LESSON 3

Rechargeable Batteries

Inquiries 1
Periods 1

CONCEPTS

Energy can be stored in a battery.

Energy can be transformed from one form to another.

Different devices use energy at different rates.

STUDENT OBJECTIVES

Test a battery.

Store energy in a battery.

Identify the energy changes that take place when a battery is connected to different devices.

OVERVIEW

In Lesson 2, students built batteries with zinc and copper electrodes immersed in a copper sulfate electrolyte. Although those batteries had enough energy to light a bulb, the energy in them could be used up quickly. In this lesson, students learn how to store energy in batteries. They use a battery charger to put an electric current through an uncharged dry-cell battery and charge it. They connect a lightbulb to the battery and observe that charging the battery stores energy in it. These activities prepare them for Lesson 4, during which they will investigate the effect charging time has on the amount of energy stored in the battery.

BACKGROUND

The battery the students built in Lesson 2 was called a "wet cell" because it had a liquid electrolyte. The battery they use in this lesson is called a "dry cell" because the electrolyte is a paste instead of a liquid. Dry cells are more convenient to work with in class than wet cells are. Students will use dry cells in this lesson and in Lesson 4.

A battery connected in an electric circuit can power a variety of devices. When a battery is used to run an electric device, it is discharging and it serves as an energy source for the device. In this inquiry, current flowing in the circuit carries the energy to a lightbulb. As the current flows through the bulb, the chemical energy stored in the battery becomes light and heat energy in the bulb. When all the battery's available chemical energy has been converted to other forms of energy, the battery is "dead." The dead battery is disposed of and replaced with a fresh battery, unless it is rechargeable. To be used again, a rechargeable battery is put in or connected to a battery charger.

When a battery is charging, energy is being put into it. The charger runs a current "backward" through the battery, reversing the chemical processes and converting electrical energy to chemical energy, which is stored in the battery. The current is said to go backward through the battery because the flow of ions in the electrolyte is opposite to the flow when the battery is discharging and supplying electrical energy to a circuit.

This cycle of charging and discharging cannot continue indefinitely because of gases that escape from the cell and because of impurities in the cells. Eventually, rechargeable batteries must be replaced.

Rechargeable batteries are common today. Several different types are made. The batteries used in this lesson are alkaline rechargeable batteries. Because the alkaline batteries have been intentionally run down, there is no energy in the batteries the students get at the beginning of this lesson. To put energy in their battery, students use a battery charger to run a current through it. They see evidence of this stored energy when they connect the battery to an electrical device that converts the energy in the battery to other forms of energy. After the battery runs down, students recharge it by reconnecting it to the battery charger.

A very common rechargeable battery is the lead-acid battery, which is used in cars and trucks. A description of the reactions in a standard car battery follows. This description is meant to be supplemental information for teachers; students are not expected to learn it, but it may help teachers answer questions that students have.

Standard Car Battery

Like all batteries, the car battery has two electrodes made of different metallic substances. In a car battery, one terminal (electrode) is lead dioxide and the other is regular metallic lead. The electrodes are immersed in a liquid sulfuric acid electrolyte. A single lead-acid cell generates about 2 volts (V) of electric potential.

When the battery is discharging, it is supplying energy for the electric circuit of the car. The battery must be part of a closed circuit if it is to supply energy to operate devices. Turning the ignition key to start the car closes a switch, which closes the electrical circuit of the car. Initially, chemical reactions in the battery supply energy to start the car. These chemical reactions then continue to supply energy to run other devices on the car. As the battery supplies energy to the car's electrical circuit, the chemical reactions between the sulfuric acid electrolyte and the electrodes cause lead sulfate to form on both electrodes.

Although car batteries are designed to produce a current strong enough to turn on a starter motor and run other devices on a car, they would not last long if they had to supply all of a car's energy. A device called an alternator generates an electric current when the engine runs. The alternator provides electric energy for the car's circuit and sends a current through the battery to charge it and to keep it from running down. (One sign that the car's alternator is not working properly is a battery that repeatedly runs down.)

When the current generated by the alternator goes through the battery, the battery is charging. The lead sulfate that collected on the electrodes turns back into lead and sulfate ions at one electrode and into lead dioxide and sulfate ions at the other electrode. The battery now has energy stored in it and can be used to run devices again.

Student Misconceptions

Students may have the following common misconceptions about batteries:

- Students may incorrectly think that electricity is stored in the battery. (The battery actually stores chemical energy—potential energy that is later transformed to electric potential energy. In this lesson, the charging process converts electrical energy to chemical energy. The chemical energy is later converted back to electrical energy, and then to light and heat in the bulb.)

- Students may incorrectly think that current is put into the battery when the battery is charged and that it is taken out when the battery is used. (The current flows *through* the battery; it is not stored in the battery.)
- Students may incorrectly think that there is no energy in the battery until the charging process is complete. (Energy flows into the battery as long as it is connected to the charger—energy in the battery increases as the battery charges.)

Reading Selection

The reading selection "Different Batteries for Different Needs," which appears at the end of this lesson in the Student Guide, discusses the composition of some of today's most common rechargeable batteries.

MATERIALS FOR LESSON 3

For each group of 4 students

1 alkaline battery charger

For each pair of students

1 rechargeable alkaline D-cell battery
1 D-cell battery holder
1 miniature lightbulb
1 miniature lightbulb holder
1 stopwatch (or clock with a second hand)
1 electric motor with wire leads and alligator clips
1 red insulated lead wire with alligator clips
1 black insulated lead wire with alligator clips

PREPARATION

1. Make sure the alkaline dry cells are dead.
2. Make sure there are enough electrical outlets for plugging in the battery chargers.

SAFTEY TIP

All of the batteries in this and other lessons need to be collected as Universal Waste. Contact your environmental health coordinator regarding local regulations for disposing of batteries.

Do not use other battery chargers to charge the alkaline batteries. Use only rechargeable alkaline batteries for this experiment. Batteries that are not rechargeable may leak or explode if put in the charger.

Getting Started

1. Start class with a brief discussion of Lesson 2. Have students describe how they built their batteries and what happened when they connected the batteries to the lightbulbs.
2. Use the questions in the Introduction in the Student Guide to initiate a discussion of students' experiences with dead batteries—especially automobile batteries—and how the batteries were recharged. At least one student may say a battery charger was used.
3. Remind students to record their observations and answers to questions in their science notebooks.

Inquiry 3.1
Charging a Battery

PROCEDURE

1. Challenge students to test their battery to see if it will light the bulb. After students have tested their batteries, have them share their conclusions. They should conclude that their batteries do not contain the energy to light a bulb.

2. Show students how to insert a battery safely into the charger and remove it, as shown in SG Figure 3.2.

NOTE If the battery is charging properly, a red light next to the charging bay will come on.

A. To insert a battery into the charger—

i. Make sure battery charger is unplugged.

ii. Open the lid and place the battery in the charger with the positive end of the battery at the positive end of the charging bay. The positive end of the battery and charging bay are marked with a plus (+) sign.

B. To remove a battery from the battery charger—

i. Unplug the battery charger, then open the lid.

ii. Remove the batteries one at a time. Then close the lid on the charger.

3. Before students begin to work, review the Safety Tips.

SAFETY TIPS

Students must use caution to avoid electrical shocks when connecting batteries to the charger. They should—

- make sure they have the charger unplugged when they are adding or removing batteries from the charger
- make sure the batteries are placed in the correct orientation in the charger. The positive end of the battery should be at the positive end of the charging bay.

4. Have students charge their batteries. Watch as students put their batteries in the charger. Assist them as needed.

5. Watch as students remove their batteries to see that they follow the proper procedure.

6. Have students complete Steps 5 and 6 in the Student Guide.

7. Have students repeat Steps 4, 5, and 6 in the Student Guide, using the electric motor in place of the lightbulb.

REFLECTIONS

Have students discuss the following questions with their partners and record the answers in their science notebooks:

A. How was your battery different after you attached it to the charging apparatus for 3.0 minutes? Support your answer with evidence. (The battery now contains energy and lights the bulb.)

B. How can you explain your observation? (The battery charger put energy in the battery. Connecting the bulb to the battery allowed the energy in the battery to flow to the bulb.)

C. What happened when you left the bulb connected to the battery? (The bulb stopped glowing after a while.) *Why did this happen?* (The battery ran out of energy.)

D. What happened to the battery's energy when you connected it to the lightbulb? (Students may not understand that connecting a lightbulb to the battery completes a circuit. Focus on the fact that the energy of the battery transforms into light and heat. If students have had some experience with circuits, you may want to explain that the bulb now lights because the charged battery is converting chemical energy to electrical energy. As electric current flows through the bulb, the electric energy becomes light and heat. As the battery's chemical energy is used up, the light intensity fades and eventually the bulb stops glowing.)

E. What happened when you repeated your experiment with the electric motor? (The electric motor runs for a longer time than the lightbulb stayed lit.)

F. From your observations, do you think the motor or the light needs more energy to operate? Give reasons for your answer. (The electric motor runs for a longer time because it uses less energy each second than the bulb does. Students should recognize that charging the battery for the same time puts the same amount of energy in the battery. If the electric motor is allowed to run down, it uses the same total amount of energy as the bulb.)

G. On the basis of on your experiences in Lessons 2 and 3, write a description of a battery in your science notebook. (Students should describe the battery as a device that can store energy. They may also include the materials they used to construct the battery.)

HOMEWORK

Have students read "Different Batteries for Different Needs," on SG pages 24–25, and answer the questions at the end of the reader.

EXTENSIONS

■ Art ■ Science

1. Have students draw a picture of a rechargeable battery. Their pictures should identify the materials used and show the arrangement of electrodes and electrolyte.

■ Science

2. You may want to show students a dry-cell battery that has been cut in half. If you do this, observe some important safety tips.

> **SAFETY TIPS**
>
> If you cut a dry cell in half, do not let students handle it—the electrolyte is acidic.
>
> Wear safety goggles, gloves, and protective clothing while handling the battery.
>
> Do not let the electrolytic paste get on hands, in eyes, or on other body parts.
>
> Dispose of the cell properly when you are finished.

ASSESSMENT

Assess how well students follow correct procedures and work cooperatively to charge their batteries. Check for complete answers to questions and correct conclusions with supporting evidence.

PREPARATION FOR LESSON 4

Make sure the alkaline rechargeable batteries are fully discharged. If they are not, connect each to a lightbulb. Leave the battery and bulb connected at least 2 minutes after the light goes out.