Lesson 2: Circuits and Electric Light

Overview

Students begin this lesson by examining the components of a portable light device- a battery operated flashlight. This initial exploration and the discussion it generates are used to begin a guided exploration of simple circuitry. Students attempt to light a bulb using a battery, a wire, and a light bulb. Students keep a record of each attempt using words and sketches, noting which ones are successful and which are not.

Teacher Background

Who hasn't stayed up late, past the bedtime warning, secretly reading a favorite book using a flashlight under the bedcovers? This lesson uses a simple and familiar light device, a battery operated flashlight, to introduce elements of simple electrical circuits. Exploration with simple materials such as batteries, bulbs, and wires allows students to begin building knowledge of a sophisticated and challenging concept, energy, in a tangible way. While energy cannot be seen, its effects can be seen. An understanding of energy is developed through direct experiences.

Learning about circuits is primarily observational at this grade span and provides students with the opportunity to begin to consider why electrical devices are designed the way they are. Students can apply their knowledge of simple electrical pathways to larger systems and being to consider what components must be in place in order to "light Maine" efficiently, safely, and economically.

As in many other electrical devices, flashlights house the components of simple circuits. A circuit is an unbroken path or closed loop, which allows an electrical energy to flow. The flashlight's components include a pathway for electric current. In a flashlight, the electric current goes through the metal wire (attached to a switch), through the metal spring, through the batteries, through the base of the light bulb, across the filament of the light bulb, and through the side of the bulb. Without this complete pathway the flashlight will not light.

In addition to a pathway, electrical currents do not flow without an energy source. Portable flashlights, such as the one explored in this lesson, often use batteries as their electrical energy source. Batteries contain chemicals that react, acting like a "pump" to move electrical charges through the circuit. The electrical charges were already present in the wires, bulbs, and receiver – the battery gets them moving. Many people think that batteries (and generators) send out a substance that gets "used up" but this is not true. When batteries "die" they do not "run out of electricity" but rather the battery's chemical reaction fails to fuel the movement of the electrical charge. It is not expected that students understand how or that batteries move electric charges. This information is provided to augment the teacher's background knowledge.

Circuits are typically constructed to utilize electrical energy transfers to a receiver to create some sort of an "effect"- lighting a bulb, making something move, producing sound, and the like. Presenting students with the idea that energy is needed to make something happen and that the "needed" energy comes from an energy source, provides an early experience that students can connect to when they encounter energy transformations in later grades.

At the beginning of this lesson, students share their initial thinking about how they might use one wire and a battery to light a bulb. There are several ideas that students often bring initially to this task. One of the more common ideas, known as the "source-consumer" model, reveals that students believe that the battery gives something to the light bulb. Students often show this by drawing a single wire attached to one (usually the top) terminal of the battery and the other end attached to the bulb. A similar model involves using two wires, each attached to each end of the battery and the bulb – each with wire carrying energy from the battery to the light bulb. (Driver et al. 1994)

Key Ideas

- A complete path to and from a source is needed for an electric current to flow.
- The flow of a complete electric current can produce light.

Lesson Goals

Students will:

- determine how to light a bulb with a battery and wire.
- recognize that electric current needs to travel in a complete loop in order to light a bulb.
- identify the essential components of a circuit including a pathway and a source.
- draw a complete circuit needed to light a bulb.

Vocabulary

circuit: a complete pathway or loop for electricity to travel (flow).

Preparation

- Prepare a basic circuit kit of materials for each student. (See Materials List below)
- Test batteries and bulbs.
- Using wire stripper, cut wire into 12" pieces and strip the end inch off of each strip. For those unfamiliar with stripping wires, review the "how to" video clip on the *PowerSleuth* website: www.powersleuth.org
- Try the four configurations that work to light a bulb using one wire and battery.
- (Optional) Prepare an overhead of Teacher Resource 2.1.

Materials

Item	Quantity
Wire stripper	1
Flashlight with batteries	1
Basic Circuit Kit: • Wire, 22-gauge, insulated (one 12" piece, stripped) • D battery • Replacement incandescent flashlight bulb	1 per student (Have spare materials on hand)
Scientist's Notebook	1 per student
Chart paper and markers (optional)	1 set
Teacher Resource 2.1: Simple Circuit Configurations	1

Time Required: 2 sessions

Connection to *National Science Education Standards (NSES)* and *Benchmarks for Science Literacy (BSL)*

- Electricity in circuits can produce light, heat, sound and magnetic effects. Electrical circuits require a complete loop through which an electrical current can pass. NSES B(K-4)
- Offer reasons for their findings and consider reasons suggested by others. BSL 12A (3-5)
- Keeping records of their investigations and observations and not change the records later. BSL 12A (3-5)

Teaching The Lesson

Engage

1 Share ideas and questions about light.

Post the compiled class question list (from Lesson 1, step 6) in a place where it will be visible throughout the module. Acknowledge the interesting variety of questions about light the students generated as a class. Explain to students that this list will remain posted for the remainder of the module and encourage students to add to the list as new questions arise.

Ask students to share their home/school assignment findings from Lesson 1:

- *What kind of lights did you find at home and/or around your community?*
- *In what ways are the lights/lamps similar to or different from each other?*
- *Which ones use electricity or batteries?*

2 Introduce batteries from battery-operated flashlight.

Show the class a traditional battery operated flashlight. Open the flashlight and remove the batteries. Try to shift the ensuing conversation towards the idea that batteries are a common way to power lights.

- *Are all batteries the same? If not, how are they different?*
- *What do the batteries do?*

As in Lesson 1 during the Engage stage, accept all answers and use this opportunity to listen to students' thinking as a way to guide questioning and discussions during this lesson.

3 Introduce the components of a simple circuit.

Show students the inside of the flashlight. Consider passing the flashlight around to allow students to take a closer look at the flashlight parts or arrange students in groups prior to this initial discussion and give each group a flashlight of their own to explore during the introduction. Explain to students that their challenge is to make a flashlight bulb light up using its individual parts which will be provided. Hold up a battery, a light bulb, and one wire. Provide a little background about each of these components:

- Batteries, in this case two D cells, power the flashlight. They are the source of electricity for the flashlight. Students who are familiar with batteries may bring up the idea that batteries contain chemicals and metals that react with each other to generate electricity.
- A small light bulb is the type used in flashlights. In order to light up, the bulb needs to receive an electric current.
- Flashlights have a wire, a pathway, to keep the electric current flowing. Consider asking students: *Where is the wire in a flashlight?* (The wire is often hidden in flashlights.)

Before students begin exploring, ask them to open their scientists' notebooks and use words and sketches to describe how they think they could light the bulb using the wire and battery. Reassure students that this is a prediction based on what they currently know and that it is alright if they are not sure. Remind students that they should support their prediction with reasoning.

Explore

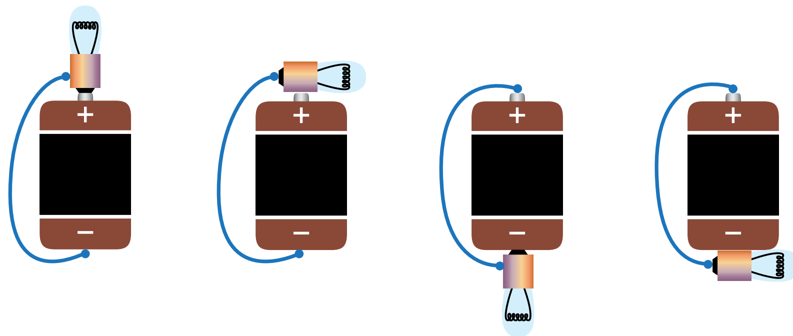
4 Build a circuit.

Explain that each student will build a circuit using one battery, one bulb, and one piece of wire. During the investigation, students are to make accurate drawings of their attempts, noting those which work and those that do not work.

> **Note:** *Emphasize the importance of recording observations and the results of attempts that seem "unsuccessful." This information will be a valuable reference for students as they use it to discuss and reflect upon their experiences and build their knowledge of simple circuitry ideas. Explain that new discoveries in science often result from paying attention to what doesn't work.*

It may be helpful to demonstrate simple but effective ways to draw the key parts of battery, bulb, and wire involved in the circuit. Ask students to focus their drawings on the parts that are important to the functionality of the circuit and to avoid spending too much time drawing irrelevant details such as the designs or lettering on the battery.

Allow time for students to explore. Encourage them to use each other as resources and challenge students to find as many ways as possible to light the bulb. (There are four configurations that work.)



As students work, circulate around the room, helping students focus their attention on determining the various critical contact points on the battery and bulb. Students will most likely be familiar with the two different ends (+ / -) of their batteries but may not carefully observe the contact points involved on the light bulb (connections must be made to the side and base of the bulb). Remind students to record all their attempts and note these contact points.

> **Note:** *Students that finish early can be given a second wire to use in constructing circuits.*

Reflect And Discuss

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5 Discuss findings during a science talk.

Ask students to bring their scientists' notebooks and sit in a circle. Have chart paper or a clean section of a white/chalk board available for students to share their findings and keep a wire, bulb, and battery on hand in case students need to demonstrate their findings.

> **Note:** *For students who are developing language and vocabulary, presentations that include drawing, explanations, and demonstrations provide a visual/oral connection. For example, students with the same configurations make presentations in teams for their classmates, one team member drawing while the other explains and demonstrates.*

The purpose of this discussion is to examine students' findings and to guide them to common understandings about circuits. Rather than "telling" students the information, the teacher's role is to facilitate a student discussion to elicit these common understandings. One way to initiate this discussion would be to ask students to examine their drawings first with an elbow partner, then as a full group, to see if they notice any patterns in the configurations that worked:

Ask students:
What do the configurations that lit the bulb have in common?

Elicit:

- A complete pathway or loop is needed for an electric current to flow. The configurations that light the bulb have a complete loop.
- Circuits have a pathway and energy source (battery).
- There are specific contact points for each of the components of the circuit that need to be connected in order for electric current to flow and light the bulb. The critical contact points for the battery are the "bump" on the top of the battery (the positive side of the battery) and the bottom flat metal part of the battery (the negative side of the battery). The critical contact points for the light bulb are the metal side of the light bulb (threaded) and the metal bottom tip of the bulb. The wire, battery, and bulb must be configured in such a way that these critical contact points are connected in a loop. (Refer to the diagrams in this lesson of the four configurations that work.)

Ask students:
What shape do configurations that lit the bulb have in common?

- There is a loop, circle, or pathway.

> **Note:** *If asked what would have helped them make the connection easier, students may suggest a battery holder and something to clip the wires to the bulb.*

Students may wish to draw on chart paper or on a black/white board or use the materials to clarify their discoveries. As students make additional suggestions, follow up with questions such as:

- *Why does it matter where the bulb, battery and wire touch?* (There are only certain places that allow the flow of electricity – these are the critical contact points.)
- *Why do you think a configuration worked or did not work? How could this configuration be rearranged so that it would work?* (Students should consider whether or not the components were connected in a loop and in such a way that the critical contact points were aligned.)

Encourage students to support their thinking with evidence collected in their notebooks. Ask students to add to their notebooks any new configurations that worked which they had not previously recorded.

6 Introduce the term circuit.

A ***circuit*** *is a complete path for electricity to travel.* Distinguish between open and closed circuits. An open circuit is an incomplete loop that will not light a bulb. A closed circuit is a complete loop that will light a bulb, as long as all the parts are functional.

Consider writing the word "circuit" on the board. Underneath the word circuit, list the words "circle" and "circus." Ask students to identify what these words have in common. (The root "circ").

Discuss with students how these words are related. Students could brainstorm additional words and discuss their meanings. (Ex: circulation, circa, etc.)

Help students "see" the circuit in the flashlight that they examined at the start of this lesson. Show students the flashlights again and initiate a discussion about the following questions:

- *Describe the complete circuit in this flashlight.* (Students should be able to recognize and trace the pathway of electricity in the flashlight. The flashlight has the same basic components as the circuit. The flashlight has additional components that aid in keeping the critical contact points held tightly together and/or enhance the effect (ex: reflector around the bulb makes the area cast by the light greater). The wire in the flashlight is often a wider band of metal and connected to a switch making it easier to turn off and on the light.
- *How could any of the configurations that we discovered that lit the bulb be used as a "flashlight?"* (Any of the configurations would work.)

Discuss with students the practicality of the idea of using their simple circuits as flashlights. Ask students to think about the similarities and differences between the configurations they discovered versus the components of the flashlight. It may be helpful to ask student to think about some of the difficulties they encountered as
8 they tried to light the bulbs. Students may mention that the wire, bulb, and battery were difficult to hold in place to make a connection. If students do not mention that using a bulb, battery, and wire as they did during the investigation isn't particularly practical, suggest this to the students. Ask students what added parts make the flashlight easier to use (has a bulb holder, reflector, switch, "housing") and/or more attractive to people (style, color, grip, etc.). Be sure to confirm that the flashlight has essentially the same components as their configurations (bulb, wire, and battery) to make a complete circuit.

7 Bring lesson to a close.

Ask students to review their initial sketches (prediction) made prior to the exploration with the battery, bulb, and wire. Ask students to explain why their initial idea about a circuit did or did not work. Were their configurations complete circuits? Why or why not? Encourage students to use words and sketches to explain their thinking. Students may find it helpful to demonstrate their ideas with materials.

> **Note:** *Students will be examining the interior of light bulbs and exploring the role of switches in Lesson 3. It is not expected that students include these details in their drawings at the close of this lesson.*

Extensions

Student may:

- use a second wire to discover configurations that work using two wires, a battery, and bulb.
- investigate series and parallel circuits.
- explore the circuitry involved in toys or other familiar devices that light up, i.e. spinning tops, sneakers that flash when people walk, and "energy balls."
- build a simple flashlight. Directions can be found on the Energizer battery website: http://www.energizer.com/learning-center/science-center/Pages/make-flashlight.aspx
- take a virtual tour of a flashlight museum: http://www.flashlightmuseum.com/ or view a vintage flashlight collection: http://www.wordcraft.net/flashlight.html
- make a battery using various fruits and vegetables: http://pbskids.org/zoom/activities/sci/lemonbatteryii.html
- construct a a potato clock: http://www.teachengineering.org/view_activity.php?url=http://www.teachengineering.com/collection/cub_/activities/cub_energy2/cub_energy2_lesson04_activity2.xml
- watch the Dragonfly TV clip about Body Electricity: http://pbskids.org/dragonflytv/show/bodyelectricity.html

Connection to Maine Agencies

MEEP (Maine Energy Education Program) has an Apple Battery exploration and will come to interested schools, free of charge. Students experiment with making a battery by inserting different types of metals into an apple and measuring the electrical current they generate. The MEEP website is http://www.meepnews.org/classroomactivities

For schools in Aroostook County, a Maine Public Service (MPS) representative will come to interested schools, free of charge, to guide and support concepts developed in this lesson. A description of programs is available at www.mainepublicservice.com. Click on the education section of the site. To schedule a visit contact Nancy Chandler at 207.760.2556 or nchandler@mainepublicservice.com.

Online References and Resources

How to strip electrical wire:
http://www.youtube.com/watch?v=0rY6KwyyekU