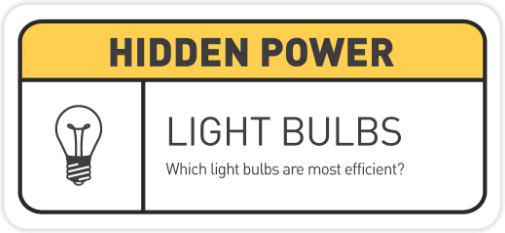

GOAL:

Visitors will understand why incandescent bulbs, fluorescent bulbs, and light emitting diodes operate at different levels of efficiency.

MATERIALS:

- Light bulb strip with cylinder shades.
- Tray model of incandescent bulb with metal ball
- Tray model of fluorescent bulb with metal ball
- Tray model of light emitting diode (LED) with metal ball

PROCEDURE:

Set-up:

1. Plug in light bulb strip and set out tray models. Keep the switch turned off until visitors approach.

Doing the demonstration:

1. Switch the light bulb strip on and have visitors hold their hand over each cylinder to feel differences in the heat that is produced by each. **(Do not allow visitors to touch the bulbs.)** The incandescent bulb becomes hot, the fluorescent bulb is warm, and the LED remains cool to the touch. Explain that the energy being given off as heat is wasted energy. Switch off the light bulb strip.

2. Remove the cylinders. **(Again, warn visitors not to touch the bulbs, as the incandescent bulb may be hot.)** Have visitors observe the different bulbs and ask them if they recognize each type of bulb.

3. Explain that the "efficiency" of a light bulb is a measure of how much light energy comes out of the bulb compared to the amount of electricity (electrical energy) that was put in. A 100% efficient light bulb would convert all the electricity to light and not produce any heat at all. Ask visitors to rank the bulbs from most efficient to least efficient. Explain that an LED is 90% efficient, a compact fluorescent bulb is 85% efficient, and an incandescent bulb is only 10% efficient.

4. Bring out the tray models to demonstrate why the efficiency is different for each. The metal ball represents electrons in each kind of bulb. Explain that the electrons collide with other particles and each collision produces either light or heat. The pegs in the model represent these other particles. Collisions that produce sound represent wasted heat energy, while collisions that are silent represent light production.

5. Have visitors observe the types of beads in each tray, then shake and listen for which tray produces the most sound. Ask them to rank the trays from loudest to quietest, and then ask them which tray represents which type of light bulb. The loudest tray represents the most inefficient incandescent bulb, while the quiet tray represents the most efficient LED.

Clean-up:

1. Make sure a metal ball is in each tray. Return supplies to storage.

EXPLANATION:

The three bulbs in the display each have a light output of 400 lumens, but they require different amounts of power. The incandescent bulb uses 60 W, the fluorescent bulb uses 7 W, and the LED bulb uses 6.5 W.

When an incandescent bulb is hooked up to a power supply, the electric current passes through a metal filament (usually tungsten), heating it until the filament is so hot that it glows. As the electrons move, they bump into the metal atoms of the filament. The energy of each collision vibrates the atoms and heats them up, eventually producing light. Only 10% of the energy used by an incandescent bulb is converted to light; the other 90% is lost as heat. The tray model represents the collisions between the electrons and the atoms of the filament.

In a fluorescent bulb, rather than passing through a filament, the electric current flows through a glass tube that is filled with mercury gas and coated on the inside with a phosphor coating. When electrons collide with the mercury atoms, the mercury atoms are excited to produce an invisible ultraviolet light. The phosphor coating then absorbs energy from the ultraviolet light and *fluoresces*, or turns the invisible light into visible light. In fluorescent light bulbs, the light is created by high-energy dislodged electrons that are produced when electric current is applied to the mercury gas; heat is created as a byproduct of these energetic electrons. About 85% of the energy used by a fluorescent bulb is converted to light. The tray model represents the collisions between the electrons and the mercury atoms.

The LED bulb contains a number of different light emitting diodes, each of which produces light from a semiconductor chip with a negatively charged terminal and a positively charged terminal. As electrons move from negative to positive, they collide with positively charged particles (“holes”) and fall from a high energy level to a lower energy level. The drop releases energy in the form of light. Since LEDs use electricity more efficiently than the other two types of bulbs (they convert about 90% of it to light), they require much less energy to produce the same amount of light as incandescent or fluorescent bulbs. The tray model represents the collisions between the electrons and the holes.

Since the type of collision differs in each type of bulb, trying to compare them may seem like comparing apples and oranges. The simplest way to think about the comparison is to consider that no matter what kind of bulb, there are electrons involved in collisions that produce light or heat. Roughly speaking, the ratio of light-producing collisions to heat-producing collisions in each bulb explains its efficiency.

WHAT COULD GO WRONG?

Visitors could touch hot bulbs and burn their skin. Bulbs could also be broken to create sharp fragments and possible hazardous waste (for the compact fluorescent bulb).

GENERAL MAINTENANCE:

Light bulbs (particularly the incandescent bulb) may need to be replaced.