SUCCESS ACADEMY EDUCATION INSTITUTE

Electricity: The Shocking Truth

Grade 4

Our Vision of Elementary School Science Excellence

Success Academy's unique commitment to science starts in kindergarten. We strive to cultivate a passion for the sciences early in life, build a comprehensive foundation of knowledge, and teach students to investigate and analyze real-world problems. Our vision of science relies on two related commitments: mastery of a substantive body of scientific knowledge and an inquiry-based approach to accumulating this knowledge. Equipping students with a firm grasp of scientific concepts is central to our model, and students must understand that these concepts aren't simply plucked from the air, but rather arrived at through scientific thinking and experimentation. To that end, our scholars do science to understand that scientific knowledge comes from posing questions, designing experiments, gathering data, and drawing conclusions. Rather than viewing scientific knowledge as etched in stone, they come to understand that ideas about the world change with new evidence. In addition, our program incorporates The Next Generation Science Standards (NGSS) and the BSCS 5E Instructional Model.

We believe excellent science classrooms are ones in which students experience curiosity and joy, and make connections between classroom science and the natural world around them. Embedded in our program is the belief that struggle and student-led inquiry are inherent to the mastery process. Through our progressive approach to learning, students realize that unexpected results do not signal failure, but instead present valuable opportunities for new questions.

Through our science program, students learn that science and engineering are creative and exciting fields. They discover that there are countless, fascinating scientific questions to be asked and engineering challenges to be solved—and will be inspired and equipped to seek out answers and solutions. No matter what path students choose to pursue in life, the SA science program will spark curiosity, sharpen problem-solving capabilities, and fuel passion for knowledge.

Essential Questions

The best questions point to and highlight big ideas. They serve as doorways through which learners explore the key concepts, themes, theories, issues, and problems that reside within the content, perhaps as yet unseen: it is through the process of actively "interrogating" the content through provocative questions that students deepen their understanding.[1]

Use the essential question to drive the unveiling and mastery of ideas, and ground the unit in an overarching purpose, often as a storyline. Mentioning the essential question or having students answer it at the end of some lessons does not mean the teacher is using it purposefully.

[1] From Wiggins, G., & McTighe, J. (2005). *Understanding by design*. Alexandria, VA: Association for Supervision and Curriculum Development.

Purpose: The Why, What, and How of This Unit

Essential Question: How can the class build the best string of lights?

Why This Unit?

Electricity is a fascinating and useful form of energy. It powers everything from single light bulbs to giant Ferris wheels! In this unit, scholars will help their teacher replace her broken set of string lights by investigating the behavior of electrical energy.

First, they discover how to make a complete circuit with one light bulb. Next, they explore the more complex series and parallel circuits as they work to power several lights at once! By analyzing data, scholars can understand the movement of electrical energy. They will use trial and error to determine the most effective way to set up a circuit. Scholars can use their findings to debate with one another and refine their comprehension of the properties of electricity.

What is the bottom line?

Science and Engineering Concepts highlighted in this unit:

- **Big Idea**: Electrical energy flows through a circuit. Electricity is only able to move freely through certain materials.
- **Big Idea**: Circuits can be connected in many different ways.
  - Series circuits consist of connected (one after the other) electrical parts. They are simple to build but easily disrupted by removing a part.
  - Parallel circuits consist of electrical parts connected individually to a power source. They are more difficult to build but stay lit, even when some parts are removed.
- **Big Idea**: Electricity is one of several types of energy. It can be transformed into other types of energy.

Science and Engineering Practices highlighted in this unit:

- **Analyze and Interpret Data**
  - Compare and contrast data collected by different groups in order to discuss similarities and differences in their findings.
  - Analyze data to refine a problem statement or the design of a proposed object, tool, or process.
- **Engage in Argument from Evidence**
  - Construct and/or support an argument with evidence, data, and/or a model.
  - Make a claim about the merit of a solution to a problem by citing relevant evidence about how it meets the criteria and constraints of the problem.

  Note: As with any unit, scholars engage in many practices in a given investigation. These practices are highlighted because they appear in the most lessons, but all high leverage SEPs can be assessed.

How will scholars be assessed?

- Use the following materials to study and score scholar work.
    - Grade 4 Electricity: The Shocking Truth Exemplar Exit Tickets (within each lesson)

Safety

Plan carefully for safety in all lessons.

- When creating circuits, if scholars feel the wire or batteries are getting hot, they should separate and put down the materials immediately.
- Alligator clips are sharp and pose a safety risk. Demonstrate for scholars how to handle properly to avoid hurting themselves.
- Scholars may have food allergies. Check the allergy list before choosing materials.

Unit Outline

Lesson 1: Bringing a Bulb to Life: Day 1

The teacher was trying to decorate the science lab for the fall but found her string of lights—her favorite decoration—wouldn't light! Can scholars figure out why and how to fix them?

- **Big Science Idea**: A light bulb needs to be connected in a certain way to light up.
- **Science and Engineering Practice**: Analyze and Interpret Data

Lesson 2: Bringing a Bulb to Life: Day 2

To increase their chances of fixing the lights, scholars must combine a battery, a wire, and a bulb.

- **Big Science Idea**: Electric current requires a continuous loop to flow.
- **Science and Engineering Practice**: Analyze and Interpret Data

Lesson 3: How Electricity Moves: The Two-Wire Challenge

Unfortunately, when the teacher opened up the plastic casing to fix the circuit, there were many wires—not just one! Today, scholars rebuild their circuits with an additional wire to help the teacher.

- **Big Science Idea**: Circuits vary in complexity, from the incredibly simple (three pieces) to the unfathomably complex.
- **Science and Engineering Practice**: Analyze and Interpret Data

Lesson 4: Building a Circuit Tester

The teacher noticed that when she cut open the plastic and plugged in the circuit, it began to get hot. Is this the reason why wires are coated in plastic? Scholars design a circuit to test whether various materials conduct electricity.

- **Big Science Idea**: The conductivity of an object influences how much electrical energy flows through it.
- **Science and Engineering Practice**: Engage in Argument from Evidence

Lesson 5: Conductivity

Scholars now have a way to test conductivity. Today, scholars use their circuit testers to identify the type of objects that conduct electricity well.

- **Big Science Idea**: An object's conductivity can vary drastically depending on its composition. Some materials transfer energy better than others.
- **Science and Engineering Practice**: Analyze and Interpret Data

Lesson 6: Series Circuits

Now that scholars understand how to connect multiple lights, they can create a series circuit.

- **Big Science Idea**: Connecting the parts of a circuit in series can leave the circuit vulnerable.
- **Science and Engineering Practice**: Engage in Argument from Evidence

Lesson 7: Parallel Circuits

Scholars have discovered the disadvantages of series circuits. Is there a better design they can use instead? Today, they will create a parallel circuit.

- **Big Science Idea**: Connecting the parts of a circuit in parallel can keep energy flowing through the circuit.
- **Science and Engineering Practice**: Engage in Argument from Evidence

Lesson 8: Energy Transformations — 2 days

The teacher purchased some other fall decorations that don't seem to conduct electricity. Can scholars find other sources of energy to power them?

- **Big Science Idea**: Energy appears in many forms, and one type of energy can transform into one or more other types.
- **Science and Engineering Practice**: Engage in Argument from Evidence

Lesson 9: Food Power

The scholars' batteries died overnight! What can be used to replace them? Today, scholars attempt to use materials from the Teacher Workroom—fruits!

- **Big Science Idea**: Certain nonmetals can act as power sources.
- **Science and Engineering Practice**: Analyze and Interpret Data

Lesson 10: The Light String Challenge

It is almost time to hang the decorations, but how will the class build the lights? Today, scholars take the information they learned throughout the unit to design and build the best string of lights.

- **Science and Engineering Practice**: Engage in Argument from Evidence

---

Lesson 1: Bringing a Bulb to Life: Day 1

The teacher was trying to decorate the science lab for the fall but found her string of lights—her favorite decoration—wouldn't light! Can scholars figure out why and how to fix them?

Lesson Objectives

- **Big Science Idea**: A light bulb needs to be connected in a certain way to light up.
    - **Key Takeaways**:
        - Connecting a bulb, battery, and wire does not automatically produce light. Electricity must circulate through a continuous path.
        - Analyzing data can provide an explanation for scientific phenomena.
- **Science and Engineering Practice**: **Analyze and Interpret Data** Scholars engage in this Science and Engineering Practice as they use data to draw conclusions about how electricity flows through a circuit.

Materials Needed

- For the teacher: broken string of fall lights, "C" battery, "AA" battery
- For each group: "D" batteries, 6-inch pieces of copper wire, small light bulbs

---

Launch

- Present a string of fall lights with a few blown out bulbs. Explain that while decorating your classroom for fall, you realized your favorite decoration—the string of lights—doesn't work!
    - What do you think happened to these bulbs? Why do you think this?
- Present the lesson challenge:
    - If we can figure out how to repair this string of lights or build a replacement, we can use them to decorate the classroom for fall! First, let's determine what makes the bulb light up by trying to light a bulb using one piece of copper wire and one battery.

Activity

- Have scholars work in pairs to light their bulb.
- **Procedure**:
    - Scholars attempt to light the bulb with one piece of copper wire and one battery.
    - Scholars diagram successful and unsuccessful attempts in their Lab Notebooks.
    - Scholars analyze the data to determine what makes the bulb light up.
- Identify scholar lab notebooks to highlight during Discourse. Showcase both successful and unsuccessful attempts in lighting their bulb.

Discourse

- **Debrief activity:**
    - How did you get your light bulb to work? Describe your successful attempt.
    - Why were the battery and wire necessary to light the bulb?
    - What designs didn't work? Why do you think they might have failed?

[**Tip**: Use a set of materials from the investigation during Discourse so scholars can show their peers how they set up their successful and unsuccessful attempts.]

- **Introduce the essential question:** How can the class build the best string of lights?
    - Have scholars share initial thoughts, questions, and knowledge about this question. Chart scholar responses to return to throughout the unit.
- **Make broader connections:** Show scholars a picture of various batteries.
    - Would you still be able to light your bulb if you switched the size of the battery in your circuit? Why or why not?
        - If scholars have already successfully created a circuit, allow them to try it in front of the class.

Accountability (Informal)

This lesson does not have an Exit Ticket. Study scholar lab notebooks to determine which scholars demonstrate understanding that to light a bulb, there needs to be a continuous path for electricity to travel. Use the data to plan which scholars to target and coach during the next lesson.

Lesson 2: Bringing a Bulb to Life: Day 2

To increase their chances of fixing the lights, scholars must combine a battery, a wire, and a bulb.

Lesson Objectives

- **Big Science Idea**: Electric current requires a continuous loop to flow.
  - **Key Takeaways**:
    - The positive and negative terminals of the battery must be connected to the tip and base of the bulb for it to light up.
    - There must be a clear path for energy to flow from the battery to the bulb. Together, this represents a closed circuit. An incomplete path between the battery and bulb is known as an open circuit.
- **Science and Engineering Practice**: **Analyze and Interpret Data** Scholars engage in this Science and Engineering Practice as they use and analyze data to determine the requirements for energy to flow through a closed circuit.

Materials Needed

- For each group: "D" batteries, 6-inch pieces of bare copper wire, small light bulbs

---

Launch

- Tell scholars about Thomas Edison and his invention of the light bulb. Show Edison's famous quote, **"I have not failed 10,000 times. I have successfully discovered 10,000 ways to NOT light a bulb."**
  - What does this tell you about Thomas Edison's work as a scientist? Why?
  - Do you think there is only one way to light a bulb? Why?
- Present the lesson challenge:
  - In case some of the lights in the string aren't arranged the way we organized our circuits yesterday, we need a backup plan. Today we will determine the requirements for lighting a bulb by finding all the different ways to create a circuit using one piece of copper wire and one battery.

Activity

- Have scholars work in pairs to light their bulb.
- **Procedure**:
  - Scholars attempt to light the bulb with one piece of copper wire and one battery.
  - Scholars diagram successful and unsuccessful attempts in their Lab Notebooks.
  - Scholars analyze the data to determine viable ways to light a bulb.

Discourse

- **Debrief activity:** Share data. What does the data tell you about how to make holiday lights?
  - What parts of the bulb and battery are connected when the bulb is lit?
    - Pass a battery around or show a picture so scholars can see the positive and negative markings on it. Define **positive terminal** and **negative terminal.**
  - What is the purpose of the copper wire? Why do you think this? Define **closed circuit.**
  - What happens if the bulb and battery aren't connected? Define **open circuit**.

- **Make connections to the essential question:** What components are necessary for our set of string lights and how should they be arranged?
    - Scholars draw conclusions from data about closed circuits. They should know the basic parts needed, a battery, light bulb and copper wire, to allow electricity to flow. They will continue to refine this knowledge in coming lessons.
- **Make broader connections:** Show scholars a picture of the major structures of the human circulatory system and explain that it allows for blood to flow through the body. Ask:
    - How is the circulatory system similar to a circuit? Why do you think so?

Accountability (Exit Ticket)

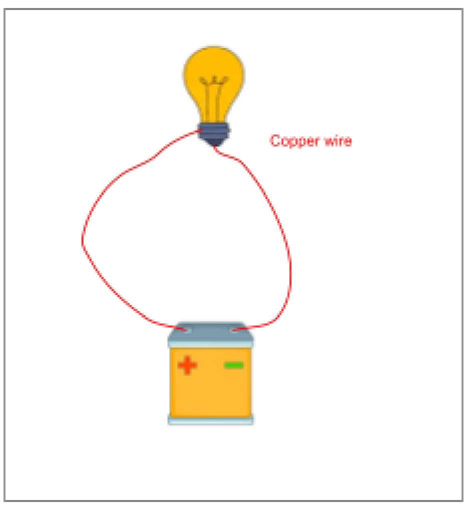
This Exit Ticket should be used to assess scholars' ability to apply the lesson's big idea. Scholars use their understanding that electricity must flow in a continuous loop to light a bulb. Use the data to plan which scholars to target before scholars move on to creating more complicated circuits.

Assignment:

Scholars are gathering materials and building an electrical circuit.

1. Circle the material that will allow electricity to flow between the battery and the light bulb. [1]
    A. copper wire
    B. wooden rod
    C. cotton string
    D. rubber tube

2. In the space below, **draw** and **label** a closed circuit using the chosen material. [1]



Scoring:

1. Award 1 point for selecting A.
2. Award 1 point for drawing an accurate closed circuit using the copper wire.

Lesson 3: How Electricity Moves: The Two-Wire Challenge

Unfortunately, when the teacher opened up the plastic casing to fix the circuit, there were many wires—not just one! Today, scholars rebuild their circuits with an additional wire to help the teacher.

Lesson Objectives

- **Big Science Idea**: Circuits vary in complexity, from the incredibly simple (three pieces) to the unfathomably complex.
    - **Key Takeaways**:
        - As long as both terminals of a battery are connected to the tip and base of a bulb, energy will flow through the circuit.
        - A closed circuit is a circuit that allows electrical energy (also known as current) to flow and light a bulb.
- **Science and Engineering Practice**: **Analyze and Interpret Data** Scholars engage in this Science and Engineering Practice as they gather data to evaluate and refine their ideas about what constitutes a closed circuit.

Materials Needed

- For the teacher: Prediction Sheet 1
- For each group: "D" batteries, 6-inch pieces of bare copper wire (twice as many as the previous lesson), small light bulbs

---

Launch

- Show scholars Prediction Sheet 1.
    - Which circuits wouldn't allow energy to flow? How do you know?
- Present the lesson challenge:
    - Explain that you went to fix the string of lights using the circuit designs the class made, but the circuitry was much more complex than you expected. Rather than simple circuits, it seemed all of the bulbs are connected in one giant circuit! To investigate, try to light a bulb using two pieces of copper wire and one battery. Then, try to add an additional light bulb or battery to see how it affects the circuit.

Activity

- Have scholars work in partnerships to create their circuits.
- **Procedure**:
    - Scholars attempt to light the bulb with two copper wires and one battery.
    - Scholars record successful and unsuccessful attempts.
    - Scholars who have multiple successful attempts may attempt to add a second battery or bulb into their circuit and record their results.

[**Tip**: Scholars often solve this challenge by tying the two pieces of wire together and replicating one of the designs from the previous lesson. To make this more challenging, tell scholars that the bulb may NOT touch the battery.]

Discourse

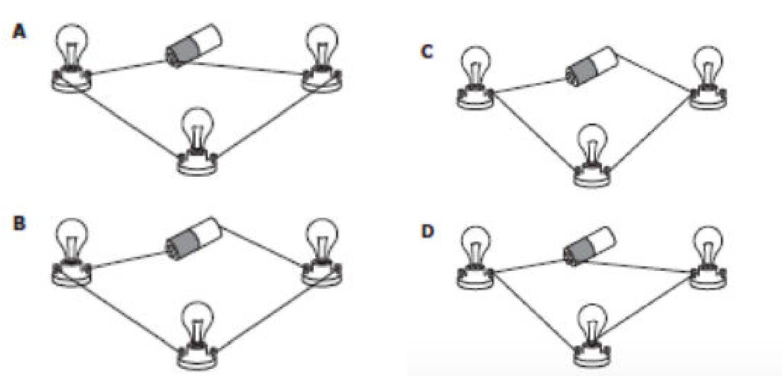
- **Debrief activity:**
    - How can you use the two wires to connect all the components? Why will that work?
    - What is flowing through the wires from the battery to the bulb? Define **electrical energy** and **current.**
    - For those who tried adding an additional battery or bulb, were you able to successfully integrate that material into your circuit? How did it affect the circuit?
- **Make connections to the essential question:** What does this tell you about how to make the best string of lights?
    - A circuit can have more than one wire. Scholars should be considering if this new knowledge should be applied to their string lights. Scholars will learn more about how to set up an efficient circuit as they explore series and parallel circuits.
- **Make broader connections:** Introduce the topic of direct current and alternating current.
    - Which type of current do you think is working in the circuits we have built so far? How do you know?

Accountability (Exit Ticket)

This Exit Ticket should be used to assess scholars' ability to apply the lesson's Big Science Idea to a more difficult context. Scholars should understand that more than one wire can be used to create a closed circuit and light a bulb. Use the data to plan which scholars to target and coach during the next lesson when they must apply this idea to creating a circuit tester.

Assignment:

A class prepared four electric circuits using a battery, connecting wires, and three light bulbs.



1. Which of these circuits can make the three bulbs light? [1]
    A. A
    B. B
    C. C
    D. D

2. Why will this set up light each bulb? [1]
    A. It is a closed circuit since both ends of the battery connect to the wire.
    B. It is a closed circuit because the light bulbs are next to one another.
    C. It is an open circuit because both the positive and negative terminals of the battery connect to the wire.
    D. It is an open circuit because electricity flows from the battery to the light bulb.

Scoring:
1. Award 1 point for selecting C.
2. Award 1 point for selecting A.

Lesson 4: Building a Circuit Tester

The teacher noticed that when she cut open the plastic and plugged in the circuit, it begins to get hot. Is this the reason why wires are coated in plastic? Scholars design a circuit to test whether various materials conduct electricity.

Lesson Objectives

- **Big Science Idea**: The conductivity of an object influences how much electrical energy flows through it.
    - **Key Takeaways**:
        - A circuit tester is used to test the conductivity of objects. Conductivity is the ability to allow electrical energy to flow.
        - Strong arguments have a claim that describes the merit of a solution and relevant scientific evidence to support it.
- **Science and Engineering Practice**: **Engage in Argument from Evidence** Scholars engage in this Science and Engineering Practice as they construct a claim that describes how to best design a circuit tester and their relevant scientific evidence to support it.

Materials Needed

- For the teacher: small, squishy ball; string of lights with cut plastic (**Safety Note**: do not plug in again after cutting)
- For each group: "D" batteries, small light bulbs, insulated wires with alligator clips, bulb holder, battery holder, paper clip, Popsicle stick, rubber band, coin, pipe cleaner, pencil, metal strip, binder clip

---

Launch

- To review the concept of a closed circuit, show scholars a small ball. Tell scholars to imagine one scholar in the first row as the power source, one scholar in the back row as the bulb, and the ball as energy.
    - If you tossed the ball from the power source to the light bulb, would the light bulb light? Why or why not?
    - What would we need to do to form a closed circuit and light the bulb? Demonstrate this using members of the class.
- Explain that because you now understand how closed circuits work, you tried to fix the string of lights again. However, the spot where you cut the plastic began to get hot. It made you wonder why the areas were covered in plastic.
- Present the lesson challenge:
    - Create a circuit tester to determine which materials allow electricity to flow through and which do not. Write an argument explaining how the circuit tester is best designed to test whether electricity can flow through an object, and how the design ensures valid results.

Activity

- Have scholars work in table groups to create their circuit testers.
- **Procedure**:

    - Scholars create and record an observational drawing of their circuit tester using the new materials.
    - Scholars write an argument about how their circuit tester is best designed to test whether electricity can flow through an object.
    - Scholars evaluate each other's arguments and refine them.
- As scholars are working, press scholars to explain their reasoning behind their arguments. Ensure scholars are not just providing evidence, but also linking this to their knowledge about closed circuits.

Discourse

- **Debrief activity:** Share designs and arguments. How did you create your circuit tester?
    - Is each argument valid? What evidence supports it?
    - What does the circuit tester measure? How do you know? Define **conductivity**.
    - Why was the bare wire getting hot, but not the wire coated in plastic?
- Choose a scholar's argument from the lesson and compare it to their refined argument based on peer evaluation and feedback.

Accountability (Informal)

Scholars should understand the necessary components of a circuit that light a bulb. Scholars should begin to show understanding of how to test conductivity. Use the data to plan which scholars to target and coach during the next lesson when scholars will first be deciding which technique should be used to test conductivity.

Lesson 5: Conductivity

Scholars now have a way to test conductivity. Today, scholars use their circuit testers to identify the type of objects that conduct electricity well.

Lesson Objectives

- **Big Science Idea**: An object's conductivity can vary drastically depending on its composition. Some materials transfer energy better than others.
    - **Key Takeaways**:
        - Objects that allow energy to flow through them are conductors; the best conductors are metals. Objects that block energy, such as plastic and wood, are insulators.
- **Science and Engineering Practice**: **Analyze and Interpret Data** Scholars engage in this Science and Engineering Practice as they gather data and draw conclusions about materials that conduct electricity.

Materials Needed

- For each group: "D" batteries, small light bulbs, insulated wires with alligator clips, light bulb holder, battery holder, paper clip, Popsicle stick, rubber band, coin, pipe cleaner, pencil, metal strip, binder clip

---

Launch

- Show a circuit tester from Lesson 4.
    - How does the electrical energy travel through the circuit?
    - What materials allow electricity to travel? Define **conductor**.
- Present the lesson challenge:
    - You can now discover which materials conduct electricity with a circuit tester. Today, we will prove which objects conduct electricity the best and discuss which objects to use for our string of lights.

Activity

- Have scholars work in table groups to prove objects' conductivity.
- **Procedure**:
    - Scholars decide which technique to use to accurately test the conductivity of objects.
    - Scholars record which objects are best at allowing electric current to flow through them.
    - Scholars construct an argument on which objects are the best for repairing the lights.

Discourse

- **Debrief activity:** Share data. Which objects could repair the lights or be used to construct a new set?
    - Which objects were the best conductors? What do they have in common?
    - Which objects did not allow electricity to flow through them? Define **insulator**.
- **Make connections to the essential question:** How will this information about conductors help us to construct the best string of lights?

    - Scholars should refine their ideas on what types of materials should be used in a circuit. For instance, a plastic wire will not conduct electricity because it is an insulator, whereas a copper wire will conduct electricity because it is a conductor.
- **Make broader connections:** Show scholars a picture of a thunderstorm and umbrella. Why are some people afraid to carry an umbrella in a thunderstorm?
    - After scholars mention the danger that metal is a conductor. Use this article to uncover the truth behind this myth.

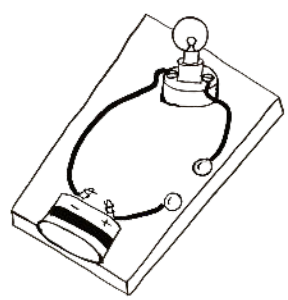
Accountability (Exit Ticket)

This Exit Ticket should be used to assess the lesson's Big Science Idea. Scholars understand that metals are conductors. Use the data to plan which scholars to check in with before Lesson 6 Exit Ticket, when this idea will be assessed again.

Note: This is the first Exit Ticket in this unit that requires scholars to use reasoning. Teachers should be working to build the instinct in scholars to include a claim, evidence, and reasoning that explains their evidence when constructing an explanation.

Assignment:

Martin connected a battery, a light bulb, and copper wires as shown in the diagram below.



1. This instrument can be used to see if materials conduct electricity. Which of these groups contains items that could all conduct electricity to complete the circuit? [1]
    A. rubber ball, plastic comb, nail
    B. paper clip, penny, screw
    C. cork, dollar bill, tweezers
    D. pencil, eraser, spoon

2. Why will the objects selected above allow the light bulb to light? Include evidence from the diagram and explain your reasoning. [2]
   The objects above are made out of metal. Metals are great conductors, meaning electrical energy can flow through them. Since metal is a conductor, it will close the circuit by allowing the current to travel through it. By creating a closed circuit, the energy from the battery will be able to flow and light the light bulb.

Scoring:

1. Award 1 point for selecting B.
2. Award points as follows:
    - 1 point for evidence: Includes accurate and relevant evidence about the metal objects or circuit (should address ideas such as the objects are metal and/or a conductor, the circuit is open and needs to be closed).
    - 1 point for reasoning: Explains how in order for electricity to flow and light the light bulb, a closed circuit must be present. By inputting a conductor into the circuit, the electricity from the battery can flow through the circuit to the light bulb.

Lesson 6: Series Circuits

Now that scholars understand how to connect multiple lights, they can create a series circuit.

Lesson Objectives

- **Big Science Idea**: Connecting the parts of a circuit in series can leave the circuit vulnerable.
  - **Key Takeaways**:
    - Series circuits only have one path for electrical energy to flow through. If one part of the series circuit doesn't allow the energy to flow through it, it becomes an open circuit.
    - Lit bulbs in series circuits are dimmer than bulbs in other circuits.
- **Science and Engineering Practice**: **Engage in Argument from Evidence** Scholars engage in this Science and Engineering Practice as they investigate series circuits and compose an argument that describes the merit of this solution and the scientific evidence they gathered to support it.

Materials Needed

- For the teacher: flashlight
- For each group: "D" batteries in battery holders, light bulbs in bulb holders, insulated wires with alligator clips, paper towel tubes, tape, switches (two brass fasteners and one paper clip)

[**Materials Tip**: Test out materials ahead of time. If materials in your classroom do not properly demonstrate a series circuit, adapt using the PhET Simulation instead.]

Launch

- Show scholars a flashlight that takes multiple batteries.
  - What will happen if I take one battery out? Why?
- Explain that the batteries are connected in series. Define **series circuit**.
- Present the lesson challenge:
  - Create a series circuit and construct an argument on whether a series circuit design is best for our string of lights.

Activity

- Have scholars work in table groups to create their series circuits.
- **Procedure**:
  - Scholars create a series circuit and compare the bulb's brightness to other circuits created.
  - Scholars observe and record the impact of removing a light bulb. Then, add a switch, observing and recording the impact of opening and closing the switch.
  - Scholars provide a written explanation of the virtues of series circuit and evaluate each other's arguments.

[**Tip**: Scholars may find paper towel tubes or tape helpful to separate the wires and clearly visualize the path of the current in their circuit.]

Discourse

- **Debrief activity:** Share parallel circuit designs. How did you create your series circuit?

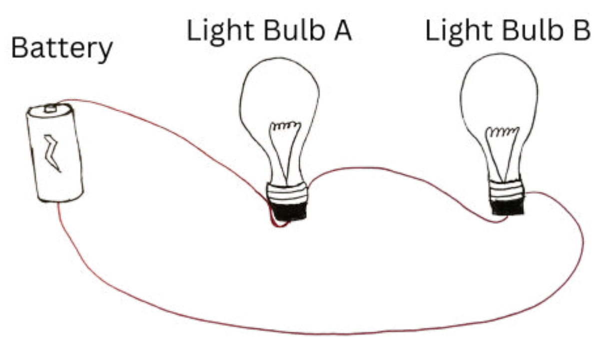
    - Have groups share and evaluate their arguments.
    - What happened to the circuit as you added and removed parts? Why?
- **Make connections to the essential question:** What are the pros and cons of setting up our string lights in a series circuit?
    - Record scholar thoughts to revisit tomorrow when they explore parallel circuits. This information will be helpful to reference as scholars refine their arguments about the best way to set up the string lights.
- **Make broader connections:** Show scholars a picture of the inside of a flashlight.
    - Is this a series circuit? How do you know?
    - If your flashlight stops working, how could you determine which battery to replace?

Accountability (Exit Ticket)

This Exit Ticket assesses the lesson's Big Science Idea. Scholars should understand what a series circuit is and that they can leave certain vulnerabilities in a circuit.

Assignment:

Alejandro is creating a series circuit using the materials below. He has not connected the copper wires yet.



1. Draw wires to create a series circuit that will light both light bulbs. [1]

2. If Light Bulb A burned out while energy was flowing through the circuit, what would happen to Light Bulb B? Provide evidence from your diagram and reasoning to support your answer. [3]
   If Light Bulb A burned out while energy was flowing through the circuit, Light Bulb B would not light up. If one bulb burns out in a series circuit, it creates an open circuit because the light bulbs are lit by one current. If Light Bulb A goes out, the energy can't flow past this point to reach Light Bulb B and it will not light up. The circuit needs to be closed in order for current to flow and both light bulbs to light up.

Scoring:

1. Award 1 point for an accurate drawing of a series circuit.
2. Award points for each of the following:
    - 1 point for a claim: Identifying that Light Bulb B would not light up.
    - 1 point for evidence: Providing an accurate piece of evidence to support their claim

(examples of supporting evidence include information from the diagram or indicating how electricity flows in one circuit within a series circuit).

- 1 point for reasoning: Stating that a closed circuit must be present for electricity to flow to both light bulbs in a series circuit.

Lesson 7: Parallel Circuits

Scholars have discovered the disadvantages of series circuits. Is there a better design they can use instead? Today, they will create a parallel circuit.

Lesson Objectives

- **Big Science Idea**: Connecting the parts of a circuit in parallel can keep energy flowing through the circuit.
  - **Key Takeaways**:
    - Parallel circuits have multiple paths for electrical energy to flow through. Parallel circuits are used so that if one part of the circuit fails, the other parts still function.
    - Lit bulbs in parallel circuits are brighter than bulbs in series circuits.
- **Science and Engineering Practice**: **Engage in Argument from Evidence** Scholars engage in this Science and Engineering Practice as they claim if parallel circuits are a better design using relevant evidence to support it.

Materials Needed

- For each group: "D" batteries in battery holders, light bulbs in bulb holders, insulated wires with alligator clips, paper towel tubes, tape, switches (two brass fasteners and one paper clip)

[**Materials Tip**: Test out materials ahead of time. If materials in your classroom do not properly demonstrate a parallel circuit, adapt using the PhET Simulation instead.]

Launch

- Explain that after some research, you found a way to connect multiple lights without creating a series circuit, but you can't remember exactly how it looked!
- Present the lesson challenge:
  - You will investigate another way to design the best light string by creating a circuit that allows multiple lights to be connected independently of one another. You will construct an argument on whether this new circuit design is better for our string of lights.

Activity

- Have scholars work in table groups to design and create their circuits.
- **Procedure**:
  - Scholars create a circuit with two independently operating lights (a parallel circuit).
  - Scholars compare the bulb's brightness to other circuits created. Then, observe and record the impact of removing a light bulb.
  - Scholars add a switch, observing and recording the impact of opening and closing the switch.
  - Scholars provide a written explanation of the virtues of series circuits and evaluate each other's arguments.

[**Tip**: Once a couple of groups successfully create parallel circuits, allow one group to share their design with the rest of the class. This will help other groups that are struggling and inspire additional designs.]

[**Tip**: Scholars may find paper towel tubes or tape helpful to separate the wires and clearly visualize the path of the current in their circuit.]

Discourse

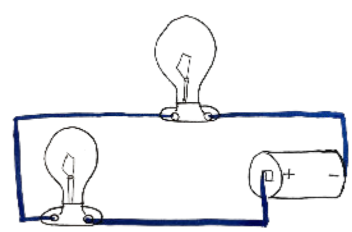
- **Debrief activity:** Share scholar designs. How did you design your circuit? Why did you design it like this? Define **parallel circuit**.
    - What happened to the circuit as you added and removed parts? Why?
    - Have groups share their arguments.
        - Does the argument have a strong claim?
        - What evidence supports it?
- **Make connections to the essential question:** Is a series or parallel circuit the best way to set up the string lights?
    - Scholars should be discussing both their evidence and reasoning behind the answer to this question using their knowledge of circuits.
- **Make broader connections:** Show scholars a picture of a power strip (or one that you have in our room) and describe its function.
    - Do power strips work as a series circuit or parallel circuit? Why do you think so? How could we find out?

Accountability (Exit Ticket)

This Exit Ticket assesses the lesson's Big Science Idea. Scholars understand that series and parallel circuits are different and that those differences affect the way energy flows through the circuit. Use the data to plan which scholars need to be targeted during a Flex Lesson or small group to ensure full understanding of series versus parallel circuits.

Assignment:

1. The diagram below shows an electrical circuit. This circuit is a series circuit because ______. [1]
    A. it has two light bulbs
    B. the same current flows through both light bulbs
    C. it uses a single battery
    D. the current is divided between the light bulbs



2. In the chart below, write an advantage and disadvantage of a **parallel circuit**. [1]

Advantage	Disadvantage
Parallel circuits have multiple paths for electrical energy to flow through.	These circuits require more materials to set up.

Scoring:

1. Award 1 point for selecting B.
2. Award 1 point for an accurate positive and negative aspect of a parallel circuit.

Lesson 8: Energy Transformations — 2 days

The teacher purchased some other fall decorations that don't seem to conduct electricity. Can scholars find other sources of energy to power them?

Lesson Objectives

- **Big Science Idea**: Energy appears in many forms, and one type of energy can transform into one or more other types.
  - **Key Takeaways**:
    - Energy and matter interact, and humans use these interactions.
    - There are several types of energy, including heat, light, sound, mechanical, chemical, and electrical energy.
    - Energy can transform, or change, into other types of energy.
- **Science and Engineering Practice**: **Engage in Argument from Evidence** Scholars engage in this Science and Engineering Practice as they compare and refine arguments on how energy can be used to power each of the decorations.

Materials Needed

- For the teacher: fall-themed windsock, fall-themed wind chimes, solar-powered string lights
- For each group: fall-themed windsock, fall-themed wind chimes, solar-powered string lights, tape, string, fan (optional: if scholars suggest)

Day 1

Launch

- Explain to scholars that you went out to get some additional fall decorations and are considering buying an electric fireplace.
  - Where have you felt heat energy during this unit? What do you think it came from?
- Explain that electrical energy is just one type of energy, and there are several types! When we create a circuit, the electrical energy is transformed, or turned into, light energy and heat energy!
  - What energy transformation occurs inside an electric fireplace?
- Tell scholars that your other new decorations don't seem to be working. You're certain they all must need some sort of energy to work, but you don't see any plugs.
- Present the lesson challenge:
  - Today, you will devise a way to provide energy for each decoration to help it work and discover other types of energy.

Activity

- Have scholars work in table groups to examine the decorations. As scholars are working, circulate and select designs to feature during Discourse.
- **Procedure**:
  - Scholars begin to discuss and design solutions to make the new decorations work.
  - Scholars record a detailed plan for each decoration in their lab notebook.
  - Scholars construct an argument about which types of energy they think are involved in making the decorations work.

Discourse

- **Debrief activity:** Share one plan and argument your team came up with. How does it help the decoration to function?
  - How does your design transfer energy from one type into another?
    - Introduce and define new types of energy, such as **mechanical energy, sound energy,** and **chemical energy**, as they come up.
  - Of all the proposed solutions, which should we use to get our decorations working properly? Why is that the best solution?

[**Engagement Tip**: Have three different groups share their designs for the same decoration. Select designs that are very different so scholars can have a lively debate about which is best.]

- **Make connections to the essential question:** How is creating devices that transform energy from one type into another important for our string lights?
  - Scholars should be discussing that without a transformation of energy it would not be possible for the lights to light up! Electrical energy from the power source needs to transform into light energy for our string lights to successfully function.
- **Make broader connections:** Tell scholars you were also looking to purchase a pumpkin as a fall decoration. Show them a picture of a pumpkin patch.
  - What kind of energy transformation allows pumpkins to grow?

Accountability (Informal)

Scholars should walk away from this lesson with a stronger understanding of the various energy transformations that humans utilize. Use the data to check in with scholars from Day 1 to ensure understanding of energy transformations.

Day 2

Launch

- Share a flawed design from Day 1 of this challenge with scholars.
  - What makes this design ineffective? How could this group improve their design?
- Present the lesson challenge:
  - Finalize your plans and refine your arguments for operating each of our new decorations and prepare to present your solutions to the class.

Activity

- **Procedure**:
  - Scholars finalize their solutions and record in their designs the types of energy they think are involved in making the decorations work.
  - Scholars refine their arguments from the previous day.

Discourse

- **Debrief activity:** Share and explain your designs and arguments.

    - What energy transformation makes the decorations work?
    - Of all the proposed solutions, which are the best solutions? Why?
- **Make broader connections:** Show scholars a picture of a food web.
    - How does a food web represent energy transformations?
    - Look at the relationship between the alligator and the turtle in this food web. What energy transformations occur when the alligator catches the turtle?

Accountability (Exit Ticket)

This Exit Ticket assesses the lesson's Big Science Idea and Science and Engineering Practice. Scholars should understand the various energy transformations that humans utilize. Use the data to plan which scholars to target and coach.

Assignment:
Erica and Darren are sitting in the same kitchen.

1. Erica is toasting a slice of bread, the toaster changes electrical energy into which other type of energy? [1]
    A. magnetic
    B. chemical
    C. mechanical
    D. heat

2. Darren is sitting by the fan. The fan uses energy to move air in the room. Which form of energy causes the blades of the fan to turn? [1]
    A. chemical
    B. electrical
    C. heat
    D. light

3. Which statement about energy is correct? [1]
    A. A little energy disappears every time an energy transformation occurs.
    B. Energy can change form, but is always conserved.
    C. Conservation of energy only occurs when some of the energy is converted to light.
    D. Energy is not conserved during a transformation.

Scoring:
1. Award 1 point for selecting D.
2. Award 1 point for selecting B.
3. Award points for selecting B.

Lesson 9: Food Power

The scholars' batteries died overnight! What can be used to replace them? Today, scholars attempt to use materials from the Teacher Workroom: fruits!

Lesson Objectives

- **Big Science Idea**: Certain nonmetals can act as power sources.
  - **Key Takeaways**:
    - Some fruits and vegetables can conduct electricity well enough to act as a power source such as a battery. This is because of the chemical energy stored inside of them.

- **Science and Engineering Practice**: **Analyze and Interpret Data** Scholars engage in this Science and Engineering Practice as they use data to draw conclusions about how fruits and vegetables can be used as a power source.

Materials Needed

- For each group: potatoes, apples, lemons, oranges, carrots, copper strips or pennies minted before 1982, zinc (galvanized) nails, insulated wires with alligator clips, small light bulbs

[**Materials Tip**: Try out materials ahead of time to determine how many fruits or vegetables are needed per group.]

Prep

- Each group will need at least three of the fruit or vegetable they are testing, three insulated wires with alligator clips, three copper strips or pennies, three zinc nails, and one light bulb.
- Label opposite ends of the fruit or vegetable with a (+) and (-) indicator.

Launch

- Have scholars name things that need electrical energy to work.
  - How does energy get to those devices?
- Explain that electrical energy runs through wires from power plants where electrical energy is usually made by burning fossil fuels such as coal and oil.
  - What are some other power sources?
- Present the lesson challenge:
  - Unfortunately, our batteries died overnight. I once heard that you can use the energy stored inside of some foods to create a battery, so I thought we could try it today!
    - What kind of energy might be stored in foods? Do you think it could power a circuit?
    - What technique could we use to connect fruit to a circuit? How do you know?
    - What kind of circuit should we build? Why?
  - Test which foods can produce the power to light a bulb.

Activity

- Have scholars decide which technique to use to accurately test the conductivity of different foods. As scholars are working, press them to explain the energy transformation that is occurring when the fruit is connected to the circuit.
- **Sample Procedure**:
  - Scholars place the copper strip or copper penny into the positive side of the food.
  - Scholars place the zinc nail into the negative side of the food.
  - Scholars connect one alligator clip to the copper strip or penny.
  - Scholars connect another alligator clip to the zinc nail.
  - Scholars attempt to light the light bulb.
  - Scholars then create a parallel circuit by adding another power source by connecting positive terminals to negative terminals.
  - Scholars attempt to light the bulb again. If it doesn't work, add another power source and try again.
  - Scholars record which foods conducted electricity.

Discourse

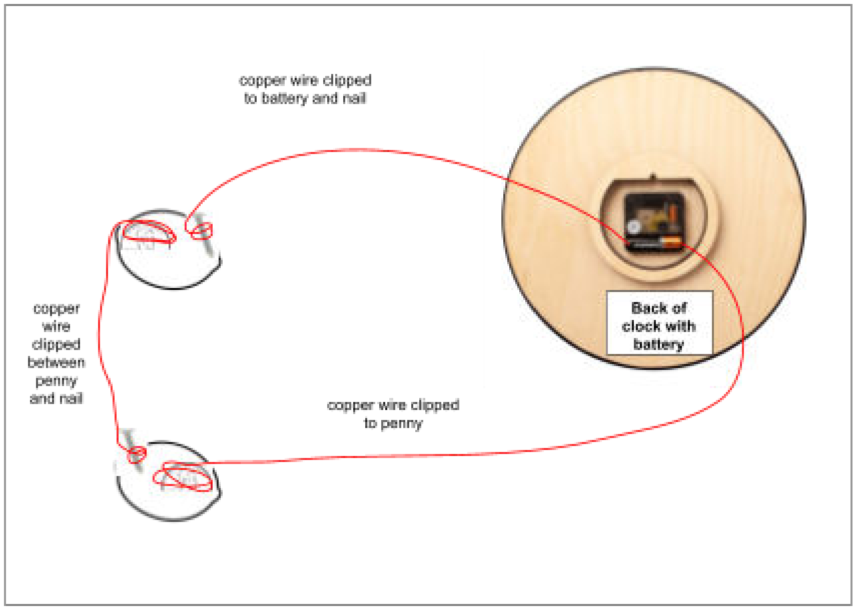
- **Debrief activity:** Share techniques. How did you decide which technique to use to test the objects? Is the data accurate?
  - Which foods were able to power our light bulbs?
  - What energy transformation occurred when you used the food to light a bulb?
  - Where does the chemical energy inside the fruits and vegetables come from? How do you know?
- Show a quick video of a giant food-powered circuit, such as this one!]
- **Make broader connections:** Show scholars a picture of a potato clock.
  - What is this device and how do you think it works?

Accountability (Exit Ticket)

This Exit Ticket requires scholars to think flexibly about their knowledge of circuits and apply their understanding to this scenario. Scholars must accurately create a model of a closed circuit in order to answer this question.

Assignment:
Aaron is completing a science experiment to power a clock below using two lemons as a power source.

1. Using **all** the materials below, **draw** and **label** a circuit that will power the clock. [2]



Scoring:

1. Award points for each as follows:
    - 1 point for drawing an accurate and closed circuit.
    - 1 point for including all the labeled materials.

Lesson 10: The Light String Challenge

It is almost time to hang the decorations, but how will the class build the lights? Today, scholars take the information they learned throughout the unit to design and build the best string of lights.

Lesson Objectives

- **Science and Engineering Practice**: **Engage in Argument from Evidence** Scholars engage in this Science and Engineering Practice as they use information collected throughout the unit to design and construct an argument around the best way to set up the string of lights.

Materials Needed

- For each group: "D" batteries, small light bulbs, bare wire, insulated wires with alligator clips, light bulb holders, battery holder

---

Launch

- Show a video of a light bulb being dissected.
    - How does electricity flow through the light bulb?
    - What makes the light bulb bright? Why?
- Present the lesson challenge:
    - We have learned an immense amount about electricity and how it flows through a circuit. It's time to make our final replacement light string design.
    - Today you will design and build the best, brightest string of lights and construct an argument on why your light string design is the best.

Activity

- Have scholars work in table groups to design their plan and build their own light string.
- **Procedure**:
    - Scholars design and create a circuit in series or parallel.
    - Scholars add as many light bulbs as they choose and write an argument about why their design is the best.
    - Scholars compare and evaluate their arguments.

Discourse

- **Debrief activity:** Share light string designs. How did you choose to design your light string?
    - Share arguments. Why will your design be the best string of lights? What evidence supports their argument?
    - What will make your light string bright? How do you know?
    - What will make your light string functional? How do you know?
- **Discuss the Essential Question:** How can the class build the best string of lights?
    - Review evidence and knowledge scholars have accumulated over the course of this unit. Determine if the class has reached a consensus on an answer to this question. Take time to answer any lingering questions scholars still have.
- **Make broader connections:** Show scholars a picture of a house decorated in lights for the holidays.

- Thinking about the string of lights you are currently designing, would you change anything about your design if it was going to be placed outside instead of inside? Why or why not?

Accountability (Informal)

Scholars should show understanding of the Big Science Ideas of this unit through their designs and arguments for the best string of lights.

Unit Vocabulary

Flashcards

- Send home Vocabulary Flashcards for scholars to study.

Vocabulary List

- **positive terminal** - the top part of a battery with a "+" sign
- **negative terminal** - the bottom part of a battery with a "-" sign
- **closed circuit** - a complete path that allows electricity to flow
- **open circuit** - an incomplete path that stops electricity from flowing
- **series circuit** - a circuit with only one path for electricity to flow through
- **parallel circuit** - a circuit with multiple paths for electricity to flow through
- **conductivity** - the ability to allow electricity to flow
- **conductor** - an object that allows electricity to flow
- **insulator** - an object that prevents electricity from flowing
- **power source** - a device that supplies energy
- **electrical energy** - energy transferred by the flow of electricity
- **light energy** - energy we can see that travels in waves
- **heat energy** - energy created by particles colliding (bumping) into one another
- **mechanical energy** - energy associated with the movement and position of objects
- **sound energy** - energy we can hear that is created through vibration
- **transform** - to change
- **current** - the flow of an electric charge

Extra Resources

In addition to the resources linked throughout the guide, use the following materials to help you prepare to launch this unit with scholars:

- Lab Notebook
- Unit-Specific Content - Resources to help you understand content at an adult level