NATIONAL GEOGRAPHIC

RESOURCE LIBRARY
LESSON

The Secret Lives of Batteries

Students engage with a variety of multimedia resources to determine the benefits and challenges of using and disposing of lithium-ion batteries. They complete a *Circular Economy Analyzer* about lithium-ion batteries and create the storyboard and script for their video challenge that comprises the final product for the unit project.

GRADES

6 - 8

SUBJECTS

Biology, Ecology, Chemistry, Earth Science, Geology, Social Studies, Economics, Storytelling, Filmmaking

CONTENTS

3 Activities

Powered by

call2recycle
Leading the charge for recycling.

ACTIVITY 1: DIGGING INTO LITHIUM | 50 MINS

DIRECTIONS

***Closing the Loop: Towards a Circular Economy* unit driving question**: How can we make our economy more circular, and why does it matter?

***The Secret Lives of Batteries* lesson driving question**: What are the steps and benefits of recycling lithium-ion batteries?

1. **Elicit students' prior knowledge about, and experiences with, electronic devices that use lithium-ion batteries.**

- Display an image of different types of common electronic devices, such as smartphones, tablets, and laptops. Note that for the purposes of this activity, students can consider any electronic device with a rechargeable lithium-ion battery, such as some electric toothbrushes, smart speakers, e-bikes, electronic and hybrid vehicles.
- Prompt the class to consider their own use of these devices: *Raise your hand if you or your family have electronic devices of some kind at home.*

    - Depending on your class' socioeconomic characteristics, you may decide to ask more specific questions, such as: *How many of you have your own smartphone, tablet, or laptop? How many devices do you have in your household altogether?*

- Ask: *How long do these devices usually last?* (Possible responses: A few months to a year; Several years; A decade or more.)
- Ask: *What happens to this device when you can no longer use it?* (Possible responses: I throw it away; I keep it in a drawer; I give it to a younger sibling, relative, or friend; I recycle it. If students respond this way, ask them how and where they found out about this.)

2. **Share surprising facts and statistics to help students understand their use of mobile devices specifically, in the context of the linear global economy.**

- Segue to mobile devices specifically rather than the broader focus on electronic devices in Step 1. Explain that millions of devices are thrown out every year in the United States. Ask: *What kinds of problems could this lead to? Consider everything you have learned about the linear economy so far in previous activities.* (Possible responses:

    - There might be materials in those devices that could be recycled into new devices.
    - It will take up space in landfills.
    - If there are toxic chemicals in any of the devices, they could leach out of the landfills and contaminate soil and water. Non-toxic chemicals could also interact to produce toxic interactions.
    - Manufacturers will have to keep mining for new raw materials instead of recycling the materials they have already extracted.

    - Many of the materials are non-renewable, and we could run out.
    - There are risks to human safety when we throw out lithium-ion batteries that power the devices.)

- Ask: *What might be some possible solutions to these problems?* (Possible responses: We could collect devices to be recycled to make the economy more circular; We could pass a law requiring manufacturers to make their devices more recyclable and to educate consumers about ways to recycle their old devices.)
- Distribute the handout *A World of Minerals in Your Mobile Device*. With a partner, have students consider the following questions while they read, prompting them to connect back to the big ideas from the previous lesson, *The Circle of Stuff*:

    - As described on the first page of the handout, mobile devices contain many different kinds of minerals. What problems might this cause? What solutions can you think of?

        - Key ideas to emphasize:

            - Since minerals are non-renewable, landfilling mobile devices containing all these minerals could lead to a shortage. Based on what we learned in the previous lesson, solutions include: increasing recycling rates for mobile devices, limiting our use of mobile devices, and redesigning them to use different, renewable materials.

    - As shown on the map on the second page of the handout, the minerals in mobile devices come from countries all around the world. What problems might this cause? What solutions can you think of?

        - Key ideas to emphasize:

            - Since minerals must be mined, the environmental and social impacts of mining (such as habitat destruction, water pollution, soil erosion, geopolitical conflict, inhumane working conditions, child labor, and more) of our mobile devices extend all around the world and have disproportionate impacts on developing countries. Based on what we learned in the previous lesson, solutions include: increasing recycling rates for mobile devices so that materials can be recycled instead of extracting raw materials, limiting our use of mobile devices, and redesigning them to use different, renewable materials.

- Lead a brief class discussion to elicit students' responses and ideas, emphasizing the concepts listed above that follow from the previous lesson. Consider documenting the

problems and solutions identified by students in a visible location, to ground their learning for the rest of the lesson and unit.

3. **Facilitate a jigsaw activity using multimedia resources for students to research the uses and environmental impacts of lithium, a key material in mobile devices.**

- Tell the class that, even though there are many minerals used in mobile devices with many impacts, this unit will focus on one mineral in particular: lithium, which is used in lithium-ion batteries. Show the video *Lithium 101* (3:14) to introduce the element and its properties.
- Divide your class into five groups of two to five students. Assign each group a number from one to five in order to jigsaw the resources below.

    - Explain that each group will learn more about lithium through one or more resources. Some of the resources are images, some are videos, and some are text. In the next activity, students from each of the five jigsaw groups will share what they learned with students from other groups.
    - Distribute the *Digging into Lithium* handout with the following questions for all groups to answer. Each student needs to record their answers so that they can share with classmates from other groups in the following activity. Preview the questions before students engage with their resources, so that they know what to focus on:

        - Share three new interesting facts you learned about lithium.
        - Do your resources portray lithium in a positive, negative, or neutral way? Explain. (For groups with more than one resource, answer this question for each resource separately.)
        - Based on your resource(s) and what you have learned about circular economies, what do you recommend?

            - A. Continue using lithium as we currently do.
            - B. Continue using lithium, but move towards a more circular economy by recycling used lithium-ion batteries.

                - C. Stop using lithium altogether.

        - Identify two pieces of evidence that support your claim in Question 3. For each piece of evidence, describe your reasoning.

    - Assign the following resources to each group:

- Group 1:
    - *Energy 101: Electric Vehicles* (video, 2:49)
    - *Lithium Ion Batteries: Why They Explode* (video, 3:15)
    - *Here's Where the Juice That Powers Batteries Comes From* (video, first 5:17 of 6:11)
- Group 2:
    - *Photos: Bolivia Seeks Electric Car Future in Salt Flats*(images, plus 1,444 words in captions)
- Group 3:
    - *The Common Uses of Lithium-Ion Batteries* (text, 1,254 words)
- Group 4:
    - *Lithium—For Harnessing Renewable Energy* (text, 1,491 words)
- Group 5:
    - *Batteries, Recycling and the Environment* (video, 13:28)

- Have students store their completed handouts in an accessible place so they can complete the jigsaw and share their findings in the next activity, *The Second Lives of Batteries*.

4. **Lead students in brainstorming about the target audience for their final product.**

- If needed, remind students about the details for the final product for the unit project: a video challenge for students to create and share on social media. The aim of the challenge will be to encourage the target audience to take part in the circular economy by recycling used electronics such as cell phones, also known as electronic waste, or e-waste.
- Organize students into project groups of three or four, with whom they will collaborate to create their video challenges (see Tips).
- Prompt groups to brainstorm about the target audience for their video challenge by considering the following questions:
    - Who would benefit from hearing about what they have learned about the circular economy and lithium-ion batteries?

- Who needs to be involved in helping to make change?
- Who will hear about and share the video challenge on social media, promoting the message and action steps identified in the video challenge?
- Whose participation will help ensure that use and disposal of lithium-ion batteries will be more circular than linear?

- Within their project groups, students should come to consensus about the target audience for their video challenge. They can do so through discussion, ranking, or voting.

Tip

Step 1: Sharing information about personal or familial access to mobile devices may be awkward for some students. This discussion may reveal socioeconomic disparities among your students, which they may or may not already be aware of. Be prepared to navigate this topic with your students should the need arise.

Step 3: The resources for each group have been arranged roughly in order of reading level. Group 1's resources consist entirely of short videos (less than six minutes each). Group 2's resources are photographs with more information in captions. Groups 3 and 4 are both assigned high-level texts with over 1,000 words each. Group 5 has a long video with advanced concepts. Keep this in mind when assigning students to jigsaw groups and encourage students to focus on the most important parts of each resource that will help them to answer the questions on the *Digging into Lithium* handout, rather than understanding every detail.

Step 3: As a cooperative learning strategy, a jigsaw increases student engagement by making each group member responsible for explaining what they learned. Watch a video from *Cult of Pedagogy* about best practices for structuring a jigsaw, see a jigsaw in action in a real classroom via *Ambitious Science Teaching*, or read more about the benefits of the jigsaw strategy at *TeachHub.com*.

Step 4: Project groups could be the same groups that students worked with in Step 3 while conducting research, or differ to provide them opportunities to collaborate with other peers. Alternately, groups could be formed after the next activity, *The Second Lives of Batteries*, so that groups have representative diversity of perspectives on lithium use.

Step 4: Depending on time constraints, this step may be completed after Step 1 of the next activity, *The Second Lives of Batteries*. The brainstorm could also be started individually as part of the *Digging into Lithium* handout, with students sharing their ideas with their project groups in the next activity.

Modification

Step 2: Consider using the story and resources at *Fairphone* as an example solution: a cell phone that has been redesigned to use responsibly sourced materials and includes a takeback initiative to recycle the components.

Step 2: An alternative wrap-up to this step would be to have students use the *An X-Ray of the Global Economy* infographic to identify which parts might be relevant to the production, use, and disposal of electronic devices.

Informal Assessment

Students' responses in class discussions and on their *Digging into Lithium* handouts demonstrate their ability to identify the uses and impacts of lithium.

Extending the Learning

Consider building on the ideas in this activity to highlight how the distribution of valuable mineral resources can lead to geopolitical conflict. A relevant example comes from Bolivia, the poorest country in South America and home to at least a quarter of the world's lithium. Bolivian president Evo Morales, a socialist and the first ever democratically-elected indigenous president of Bolivia, had repeatedly promised that the profits from the extraction of lithium would benefit the Bolivian people first and foremost. These comments may have made international mining companies less likely to invest their technology and expertise in Bolivia,

knowing they would be unlikely to make large profits. Then, on November 10, 2019, Morales was violently overthrown; Morales claimed that his stance towards lithium played a role in the coup. Another example is mining for cobalt (another key material in lithium-ion batteries) in the Democratic Republic of Congo. The extraction process has been shown to involve children labor and unsafe working conditions for all involved. A recent lawsuit names global tech companies (including Apple, Google, Tesla and Microsoft) as having knowledge about the possibility of child labor used to extract the cobalt for their products. These complex geopolitical issues may be a compelling line of research for students with an interest in international relations, colonialism, capitalism, and indigenous rights.

OBJECTIVES

Subjects & Disciplines

Biology

- Ecology

- Chemistry

Earth Science

- Geology

Social Studies

- Economics

Learning Objectives

Students will:

- Identify the minerals and resources used in mobile devices.
- Propose problems associated with and solutions for landfilling mobile devices.
- Determine how a circular economy for lithium-ion batteries can minimize their negative impacts.
- Support a claim about lithium with evidence and reasoning.

Teaching Approach

- Project-based learning

Teaching Methods

- Discussions
- Jigsaw
- Reading

Skills Summary

This activity targets the following skills:

- 21st Century Student Outcomes
  - Information, Media, and Technology Skills
    - Information Literacy
    - Information, Communications, and Technology Literacy
  - Learning and Innovation Skills
    - Communication and Collaboration
    - Critical Thinking and Problem Solving
  - Life and Career Skills
    - Leadership and Responsibility
    - Productivity and Accountability
- 21st Century Themes
  - Environmental Literacy
  - Global Awareness
- Critical Thinking Skills
  - Analyzing
  - Applying
  - Evaluating
  - Understanding
- Geographic Skills
  - Acquiring Geographic Information
  - Analyzing Geographic Information
  - Answering Geographic Questions
- Science and Engineering Practices
  - Constructing explanations (for science) and designing solutions (for engineering)
  - Engaging in argument from evidence
  - Obtaining, evaluating, and communicating information

National Standards, Principles, and Practices

NATIONAL GEOGRAPHY STANDARDS

- **Standard 11:**

The patterns and networks of economic interdependence on Earth's surface

- **Standard 14:**

How human actions modify the physical environment

- **Standard 16:**

The changes that occur in the meaning, use, distribution, and importance of resources

NATIONAL SCIENCE EDUCATION STANDARDS

- **DCI ESS3.A::**

Natural Resources: Humans depend on Earth’s land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geologic processes.

NEXT GENERATION SCIENCE STANDARDS

- **Crosscutting Concept 5:**

Energy and matter: Flows, cycles, and conservation

- **MS-ESS3: Earth and Human Activity:**

MS-ESS3-3: Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment

- **Science and Engineering Practice 4:**

Analyzing and interpreting data

- **Science and Engineering Practice 6:**

Constructing explanations and designing solutions

- **Science and Engineering Practice 7:**

Engaging in argument from evidence

- **Science and Engineering Practice 8:**

Obtaining, evaluating, and communicating information

Preparation

Background Information

Even if students do not have their own mobile device, smartphones and tablets are a ubiquitous technology across United States households. Focusing on mobile devices is an ideal way to bring alive the concept of a circular economy and connect to students' everyday lives and experiences, which has the potential to increase their classroom engagement and motivation. Additionally, given that only 13 percent of smartphones are recycled annually in the United States, there is a demonstrated need for the smartphone industry (and consumer behavior) to move towards being more circular and less linear.

Lithium-ion batteries are incredibly efficient and relatively inexpensive, leading to the powering of many modern devices, ranging from smartphones to electric toothbrushes to electric vehicles. This decreases our global reliance on fossil fuels, helping to combat climate change. The lithium industry also creates jobs and income for people in developing nations. In line with the key principles of a circular economy, lithium-ion batteries are able to be recycled, so that the source materials can be recovered and used in new batteries.

As highlighted in this activity, lithium-ion batteries also cause problems. Lithium is a non-renewable mineral resource, and mining for it has negative environmental and social impacts on the local environment and communities. Energy, which currently comes from fossil fuels, is used to extract, process, and transport lithium. Improper lithium battery disposal can be dangerous, leading to fires.

In all, lithium-ion batteries are a key, and appropriately complex, example to demonstrate the utility of a circular economy and need for an advocacy campaign to promote recycling, which students are compelled to create throughout this unit.

Prior Knowledge

["Circular versus linear economy","Environmental impacts of mining and landfills","Renewable versus non-renewable resources"]

Recommended Prior Activities

- None

Vocabulary

Term	Part of Speech	Definition
circular economy	*noun*	a system of production that extends the lifespan of consumer goods by maximizing reusing and recycling, and minimizing throwing things away.
extraction	*noun*	process by which natural resources are extracted and removed from the earth.
linear economy	*noun*	system where raw materials are collected and transformed into products, which are eventually discarded as waste.
lithium	*noun*	chemical element with the symbol Li; the lightest metal known, often used in lithium-ion batteries.
lithium-ion battery	*noun*	lightweight, high-density rechargeable battery commonly used for electronics.
nonrenewable resource	*noun*	natural resource that exists in a limited supply.
recycle	*verb*	to clean or process in order to make suitable for reuse.
renewable resource	*noun*	resource that can replenish itself at a similar rate to its use by people.

ACTIVITY 2: THE SECOND LIVES OF BATTERIES | 1 HR 15 MINS

DIRECTIONS

***Closing the Loop: Towards a Circular Economy* unit driving question**: How can we make our economy more circular, and why does it matter?

***The Secret Lives of Batteries* lesson driving question**: What are the steps and benefits of recycling lithium-ion batteries?

1. **Provide students an opportunity to share what they learned about the uses and impacts of lithium-ion batteries during the *Digging into Lithium* activity and debate the need for a circular economy.**

- Along one long wall in your classroom, post three signs:
    - A. We should continue using lithium as we currently do.
    - B. We should continue using lithium but move towards a more circular economy by recycling used lithium-ion batteries.
    - C. We should stop using lithium altogether.

- Have students stand next to the sign that most closely aligns with their views, emphasizing that the ideas are on a continuum, so they may be somewhere in between. Prompt students to briefly discuss their ideas and why they voted for a particular view with the classmates standing near them.
- Remind the class that each group learned different information about lithium in the previous activity, *Digging into Lithium*. Now, members from each group will share their information with each other so that the whole class has the same basis of information with which to decide.
    - Ensure that all students have their completed *Digging into Lithium* handout, which should be in their project folder.
    - Organize students into new groups. All new groups should have at least one member from each of the five jigsaw groups in *Digging into Lithium*.
    - Distribute the handout *Lithium Jigsaw Notes*.
        - Instruct students to take notes on the handout based on the information shared by members of each group.
        - After recording the key ideas from each group member, have students select the conclusion that best fits with the new information they have learned.
        - Then, have students answer the questions on the back of the handout.

- After all groups have completed sharing and answering questions, have students vote again by standing next to the sign that most closely aligns with their views.
- Ask: *For students who changed your position, what information made you change your mind?* Discuss a few students' answers.

2. **Facilitate a discussion to achieve consensus among students about the best way to minimize the environmental impacts of lithium-ion batteries.**

- Make a T-chart to record pros and cons (or impacts and benefits) of lithium-ion batteries. Explain to students that this chart will serve two purposes: it will help the class achieve consensus about whether a circular economy for lithium-ion batteries is necessary, and it will also be an anchor chart to record this information for future activities.
- Ask students to share their ideas about how to define the term *consensus*, leading them to the idea that consensus is when everybody agrees about something.
- Ask: *What are all the pros (or benefits) of lithium-ion batteries?* Have students generate a list with a partner before sharing with the class. Record answers on the T-chart. (Possible responses:

  - When used in tandem with renewable electricity generation, lithium-ion batteries can replace the need for fossil fuels, especially in electric vehicles. This helps combat climate change, and also reduces extraction impacts of fossil fuels.
  - Lithium-ion batteries can store energy from renewable power. This is important because renewable energy sources such as wind and solar can be intermittent, so the energy they generate sometimes needs to be stored to be used later.
  - Lithium-ion batteries are rechargeable, which reduces single-battery waste.
  - Lithium-ion batteries are small, lightweight, and compact, which makes them ideal for use in mobile devices.
  - The lithium industry can create jobs and income for people in developing nations.
  - There is a process for recycling lithium batteries that allows the materials to be recovered and used in new batteries.)

- Ask: *What are all the cons (or negative impacts) of lithium-ion batteries?* Have students generate a list with a partner before sharing with the class. Record answers on the T-chart. (Possible responses:

  - Lithium mining impacts people's traditional way of life in Bolivia and other countries around the world.
  - Lithium mining requires large amounts of water, which is a precious natural resource, especially in the mostly desert ecosystems where lithium is found.
  - Lithium mining generates other types of wastes, including magnesium and lime.
  - Energy is used to extract, process, and transport lithium. Much of this energy currently comes from fossil fuels.
  - Improper lithium battery disposal can be dangerous, leading to fires.

- Recycling rates for products containing lithium-ion batteries are low.
- The profits from the lithium industry may not be shared equally among all workers in the supply chain.

- Do a consensus check by asking students to vote (simply by raising their hands) for their preferred option. If your class already agrees with Option B (We should continue using lithium but move towards a more circular economy), skip to the next step.

    - If there is disagreement in your class about which option is best, have a representative from each group try to convince their classmates. While full consensus from all students is not strictly necessary, the more students agree that Option B is best, the more engaged the class will be in working on their final product.
    - In the unlikely, but not impossible, scenario that your class reaches consensus around an option other than B, consider using the points below and emphasize that they will have an opportunity to come to consensus again at the end of the activity:

        - If your class reaches consensus around Option A (We should keep using lithium as we currently are), you can use some of the following resources and arguments to sway them towards Option B:

            - Toxic chemicals used in lithium mining have contaminated soil, air, and water resources in South America, leading to problems for farmers and conflicts between communities.
            - Lithium mining operations have also been linked to toxic chemical releases leading to the death of fish and yaks in Tibet.
            - Mining lithium often involves environmental impacts on fragile and pristine environments, as in the case of Death Valley and Rhyolite Ridge.
            - The recycling rate of lead-acid batteries is close to 100 percent, showing that a circular economy for batteries is possible.
            - You can also use some of the general arguments in favor of circular economies as presented in the activity *There's No Such Place as Away.*

        - If your class reaches consensus around Option C (We should stop using lithium altogether), consider using some of the following resources and arguments to incorporate aspects of Option B, in line with the principles of circular economies:

            - Transportation is one of the top contributors to greenhouse gas emissions worldwide, and using lithium-ion batteries in electric vehicles to replace gasoline

and diesel fuel can make a huge impact on worldwide carbon emissions (especially when paired with grid decarbonization).
    - The recycling rate of lead-acid batteries is close to 100 percent, showing that a circular economy for batteries is possible.
    - You can also use some of the general arguments in favor of circular economies as presented in *There's No Such Place as Away*.

3. **Introduce resources about recycling lithium-ion batteries, to prepare for students' unit project work.**

- Introduce the organization *Call2Recycle*, which provides an easy way for consumers and businesses to recycle batteries, including lithium-ion batteries.
- Explain that students will use two Call2Recycle resources to build on their T-chart from Step 1 and prepare for creating a *Circular Economy Analyzer* document for lithium-ion batteries. Prompt students to pay attention to any additional benefits and negative impacts of lithium-ion batteries as they engage with the resources:
    - Distribute or provide access to *The Secret Life of Batteries* infographic. Have students read through it in partner groups or review as a whole class.
    - Show the video *How Call2Recycle Recycles Batteries* (4:05).
- Revisit the T-chart from Step 1 and add any additional benefits and negative impacts of lithium-ion batteries from the infographic and video.
    - If applicable, consider doing another consensus check to see if students now have a different opinion regarding use of lithium and lithium-ion batteries.

4. **Guide students in synthesizing their complex knowledge about the impacts and benefits of lithium-ion batteries.**

- Elicit students' ideas on what they learned about lithium-ion battery production and disposal and how it relates to the concept of a circular economy from *The Circle of Stuff* lesson.
    - Students should see connections between recycling lithium-ion batteries and how the process keeps key minerals and materials circulating rather than going to landfill.
- Distribute a new copy of the *Circular Economy Analyzer*.

- Have students work in their project groups to fill out both parts of the document, using what they have learned about lithium-ion batteries. Allow students access to the jigsaw resources, the Call2Recycle video and infographic, and other internet resources in order to find all of the information they need.
- Use the *Circular Economy Analyzer: Lithium-Ion Batteries Answer Key* to help support students' thinking if needed.

- Remind students that this version of the *Circular Economy Analyzer* handout will provide information and even serve as a draft of a visual that they can use in their final product for the unit project, a video challenge to urge viewers to recycle lithium-ion batteries and e-waste.
- Have students store their completed handouts in their project folders.

Tip

Step 1: If teaching this activity virtually, use a polling or chat feature to have students vote for Option A, B, or C and tally their votes. Breakout rooms or a discussion board can then be used to facilitate group conversation.

Step 2: Achieving consensus is a delicate balancing act, and your class may never achieve it completely. On the other hand, it is possible that your class will reach consensus very early in the process. Feel free to adapt the structure of this activity accordingly, lengthening or condensing discussion as your schedule permits. Informed, open debate is a sign of a healthy science classroom, and the teacher should serve as a guide and facilitator without exerting undue influence over students' opinions or rushing them to a predetermined outcome.

Modification

Step 2: The resources and structure of this unit are designed to encourage students to reach consensus around Option B, that we should continue using lithium but move toward a more circular economy. However, even with the most carefully curated resources, no one can predict exactly what opinions students will develop, and freedom of thought is a hallmark of critical, independent thinkers. If a small minority of students, or even your whole class, is able to defend one of the other options based on evidence from the resources provided, encourage them to develop their opinions by learning more. Keep in mind, however, that the remainder

of the activities in this unit follow from the assumption that most of the class agrees that a circular economy for lithium-ion batteries is necessary. Depending on your students' convictions and your capacity, you may choose to modify the following activities in this unit to suit the perspectives of a subset of students who believe that lithium should not be used at all or that the lithium industry is acceptable in its current form.

Informal Assessment

Students' *Circular Economy Analyzer* on lithium-ion batteries provide evidence of their ability to explain the influence of engineering, technology, and science on society and the natural world, and to design a method for minimizing a human impact on the environment.

Extending the Learning

Developing a circular economy for lithium-ion batteries is an engineering challenge currently being addressed at the highest levels of research and development. Challenge students to learn more about cutting-edge technologies and systems and to incorporate this information into their *Circular Economy Analyzer*.

OBJECTIVES

Subjects & Disciplines

Biology

- Ecology

Earth Science

- Geology

Social Studies

- Economics

Learning Objectives

Students will:

- Share their evidence-based recommendations about how to use and develop a circular economic system for lithium-ion batteries.
- Synthesize information about the positive and negative impacts of the lithium industry in order to identify areas of strength and weakness.

- Create a diagram to show how recycling lithium-ion batteries contributes to creating a circular economic system.

Teaching Approach

- Project-based learning

Teaching Methods

- Discussions
- Reflection
- Writing

Skills Summary

This activity targets the following skills:

- 21st Century Student Outcomes
  - Learning and Innovation Skills
    - Critical Thinking and Problem Solving
- 21st Century Themes
  - Environmental Literacy
  - Global Awareness
- Critical Thinking Skills
  - Analyzing
  - Evaluating
- Geographic Skills
  - Answering Geographic Questions
- Science and Engineering Practices
  - Constructing explanations (for science) and designing solutions (for engineering)
  - Engaging in argument from evidence

National Standards, Principles, and Practices

NATIONAL GEOGRAPHY STANDARDS

• **Standard 11:**
The patterns and networks of economic interdependence on Earth's surface
• **Standard 14:**
How human actions modify the physical environment
• **Standard 16:**
The changes that occur in the meaning, use, distribution, and importance of resources

NATIONAL SCIENCE EDUCATION STANDARDS

• **DCI ESS3.A::**
Natural Resources: Humans depend on Earth’s land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geologic processes.

NEXT GENERATION SCIENCE STANDARDS

• **MS-ESS3: Earth and Human Activity:**
MS-ESS3-3: Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment

Preparation

BACKGROUND & VOCABULARY

Background Information

Foregrounding nuanced perspectives on socio-scientific topics is a powerful way to engage students and bring them into the possible controversies and unsettled topics that underlay scientific content in the classroom. In this activity, students are empowered to take a stance, explore the evidence, and then (importantly), revisit their original stance to see if their thinking has changed. This mirrors contemporary approaches to solving complex scientific problems. Additionally, in order to accurately and genuinely create the final product for the unit, students need to engage with the benefits *and* drawbacks of lithium-ion batteries, as highlighted in the activity and below.

Lithium-ion batteries are incredibly efficient and relatively inexpensive, leading to solving many problems through powering modern devices, ranging from smartphones to electric toothbrushes to electric vehicles. This decreases our global reliance on fossil fuels, helping to combat climate change. The lithium industry also creates jobs and income for people in developing nations. In line with the key principles of a circular economy, lithium-ion batteries are able to be recycled, so that the source materials can be recovered and used in new batteries.

As highlighted in this activity, lithium-ion batteries also cause problems. Lithium is a non-renewable mineral resource, and mining for it has negative environmental and social impacts on the local environment and communities. Energy, which currently comes from fossil fuels, is used to extract, process, and transport lithium. Improper lithium battery disposal can be dangerous, leading to fires that are incredibly toxic and difficult to put out due to the amount of fuel in landfills.

Prior Knowledge

["Environmental and health impacts of mining lithium (from previous activity)","Circular versus linear economies"]

Recommended Prior Activities

- None

Vocabulary

Term	Part of Speech	Definition
circular economy	*noun*	a system of production that extends the lifespan of consumer goods by maximizing reusing and recycling, and minimizing throwing things away.
e-waste	*noun*	electronic devices or their parts that have been thrown away.
greenhouse gas	*noun*	gas in the atmosphere, such as carbon dioxide, methane, water vapor, and ozone, that absorbs solar heat reflected by the surface of the Earth, warming the atmosphere.
landfill	*noun*	site where garbage is layered with dirt and other absorbing material to prevent contamination of the surrounding land or water.

Term	Part of Speech	Definition
linear economy	*noun*	system where raw materials are collected and transformed into products, which are eventually discarded as waste.
lithium	*noun*	chemical element with the symbol Li; the lightest metal known, often used in lithium-ion batteries.
lithium-ion battery	*noun*	lightweight, high-density rechargeable battery commonly used for electronics.
mining	*noun*	process of extracting ore from the Earth.
nonrenewable resource	*noun*	natural resource that exists in a limited supply.
recycle	*verb*	to clean or process in order to make suitable for reuse.
renewable resource	*noun*	resource that can replenish itself at a similar rate to its use by people.

ACTIVITY 3: CREATE YOUR VIDEO STORYBOARD | 1 HR 15 MINS

DIRECTIONS

***Closing the Loop: Towards a Circular Economy* unit driving question**: How can we make our economy more circular, and why does it matter?

***The Secret Lives of Batteries* lesson driving question**: What are the steps and benefits of recycling lithium-ion batteries?

1. **Review key ideas about how to change the patterns of lithium-ion battery use and disposal to align with a circular rather than linear economy.**

- Prompt students to review their *Circular Economy Analyzer* from *The Second Lives of Batteries* activity. Lead a class discussion to elicit students' ideas about how to make the lithium-ion battery use and disposal process more circular than linear. Record their ideas in a public place, emphasizing the ideas that relate to the recycling of devices that use lithium-ion batteries but also allowing students to share other ideas, such as refurbishing devices or keeping them for longer amounts of time.
- In preparation for transitioning to their final product work, review the steps of recycling lithium-ion batteries (from the *How Call2Recycle Recycles Batteries* video (4:05) and

provided on the *Circular Economy Analyzer: Lithium-Ion Batteries Answer Key,* both from *The Second Lives of Batteries* activity):

  - Batteries are crushed, shredded, separated, and melted to recover materials including pure lithium and other component materials that can be used to make new batteries or other products.

- Emphasize that students' final products should include both the ideas that they generated that expand beyond recycling in the first part of this step, as well as communicating these steps of recycling.

2. **Elicit students' ideas about the qualities of effective video messages or memes.**

- Remind students about the details for the final product for the unit project: a video challenge for students to create and share on social media. The aim of the challenge will be to encourage the target audience to take part in the circular economy by recycling used electronics such as cell phones, also known as e-waste. Videos should be 60-90 seconds long and include information about the limitations of linear economies and the solutions offered by circular economies. The videos will also include information about how, when, and where to recycle electronic waste, with an emphasis on National Battery Day on February 18 and International E-Waste Day on October 14.
- With their final product in mind, ask: *What are some short video messages or memes that have been successful in communicating an important message?*

  - Encourage students to share school-appropriate examples. If time allows, consider showing two to three examples, such as the video *Earth Is Our Home—Let's Protect It* (1:13).

- Lead the class through a brief brainstorm to identify the key qualities that make the video message(s) successful. Highlight responses noting that the videos 1) quickly capture the attention of a target audience; 2) clearly communicate a key takeaway message; 3) provide ideas about how the viewer can take action; and 4) are brief and visually appealing.

  - Align these elements with the criteria that students will address in their own videos: a target audience, action steps for the viewer including relevant resources to do so, citing external sources, and visual appeal.

3. **Prompt project groups to collaboratively identify the main aspects that will be included in their video.**

- Organize students into their project groups from the previous activities in *The Secret Lives of Batteries* lesson. Distribute or provide access to the *Video Storyboard and Script* handout for each group.
- Direct groups to complete the questions on the first page of the handout, in which they will identify the target audience, how to make the video appealing and engaging, key ideas, and sources that they want to include in their video. Highlight the key qualities of a successful video message that the class identified in Step 1.
- Students should have already brainstormed and possibly decided on a target audience for their video during the last step of the *Digging into Lithium* activity. They may still need to finalize their collaborative decision at this point, whether through discussion, ranking, or voting.

    - Encourage students to consider their target audience as they decide how to make their video visually appealing and how to appropriately explain concepts and vocabulary. Point them to previous activities in the unit and the *National Geographic Glossary* for key terms and definitions to include.
    - Point students to resources they have used and created throughout the unit that can be used in their video, especially their *Circular Economy Analyzer* for lithium-ion batteries from *The Second Lives of Batteries* activity. Additionally, students should peruse the resources available on the *Call2Recycle* website, including *The Secret Life of Batteries*infographic that was introduced previously.

- Circulate to support groups as they address the questions. Promote students in collaborating on making decisions about what will be included in their video, even if the group is not able to come to consensus about every detail.

4. **Support project groups as they create their video storyboard.**

- As project groups complete the first page of the *Video Storyboard and Script* handout, have them check in to ensure they are on track and ready to move on to the storyboard and script. Provide additional time and resources from the unit as needed.
- Project groups can then continue with developing their storyboard and script.

    - Consider options to help groups complete the task and promote collaboration, such as having each group member in charge of a different part, or having different group roles

(for example: Script Writer, Animator/Illustrator, Fact Checker). Students can divide the storyboard into different sections taking on different roles as they create their video challenge. Ensure students consult the *Final Product Checklist and Rubric* to make sure they structure their storyboard to include the required components.

5. **Direct project groups to identify the parts of their storyboard on which they want to receive feedback.**

- As groups finish up their storyboard and script, distribute the *Video Storyboard and Script: Peer Review Feedback Sheet* to each student. Assist students as they complete a self-evaluation of their storyboard and script using the *Final Product Checklist and Rubric*. They may decide to use highlighters and sticky notes in this step as they find evidence to support where they scored themselves on the rubric.
- Have students record what they want feedback on or assistance with on the top section of their *Peer Review Feedback Sheet*, for use in the next activity, *Peer Review: Video Storyboard*.

Tip

Step 2: Consider having a few school-appropriate examples of compelling video messages or memes ready to share with the class, in place of or in addition to eliciting ideas from students.

Informal Assessment

Students' storyboard drafts demonstrate their ability to communicate scientific information in a clear, coherent, and accurate manner that is appropriate to a purpose and an audience.

OBJECTIVES

Subjects & Disciplines

Earth Science

Social Studies

- Economics

Storytelling

- Filmmaking

Learning Objectives

Students will:

- Generate ideas about how to make the lithium-ion battery use and disposal process more circular than linear.
- Identify the key qualities of effective video messages.
- Collaborate to draft their video storyboard and script using clear, coherent, and precise language in order to inform a specific target audience why and how to recycle electronic devices that contain lithium-ion batteries.

Teaching Approach

- Project-based learning

Teaching Methods

- Cooperative learning
- Discussions
- Self-directed learning

Skills Summary

This activity targets the following skills:

- 21st Century Student Outcomes
  - Information, Media, and Technology Skills
    - Information Literacy
    - Information, Communications, and Technology Literacy
  - Learning and Innovation Skills
    - Communication and Collaboration
    - Creativity and Innovation
  - Life and Career Skills
    - Flexibility and Adaptability
    - Initiative and Self-Direction

    - Leadership and Responsibility
    - Productivity and Accountability
    - Social and Cross-Cultural Skills
- 21st Century Themes
    - Environmental Literacy
- Critical Thinking Skills
    - Applying
    - Creating
- Science and Engineering Practices
    - Obtaining, evaluating, and communicating information

National Standards, Principles, and Practices

NATIONAL SCIENCE EDUCATION STANDARDS

• DCI ESS3.A::

Natural Resources: Humans depend on Earth’s land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geologic processes.

COMMON CORE STATE STANDARDS FOR ENGLISH LANGUAGE ARTS & LITERACY

• CCSS.ELA-LITERACY.WHST.6-8.2.D::

Use precise language and domain-specific vocabulary to inform about or explain the topic.

• WHST.6-8.4:

Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

NEXT GENERATION SCIENCE STANDARDS

• Crosscutting Concept 5:

Energy and matter: Flows, cycles, and conservation

• MS-ESS3: Earth and Human Activity:

MS-ESS3-3: Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment

• **Science and Engineering Practice 8:**
Obtaining, evaluating, and communicating information

Preparation

BACKGROUND & VOCABULARY

Background Information

In today's internet-driven society, short videos are an ideal format for communicating information and ideas, especially in regard to changing individual behaviors to contribute to broader social change. For videos to have maximum impact, they need to:

1. quickly capture the attention of a target audience,
2. clearly communicate a key takeaway message,
3. provide ideas about how the viewer can take action
4. be brief and visually appealing.

Using storyboards to draft the narrative arc is crucial across all types of media, even short videos. The storyboard helps the creators define what the viewer will see and hear at each stage of the video before committing ideas to recording. It can even help groups figure out their key message and how to best communicate that message. Finally, it will save groups time and energy by knowing ahead of time what they want to say and record to video.

Prior Knowledge

["Environmental and health impacts of mining lithium","How and why to recycle lithium-ion batteries","Circular versus linear economies"]

Recommended Prior Activities

- None

Vocabulary

Term	Part of Speech	Definition
circular economy	*noun*	a system of production that extends the lifespan of consumer goods by maximizing reusing and recycling, and minimizing throwing things away.

Term	Part of Speech	Definition
linear economy	*noun*	system where raw materials are collected and transformed into products, which are eventually discarded as waste.
recycle	*verb*	to clean or process in order to make suitable for reuse.
storyboard	*noun*	panel or series of panels where sketches are arranged in chronological order; used to prepare for a film, TV show, commercial, etc.