POWERING
Local Communities

Powering Local Communities with Biomass

MISSISSIPPI STATE UNIVERSITY
EXTENSION

Contents

Module 1:
Biomass Basics

Overview

Participants will learn what biomass is, where it comes from, and how it can be used to supply energy. This information will help teach the connection between agriculture and energy.

Audience

4-H'ers and other youth participants

Module Time

45 minutes to 1 hour

Learning Objectives

Participants will accomplish the following:

- **Knowledge:** Describe what biomass is and how it can be used to supply energy.
- **Comprehension:** Identify different types of biomass.
- **Application:** Increase awareness of biomass value and uses.

Evaluation

The evaluation is based on a pre-post retrospective format. Here, the evaluation is administered at the **end** of the module. Participants are asked to think back to an earlier time and consider knowledge before the module versus after the module.

For participants ages 8–13, use the junior evaluation; for participants ages 14–18, use the senior evaluation. If you use the QR code to complete the evaluations, the evaluation results will be sent to you.

Educational Standards

College and Career Readiness Science Standards

5th Grade

BIO.5 Students will investigate and evaluate the interdependence of living organisms and their environment.

5.4 Students will develop and use models to describe the flow of energy and amount of biomass through food chains, food webs, and food pyramids.

7th Grade

L.7.3 Students will demonstrate an understanding of the importance that matter cycles between living and nonliving parts of the ecosystem to sustain life on Earth.

8th Grade

E.8.10.3 Using scientific data, debate the societal advantages and disadvantages of technological advancements in renewable energy sources.

High School Environmental Science

ENV2.2 Investigate and research pros and cons of using traditional sources of energy and alternative sources of energy.

ENV2.3 Compare and contrast biodegradable and nonbiodegradable wastes and their significance in landfills.

Agriculture and Natural Resources (CTE Secondary)

BS.03 Demonstrate the application of biotechnology to solve problems in agriculture, food, and natural resources (AFNR) systems.

BS.03.03 Apply biotechnology principles, techniques, and processes to protect the environment and maximize use of natural resources (e.g., biomass, bioprospecting, industrial biotechnology, etc.).

BS.03.05 Apply biotechnology principles, techniques, and processes to produce biofuels (e.g., fermentation, transesterification, methanogenesis, etc.).

ESS.04 Demonstrate the operation of environmental service systems (e.g., pollution control, water treatment, wastewater treatment, solid waste management, and energy conservation).

ESS.04.04 Compare and contrast the impact of conventional and alternative energy sources on the environment and operation of environmental service systems.

NRS.03 Develop plans to ensure sustainable production and processing of natural resources.

NRS03.01 Sustainably produce, harvest, process, and use natural resource products (e.g., forest products, wildlife, minerals, fossil fuels, shale oil, alternative energy, recreation, aquatic species, etc.).

Instructor Lesson Materials

- ❑ Biomass Basics lesson guide (this document)
- ❑ Biomass Basics PowerPoint presentation
- ❑ Biomass Basics handout (one for each participant)
- ❑ Which Ones Are Biomass? worksheet (one for each participant)
- ❑ Sign-in sheet
- ❑ Evaluation (junior and/or senior version; one for each participant)
- ❑ Pens/pencils
- ❑ Supplies for Biomass Bag activity (listed under the Activity heading)
- ❑ Examples of biomass and non-biomass materials (optional; listed below)

Biomass Examples

- Food and food waste
- Plants and yard waste
- Wood and wooden furniture
- Paper and cardboard
- Cotton, wool, and leather clothing
- Hair and excrement from humans and animals

Non-Biomass Examples

- Pens
- Most snack packaging
- Bottle lids and other plastics
- Toys
- Glass
- Electronics
- Coins and other metal objects
- Batteries
- Sand and rocks

Equipment

- Laptop
- Projector/TV
- Speakers
- Internet connection to show video

Video Links

- National Renewable Energy Lab (NREL) video (included in PowerPoint): *https://www.youtube.com watch?v=7cCSV0IO4zE*
- Biomass Bag video: *https://www.youtube.com/watch?v=yC9pb_9UYd4*

Preparing for the Module

Several weeks in advance

- Determine an appropriate meeting location and time.
- Send out notices for the meeting.

At least one week before the meeting

- Read the lesson guide and PowerPoint materials. Review the instructor notes and add notes of your own as needed.
- Watch the provided videos to prepare for the activity.
- Review the handouts/reference materials and supplemental materials carefully.
- Make copies of handouts and evaluations.
- Review the Biomass Bag activity and the examples of biomass and non-biomass materials. Assemble/purchase the needed materials.

Day before the meeting

- Load course materials onto the computer you will use.
- If providing, assemble snacks/beverages, such as water, sodas, crackers, fruit, plates, napkins, etc. (Note: You can use snacks and packaging as examples of biomass and non-biomass materials.)

Day of the meeting

- Set up the computer and LCD projector, and check speakers.
- Set out course materials (Biomass Basics handout and Which Ones Are Biomass? worksheet). Place these materials on participants' tables or near the registration table for students to pick up.
- Set out the sign-in list.
- Set up the biomass/non-biomass materials on a table or have them in a container for easy access.

Biomass Basics Lesson Guide

Notes to Instructor

- The times listed in this lesson guide are approximate; it could take more or less time depending on participation/questions.
- Remember to use the activities, biomass/non-biomass materials, and videos to keep participants interested, and do not be too dependent on the PowerPoint slides.
- Encourage participation and questions throughout the presentation. Be interactive with your learners.

Introduction and Objectives (2 minutes; slides 1–4)

If needed, allow participants to introduce themselves, or play an "icebreaker" game.

Open the PowerPoint and say: Today, we are going to be talking about biomass and how it can be used to create energy.

Go to slide 2.

Ask: Has anyone ever heard of biomass? Can anybody tell me what it is?

Allow participants to answer and then read the answers provided on slide 3.

Ask: Does anybody know what organic matter is?

Allow time to answer before reading the answer on slide 4.

Biomass Examples (4 minutes; slide 5)

Show the biomass examples on slide 5 and say: These are a few more examples of biomass that you might be familiar with.

Ask: Does anybody know what this first picture is? (Point to the top left picture; click once for the answer to appear.)

Repeat this process for the other five pictures.

Give participants a chance to answer before revealing the answers. Answers will reveal one at a time starting with the top row.

Biomass in Mississippi (5 minutes; slides 6–10)

Before going to slide 6, ask participants: Do you know what the number one ag commodity in Mississippi is?

Give participants a few seconds to make guesses before revealing the answer on slide 6. Repeat this process for the next four slides.

Biomass Identification Game (5 minutes; slides 11–12)

Note: You can choose to use the PowerPoint slide, the worksheet, real-life examples, or any combination of these.

Pass out the Which Ones Are Biomass? worksheet (or display real-life examples). If using the worksheet/PowerPoint, allow students time to fill out their worksheet before going over the correct answers on slide 12.

Introduction (continued; 2 minutes; slides 13–14)

Ask: Do you think we can use biomass to supply energy?

Give participants a chance to answer.

Ask: How do you think we can use the biomass examples we've talked about to supply energy?

Give participants an opportunity to answer and then read the answer on slide 14.

Biomass Cycle (4 minutes; slides 15–20)

Display slide 15 and say: This is the cycle of biomass energy. As we go through the next few slides, we are going to talk about the different pieces involved in this cycle.

Go to slide 16 and point out the piece of the cycle that is circled before reading the description on the slide.

Repeat for slides 17–20.

NREL Energy Basics: Biomass (4 minutes; slide 21)

Say: This is a short video that is going to show us more about how biomass can be used to create energy.

Show the provided video (length: 3:21).

Benefits of Biomass Energy (2 minutes; slide 22)

Read the points on slide 22 that talk about some benefits of using biomass for energy.

Key Points (4 minutes; slides 23–24)

Ask: What did you learn today?

Allow participants to answer.

Say: Some of the key points from today are…

Read the information provided on slide 24.

Biomass Bag Activity (15–20 minutes; slides 25–27)

Refer to the Activities section for instructions.

For the full activity, use Version 1 of the activity found on page 7.

For quicker results, use Version 2 found on page 8.

Say: Now that we know allowing biomass to break down creates biogas that can be used to generate energy, we are going to do an activity where we create our own biomass bag. We will add some biomass to a bag and then seal it to allow it to act like a mini digestor and trap the biogas created when the biomass breaks down.

Use the video on slide 25 and instructions on slide 26 to guide participants through the activity, and then show the pictures on slide 27.

Evaluation (5 minutes)

Administer the appropriate evaluation. If using the paper version of the evaluation, pass them out to all participants and collect them once completed.

If using the Qualtrics version, allow participants to scan the QR code in PowerPoint. For Junior participants, use the QR code on slide 28. For Senior participants, use the QR code on slide 29.

Activities

Biomass Bag Activity (Version 1)

This is a modified version of an activity used with permission from The NEED Project. For more great activities, visit *www.need.org*.

Materials

- ❑ Resealable plastic bag (one per participant)
- ❑ 1 teaspoon of powdered yeast (per participant)
- ❑ 1 tablespoon of warm water (per participant)
- ❑ Leaves, grass clippings, other yard waste
- ❑ Fruit (strawberries work well)
- ❑ Other food scraps (lettuce, spinach, etc.; avoid meats)

Additional supplies needed for older participants:

- ❑ Breathalyzer
- ❑ Clear tubing
- ❑ 50 mL syringe

Procedure

- Open the plastic bag. Grab some leaves and food scraps and put them in your bag.
- Add a spoonful (about a teaspoon) of yeast to the bag.
- Add a tablespoon of water so the mixture is moist.
- Force as much air out of the bag as possible before closing it.
- Place the bag in a warm place.
  - For younger students:
    - » Place an index card horizontally across the top of the bag and use a ruler to measure the height of the index card.
    - » Continue to check the bag every 30 minutes for a few hours and use the index card to measure the change in height of the bag.
    - » Measuring the change in height allows you to measure the biogas created without opening the bag.
  - For older students (using the additional supplies):
    - » Connect the clear tubing to the end of the syringe and make sure it is secure. If the tubing is not secure, use tape to secure it.
    - » After the bag is inflated from the biogas, carefully open a small section and insert the clear tubing.
    - » Fill the syringe with biogas from the biomass bag.
    - » Remove the clear tubing from the bag and insert it into the mouthpiece of the breathalyzer.
    - » Slowly push the biogas from the syringe into the breathalyzer to measure the ethanol percentage in the gas.

Biomass Bag Activity (Version 2)

Materials

- ❑ Resealable plastic bag (one per participant)
- ❑ 1 tablespoon of cornmeal or sugar (per participant)
- ❑ 1 teaspoon of yeast (per participant)
- ❑ 1 tablespoon of warm water (per participant)

Additional supplies needed for older participants:

- ❑ Breathalyzer
- ❑ Clear tubing
- ❑ 50 mL syringe

Procedure

- Open the plastic bag.
- Add about 1 tablespoon of cornmeal or sugar and 1 teaspoon of yeast to the bag.
- Add about 1 tablespoon of water to the bag and gently mix until the entire mixture is wet. If the mixture is too dry, slowly add more water to the bag.
- Force as much air out of the bag as possible before closing it.
- Place the bag in a warm place.
  - For younger students:
    - » Place an index card horizontally across the top of the bag and use a ruler to measure the height of the index card.
    - » Continue to check the bag every 5–10 minutes and use the index card to measure the change in height of the bag.
    - » Measuring the change in height allows you to measure the biogas created without opening the bag.
  - For older students (using the additional supplies):
    - » Connect the clear tubing to the end of the syringe and make sure it is secure. If the tubing is not secure, use tape to secure it.
    - » After the bag is inflated from the biogas, carefully open a small section and insert the clear tubing.
    - » Fill the syringe with biogas from the biomass bag.
    - » Remove the clear tubing from the bag and insert it into the mouthpiece of the breathalyzer.
    - » Slowly push the biogas from the syringe into the breathalyzer to measure the ethanol percentage in the gas.

Biomass Basics

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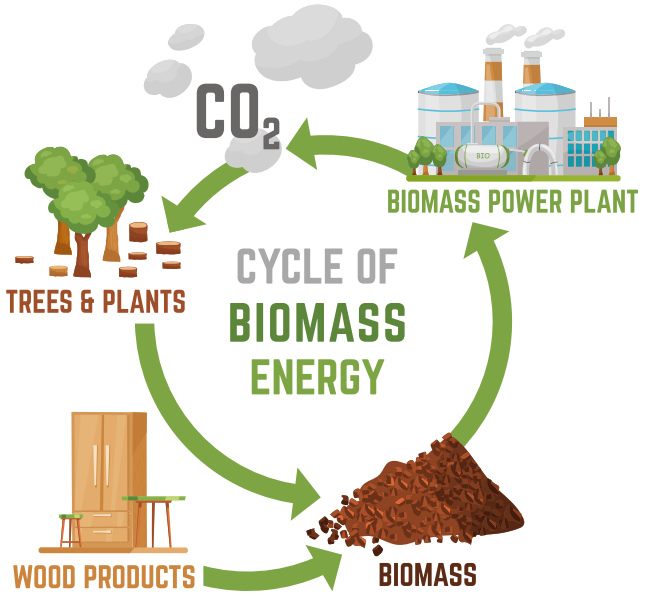
WHAT IS BIOMASS?

Biomass is any organic matter that can be used as a form of fuel.



BIOMASS FACTS

Agricultural crops like corn, soybeans, and sugar cane, landfill gases, forestry waste, and food waste are all forms of biomass we can use to generate energy.

Just like our bodies use food to create the energy we need, biomass can be used to create energy to power communities.

Using biomass can lower the cost of producing energy because of the variety of materials that can be used as fuel.

Forestry, agricultural, and food waste are consistently available and can be sustainably managed, which makes biomass a cleaner energy source that is better for the environment.

HOW DO WE USE BIOMASS FOR ENERGY?

The biomass produces high-pressure steam when it is burned in a boiler. The steam flows over a series of blades, causing them to rotate. The rotation of the turbine drives a generator, which produces electricity.

Which Ones Are Biomass?

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Instructions: Look at the pictures below and circle the ones that you think are biomass and cross out the ones that are not.

A.

B.

C.

D.

E.

F.

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Biomass Basics Evaluation (Juniors)

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Tell us what you learned!

For each topic, please rate your knowledge **BEFORE** this lesson.

Different types of biomass	Poor	Fair	Good	Excellent
How biomass can be used to produce electricity	Poor	Fair	Good	Excellent
Benefits of using biomass to generate energy	Poor	Fair	Good	Excellent

For each topic, please rate your knowledge **AFTER** this lesson.

Different types of biomass	Poor	Fair	Good	Excellent
How biomass can be used to produce electricity	Poor	Fair	Good	Excellent
Benefits of using biomass to generate energy	Poor	Fair	Good	Excellent

Tell us how we did!

The information was useful.	No ☹	Kind of 😐	Yes 🙂
The information was easy to understand.	No ☹	Kind of 😐	Yes 🙂
The presenter knew about using biomass to produce energy.	No ☹	Kind of 😐	Yes 🙂
The presenter asked if anyone had questions.	No ☹	Kind of 😐	Yes 🙂
I liked the Which Ones Are Biomass? worksheet.	No ☹	Kind of 😐	Yes 🙂
I liked the Biomass Bag activity.	No ☹	Kind of 😐	Yes 🙂

Tell us how to improve this activity!

_____

_____

_____

_____

Tell us about yourself!

Age: _____ Sex: ❑ Male ❑ Female

Race: ❑ African American ❑ American Indian or Alaska Native ❑ Asian, Native Hawaiian, or Other Pacific Islander

❑ White ❑ Two or More Races ❑ Other/Unidentified

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Biomass Basics Evaluation (Seniors)

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Tell us what you learned!

For each topic, please rate your knowledge **BEFORE** this lesson.

Different types of biomass	Poor	Fair	Good	Excellent
How biomass can be used to produce electricity	Poor	Fair	Good	Excellent
Benefits of using biomass to generate energy	Poor	Fair	Good	Excellent

For each topic, please rate your knowledge **AFTER** this lesson.

Different types of biomass	Poor	Fair	Good	Excellent
How biomass can be used to produce electricity	Poor	Fair	Good	Excellent
Benefits of using biomass to generate energy	Poor	Fair	Good	Excellent

Tell us how we did!

The information was useful.	Strongly Disagree	Disagree	Agree	Strongly Agree
The information was easy to understand.	Strongly Disagree	Disagree	Agree	Strongly Agree
The presenter knew about using biomass to produce energy.	Strongly Disagree	Disagree	Agree	Strongly Agree
The presenter asked if anyone had questions.	Strongly Disagree	Disagree	Agree	Strongly Agree
I liked the Which Ones Are Biomass? worksheet.	Strongly Disagree	Disagree	Agree	Strongly Agree
I liked the Biomass Bag activity.	Strongly Disagree	Disagree	Agree	Strongly Agree

Tell us how to improve this activity!

_____

_____

_____

_____

Tell us about yourself!

Age: _____ Sex: ❑ Male ❑ Female

Race: ❑ African American ❑ American Indian or Alaska Native ❑ Asian, Native Hawaiian, or Other Pacific Islander

❑ White ❑ Two or More Races ❑ Other/Unidentified

Module 2:
Biomass Battery

Overview

Participants will learn about the main components of a battery and how biomass can be used to supply energy.

Audience

4-H'ers and other youth participants

Module Time

1 to 1.5 hours

Learning Objectives

Participants will accomplish the following:

- **Knowledge:** Describe the basic components of a battery and how biomass can act like a battery to supply energy.
- **Comprehension:** Explain the steps involved in creating a biomass battery and how it works.
- **Application:** Construct a biomass battery.

Evaluation

The evaluation is based on a pre-post retrospective format. Here, the evaluation is administered at the **end** of the module. Participants are asked to think back to an earlier time and consider knowledge before the module versus after the module.

For participants ages 8–13, use the junior evaluation; for participants ages 14–18, use the senior evaluation. If you use the QR code to complete the evaluations, the evaluation results will be sent to you.

Educational Standards

College and Career Readiness Science Standards

4th Grade

P.4.6A.2 Plan and conduct scientific investigations to classify different materials as either an insulator or conductor of electricity.

P.4.6A.4 Develop models that demonstrate the path of an electric current in a complete, simple circuit (e.g., lighting a light bulb or making a sound).

P.4.6A.5 Use informational text and technology resources to communicate technological breakthroughs made by historical figures in electricity (e.g., Alessandro Volta, Michael Faraday, Nicola Tesla, Thomas Edison, incandescent light bulbs, batteries, light-emitting diodes).

P.4.6A.6 Design a device that converts any form of energy from one form to another form (e.g., construct a musical instrument that will convert vibrations to sound by controlling varying pitches, a solar oven that will convert energy from the sun to heat energy, or a simple circuit that can be used to complete a task). Use an engineering design process to define the problem, design, construct, evaluate, and improve the device.

Foundations of Biology

FB.1.4 Enrichment: Research, analyze, explain, and communicate the influence of society, including cultural components, on the direction and progress of science and technology (e.g., medical treatments, emerging viruses, antibiotic resistance, vaccinations and re-emergent diseases, alternative energy development, and/or biomimicry).

Physics

PHY.5.4 Develop and use models (e.g., circuit drawing and mathematical representation) to explain how electric circuits work by tracing the path of electrons, including concepts of energy transformation, transfer, conservation of energy, electric charge, and resistance using online simulations, probe systems, and/or laboratory experiences.

Agriculture and Natural Resources (CTE Secondary)

BS.03 Demonstrate the application of biotechnology to solve problems in agriculture, food, and natural resources (AFNR) systems.

BS.03.03 Apply biotechnology principles, techniques, and processes to protect the environment and maximize use of natural resources (e.g., biomass, bioprospecting, industrial biotechnology, etc.).

NRS.03 Develop plans to ensure sustainable production and processing of natural resources.

NRS.03.01 Sustainably produce, harvest, process, and use natural resource products (e.g., forest products, wildlife, minerals, fossil fuels, shale oil, alternative energy, recreation, aquatic species, etc.).

PST.01 Apply physical science principles and engineering applications to solve problems and improve performance in AFNR power, structural, and technical systems.

PST.01.01 Performance Indicator: Apply physical science and engineering principles to assess and select energy sources for AFNR power, structural, and technical systems.

Instructor Lesson Materials

- ❑ Biomass Battery lesson guide (this document)
- ❑ Biomass Battery PowerPoint presentation
- ❑ Battery Breakdown worksheet (junior and/or senior version; one for each participant)
- ❑ Biomass Battery worksheet (one for each participant)
- ❑ Sign-in sheet
- ❑ Evaluation (junior and/or senior version; one for each participant)
- ❑ Pens/pencils
- ❑ Voltmeter
- ❑ Supplies for Biomass Battery activity (listed under the Activity heading)

Equipment

- Laptop
- Projector/TV
- Speakers
- Internet connection to show video

Video Links

- TedED video included in PowerPoint: *https://www.youtube.com/watch?v=9OVtk6G2TnQ*
- Biomass Battery video: *https://www.youtube.com/watch?v=HICzqFaGsRk*

Preparing for the Module

Several weeks in advance

- Determine an appropriate meeting location and time.
- Send out notices for the meeting.

At least one week before the meeting

- Read the lesson guide and PowerPoint materials. Review the instructor notes and add notes of your own as needed.
- Review the handouts/reference materials and supplemental materials carefully.
- Make copies of the handouts and evaluations for this session.
- Assemble/purchase needed materials.

Day before the meeting

- Load course materials onto the computer you will use.
- Edit the PowerPoint to include slides for the appropriate age group of your participants.

Day of the meeting

- Set up the computer and LCD projector, and check speakers.
- Set out course materials (Battery Breakdown worksheet, Biomass Battery worksheet, and evaluations). Place these materials on participants' tables or near the registration table for students to pick up.
- Set out the sign-in list.

Biomass Battery Lesson Guide

Notes to Instructor

- The times listed in this lesson guide are approximate; it could take more or less time depending on participation/questions.
- Remember to use activities, demonstration materials, and videos to keep participants interested, and do not be too dependent on the PowerPoint slides.
- Encourage participation and questions throughout the presentation. Be interactive with your learners.

Introduction (1 minute; slide 1)

If needed, allow participants to introduce themselves, or play an "icebreaker" game.

Open the PowerPoint and say: Today, we are going to be talking more about how biomass can be used to create energy and even creating our own "biomass battery." Before creating our biomass battery, we are going to talk about regular batteries and how they work.

Definitions and Battery Types (5 minutes; slides 2–4)

For junior students (ages 8–13), use the definition on slide 3.

For senior students (ages 14–18), use the definition on slide 4.

Ask: Can anybody tell me what a battery is?

Give participants a chance to answer.

Ask: Can you think of things that use batteries?

Uses of Batteries (3 minutes; slide 5)

Say: Here are some other examples of things that use batteries.

Click to animate the first image and ask: Can somebody tell me what this is?

Give participants a chance to answer before repeating the process with the rest of the images. Click when asking about each one to animate the image.

Answers from top left: camera, smoke detector, watch, flashlight, game controller

Batteries and How They Work (5 minutes; slides 6–9)

For junior students (ages 8–13), use the definitions on slides 6 and 8.

For senior students (ages 14–18), use the definitions on slides 7 and 9.

Say: Now, we are going to learn about the different parts of a battery.

Click once to make the first definition and highlight circle appear, and read the definition of *anode*. Click once to make the next definition and highlight circle appear. Read the definition of *cathode*, and then click to make the next definition appear. Read the definition of *electrolyte*, and then click once to make the highlight circle disappear.

Say: The cathode accepts the same number of electrons that the anode releases.

Go to the next slide for the appropriate age group, and click once to make the first definition and highlight circles appear. Read the definition of *electrodes*. Click once to make the highlight circles disappear and the next definition and highlight circle appear, and read the definition of *insulator*. Click once to make the next definition and highlight circle appear, and read the definition of *current*. Click to make the next definitions appear, and read the definitions of *voltage* and *circuit*.

Note: The last two terms, *voltage* and *circuit*, will appear together and will not have highlight circles.

How Batteries Work (2 minutes; slides 10–12)

For junior students (ages 8–13), use the answer provided on slide 11.

For senior students (ages 14–18), use the answer provided on slide 12.

Go to slide 10 and ask: Does anyone have an idea of how these parts make a battery work?

Give participants a chance to answer before reading the answer provided.

Battery Video (5 minutes; slide 13)

Say: Now, we are going to watch a short video that will talk about the history of batteries and give us a recap of how they work.

Play the YouTube video on slide 13.

Battery Breakdown Worksheet (10 minutes)

Say: Now, we are going to take a quick break and do a Battery Breakdown worksheet to make sure we all know the different parts of a battery.

Give participants time to complete the worksheet and answer any questions they have. (For help answering questions, see the worksheet answer keys.)

LEDs and How They Work (2 minutes; slide 14)

Say: Now that we all understand what a battery is and how it works, let's talk about light-emitting diodes. Does anyone know what a light-emitting diode is?

Give participants a chance to answer.

Say: Light-emitting diodes are also called LEDs. Has anyone heard of LED lights? Can anyone tell us how an LED works?

Give participants a chance to answer.

Say: This picture shows us the different parts of an LED light like the ones we will be using for our activity later.

Read the bullet points on slide 14 and then say: Some LEDs we are familiar with are holiday lights, phone screens, and traffic lights. LEDs are commonly used in houses now because they are more efficient and last longer than traditional light bulbs.

Biomass Refresher (2 minutes; slide 15)

Ask: Do you remember what biomass is?

Give participants a chance to answer before clicking to reveal the answer (on slide 15) and reading it aloud.

Ask: What about how biomass can be used to create energy?

Give participants a chance to answer before clicking to reveal the answer and reading it aloud.

Ask: What are some examples of biomass that you can think of?

Give participants a chance to answer before moving to the next slide.

Biomass Examples (2 minutes; slide 16)

Say: Here are some examples of biomass we might know.

Go through and briefly talk about the biomass that is in each picture.

Biomass Battery Activity Part 1 (15–20 minutes; slides 17–18)

Say: Now that we know how batteries work and remember what biomass is, we are going to create our own biomass battery. We are going to use voltmeters and some different objects in the first part to see how much voltage can be produced by our biomass. I'm going to show part of a video that will demonstrate how we should do this.

Play the instructional video on slide 17 until the 1:34 mark.

Say: Now that we've watched how this is done, we can gather our supplies and get started. Be sure to record your results in the table on your Biomass Battery worksheet.

Split students into pairs/groups if needed (depending on how many voltmeters are available).

Pass out/allow participants to collect worksheets and supplies.

Say: Choose two of the objects from your supply bag and insert them into your biomass. Your voltmeter will need to be set to the V⎓ 200m setting. Use the voltmeter to measure the voltage being produced.

Helpful tip: If the voltmeter displays a 1, switch to the V⎓ 2000m setting.

Allow participants to repeat these steps if time allows and record their results in Table 1 on their worksheets.

Use the pictures on slide 18 and the video on slide 17 to guide the participants through the activity.

Biomass Battery Activity Part 2 (25–30 minutes; slides 17 and 19)

Say: Now you know there is potential voltage in your biomass, so we are going to try and use it to make an LED light up. I'm going to show the rest of the video so we can see how to create a biomass battery.

Play the rest of the instructional video on slide 17.

Say: Now that we know how to create our biomass batteries, we can gather the rest of our supplies and start making our circuits.

Say: Gather a few additional pieces of biomass (potatoes, sweet potatoes, or lemons, whole or half), one galvanized nail and one piece of copper wire per piece of biomass, a few wires with alligator clips, and an LED light.

Say: Insert one galvanized nail and one piece of copper wire into each piece of biomass.

Say: The next step is to connect the biomass using the wires with alligator clips; use the clips to connect the copper wire to the galvanized nail of the next piece of biomass. Use the last two alligator clips to connect to your LED.

Ask: Is anyone's LED working? If not, try adding some more biomass and see if it comes on.

Say: Make sure to answer the questions on your worksheet after you finish your battery.

Allow participants to keep experimenting with the types and amount of biomass they are using to power their LED. Use the video on slide 17 and the pictures on slide 19 to guide participants through the activity.

Biomass Battery Explanation (2 minutes; slide 20)

Ask: Does anyone know how biomass acts like the batteries we talked about earlier to make the LED light up?

Give participants a chance to answer before clicking twice to reveal the explanation on slide 20; read it aloud.

Evaluation (5 minutes)

Administer the appropriate evaluation. If using the paper version of the evaluation, pass them out to all participants and collect them once completed.

If using the Qualtrics version, allow participants to scan the QR code in PowerPoint. For Junior participants, use the QR code on slide 21. For Senior participants, use the QR code on slide 22.

Activities

Biomass Battery Part 1

Materials

- ❑ Biomass (sweet potatoes, potatoes, or lemons; one per participant)
- ❑ Voltmeter
- ❑ Various metal objects (bobby pins, paper clips, coins, soda can tabs)

Procedure

- Choose two metal objects from the supply list and insert them into a piece of biomass.
- Set the voltmeter to the V⎓ 200m setting. Use the voltmeter to measure the voltage being produced by the biomass.
  - If the voltmeter displays a 1, switch to the V⎓ 2000m setting.
  - If the voltmeter displays a negative value, swap the black and red probes.
- Repeat as many times as you would like and record your results in Table 1 on the Biomass Battery worksheet.
- Does the size of the biomass affect the voltage being produced? Does the voltage increase or decrease when using a bigger piece of biomass?

Biomass Battery Part 2

Materials

- ❑ Additional pieces of biomass
- ❑ Wires with alligator clips
- ❑ Copper wire (one piece per piece of biomass)
- ❑ Galvanized nail (one piece per piece of biomass)
- ❑ LED

Procedure

- Insert one galvanized nail and one piece of copper wire into each piece of biomass.
- Connect the biomass using the wires with alligator clips; use the clips to connect the copper wire to the galvanized nail of the next piece of biomass.
- Repeat this process until all of your biomass is connected.
- Use the two alligator clips that are not connected to any biomass to connect to the LED. (One should be connected to a piece of copper wire and the other should be connected to a galvanized nail at the other end of your circuit.)
- Use the pictures on slide 19 to make sure everything is connected correctly.
- See if the LED is illuminated. If the LED is not working, try adding more biomass.

Battery Breakdown (Juniors)

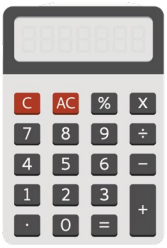
Instructions: Use the word bank to fill in the blank with the correct word.

Word Bank

anode	insulator	voltage	oxidation
electrolyte	battery	current	reduction
cathode	circuit	electrodes	electrons

1. A(n) _____ is a device that stores power and sends it out to make things work.
2. The _____ is the negative electrode where the electric current is produced.
3. The _____ is the "juice" inside of a battery that moves the electric current from the negative electrode to the positive electrode.
4. The strength of the current is called the _____.
5. A(n) _____ is a material that does not allow electricity to flow through it.
6. The _____ is the positive electrode that receives the electric current.
7. The conductors that let the electric current move in and out of the battery are the _____.
8. Electricity flows through a path called a(n) _____.
9. _____ is the flow of electrons, also called electricity.
10. The process where electrons are lost is _____.
11. The process where electrons are gained is _____.

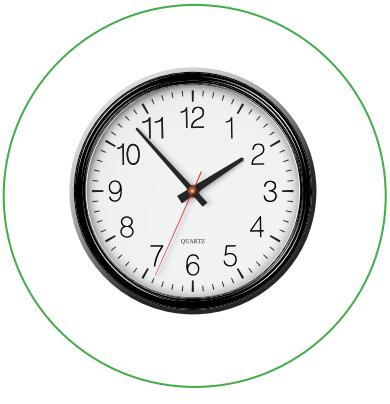
Instructions: Circle the items that use batteries.



Battery Breakdown (Juniors) Answer Key

1. A **battery** is a device that stores power and sends it out to make things work.
2. The **anode** is the negative electrode where the electric current is produced.
3. The **electrolyte** is the "juice" inside of a battery that moves the electric current from the negative electrode to the positive electrode.
4. The strength of the current is called the **voltage**.
5. An **insulator** is a material that does not allow electricity to flow through it.
6. The **cathode** is the positive electrode that receives the electric current.
7. The conductors that let the electric current move in and out of the battery are the **electrodes**.
8. Electricity flows through a path called a **circuit**.
9. **Current** is the flow of electrons, also called electricity.
10. The process where electrons are lost is **oxidation**.
11. The process where electrons are gained is **reduction**.

Instructions: Circle the items that use batteries.



Battery Breakdown (Seniors)

Instructions: Use the word bank to fill in the blank with the correct word.

Word Bank

anode	insulator	voltage	oxidation	energy
electrons	battery	current	reduction	
cathode	circuit	electrodes	electrolyte	

1. A device that stores chemical energy and converts it to electrical energy by moving electrons around to create an electric current is a _____.
2. The _____ is the negative electrode that holds electrons loosely and releases electrons to the external circuit through an oxidation reaction to travel to the positive terminal.
3. The medium (liquid, solid, or paste/gel) that separates the cathode and the anode terminals and allows charged particles (ions) to flow between them is the _____.
4. _____ is the electric potential difference between two points on a circuit, or the strength of a current.
5. Glass, wood, and plastic are examples of _____. These are materials that act as a barrier to prevent energy transfer by reducing the flow of electricity or heat.
6. The _____ is the positive electrode that accepts electrons through a reduction reaction and holds them tightly.
7. The two terminals made of different chemicals (usually metals) that are separated by the electrolyte and allow electrons to flow and generate an electrical current are the _____.
8. A _____ is the path for the transmission of electric current.
9. _____ is the rate at which charged particles (electrons) flow past a point on a circuit.
10. The process that occurs in Volta's cell is called _____ and _____.

Instructions: Label the parts of a battery.

Word Bank

cathode

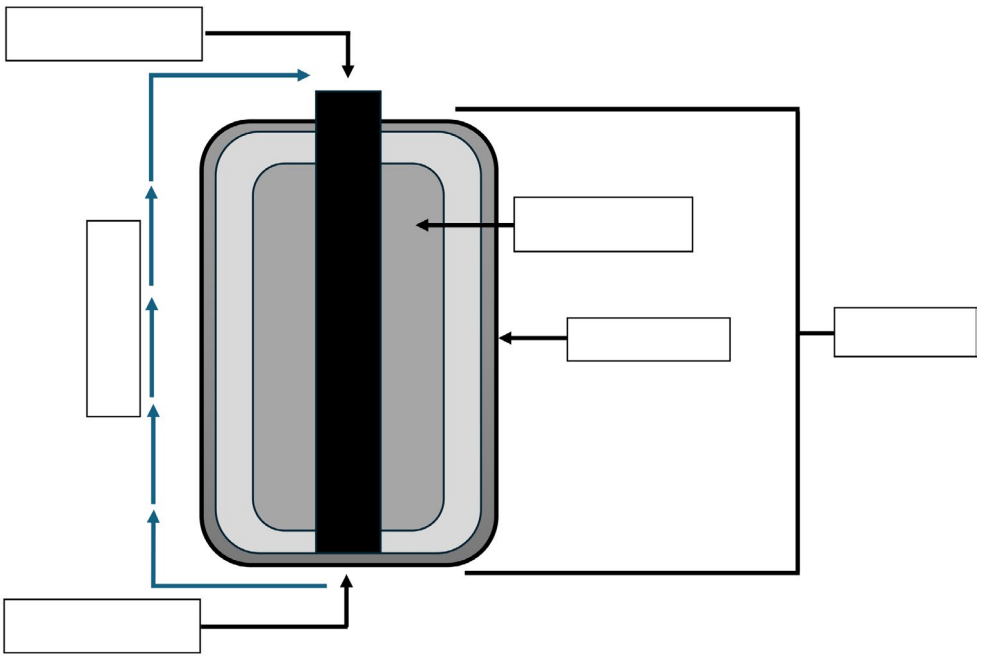
anode

electrolyte

battery

insulator

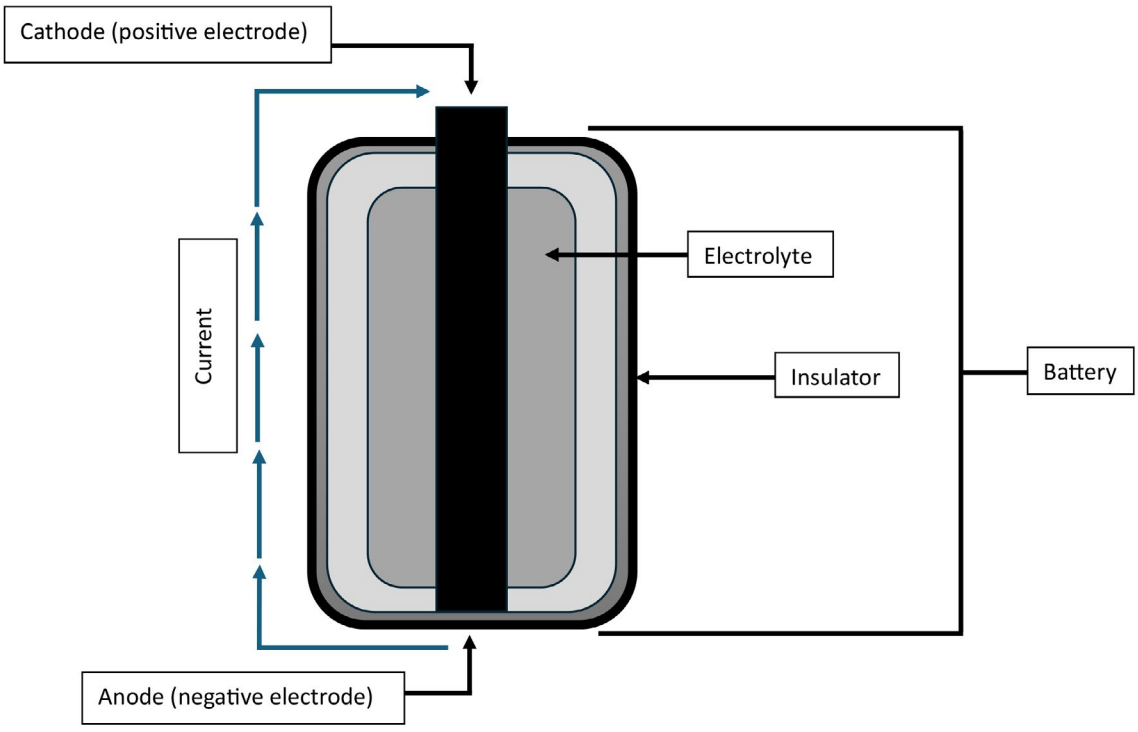
current



Battery Breakdown (Seniors) Answer Key

1. A device that stores chemical energy and converts it to electrical energy by moving electrons around to create an electric current is a **battery**.
2. The **anode** is the negative electrode that holds electrons loosely and releases electrons to the external circuit through an oxidation reaction to travel to the positive terminal.
3. The medium (liquid, solid, or paste/gel) that separates the cathode and the anode terminals and allows charged particles (ions) to flow between them is the **electrolyte**.
4. **Voltage** is the electric potential difference between two points on a circuit, or the strength of a current.
5. Glass, wood, and plastic are examples of **insulators**. These are materials that act as a barrier to prevent energy transfer by reducing the flow of electricity or heat.
6. The **cathode** is the positive electrode that accepts electrons through a reduction reaction and holds them tightly.
7. The two terminals made of different chemicals (usually metals) that are separated by the electrolyte and allow electrons to flow and generate an electrical current are the **electrodes**.
8. A **circuit** is the path for the transmission of electric current.
9. **Current** is the rate at which charged particles (electrons) flow past a point on a circuit.
10. The process that occurs in Volta's cell is called **oxidation** and **reduction**.

Instructions: Label the parts of a battery.



Biomass Battery Activity: Measuring Voltage

Part 1

Instructions: Follow the directions for part 1 of the Biomass Battery activity, and use the table below to record your results.

Table 1. Voltage measured using different metal objects.

Biomass being used	Object being touched by the RED probe	Object being touched by the BLACK probe	Voltage

Part 2

Instructions: Answer the following questions after completing part 2 of the Biomass Battery activity.

1. What kind of biomass did you use to make your battery? _____

   _____

2. How many pieces of biomass did it take to make the LED work? _____

3. Did using more pieces of biomass make the LED brighter? _____

4. Connect your biomass battery to the voltmeter instead of the LED. What is the voltage reading? _____

   _____

Biomass Battery Evaluation (Juniors)

Tell us what you learned!

For each topic, please rate your knowledge **BEFORE** this lesson.

Main parts of a battery	Poor	Fair	Good	Excellent
How biomass can be used to produce electricity	Poor	Fair	Good	Excellent
How to make a "biomass battery"	Poor	Fair	Good	Excellent

For each topic, please rate your knowledge **AFTER** this lesson.

Main parts of a battery	Poor	Fair	Good	Excellent
How biomass can be used to produce electricity	Poor	Fair	Good	Excellent
How to make a "biomass battery"	Poor	Fair	Good	Excellent

Tell us how we did!

The information was useful.	No ☹	Kind of 😐	Yes 🙂
The information was easy to understand.	No ☹	Kind of 😐	Yes 🙂
The presenter knew about using biomass to produce energy.	No ☹	Kind of 😐	Yes 🙂
The presenter asked if anyone had questions.	No ☹	Kind of 😐	Yes 🙂
I liked the Which Ones Are Biomass? worksheet.	No ☹	Kind of 😐	Yes 🙂
I liked the Biomass Bag activity.	No ☹	Kind of 😐	Yes 🙂

Tell us how to improve this activity!

_____

_____

_____

_____

Tell us about yourself!

Age: _____ Sex: ❑ Male ❑ Female

Race: ❑ African American ❑ American Indian or Alaska Native ❑ Asian, Native Hawaiian, or Other Pacific Islander

❑ White ❑ Two or More Races ❑ Other/Unidentified

Biomass Battery Evaluation (Seniors)

Tell us what you learned!

For each topic, please rate your knowledge **BEFORE** this lesson.

Main parts of a battery	Poor	Fair	Good	Excellent
How biomass can be used to produce electricity	Poor	Fair	Good	Excellent
How to make a "biomass battery"	Poor	Fair	Good	Excellent

For each topic, please rate your knowledge **AFTER** this lesson.

Main parts of a battery	Poor	Fair	Good	Excellent
How biomass can be used to produce electricity	Poor	Fair	Good	Excellent
How to make a "biomass battery"	Poor	Fair	Good	Excellent

Tell us how we did!

The information presented was useful.	Strongly Disagree	Disagree	Agree	Strongly Agree
The information was easy to understand.	Strongly Disagree	Disagree	Agree	Strongly Agree
The presenter was knowledgeable about using biomass to produce energy.	Strongly Disagree	Disagree	Agree	Strongly Agree
The presenter invited questions and discussion.	Strongly Disagree	Disagree	Agree	Strongly Agree
I enjoyed the Battery Breakdown worksheet.	Strongly Disagree	Disagree	Agree	Strongly Agree
I enjoyed the Biomass Battery activity.	Strongly Disagree	Disagree	Agree	Strongly Agree

Tell us how to improve this activity!

_____

_____

_____

_____

Tell us about yourself!

Age: _____ Sex: ❑ Male ❑ Female

Race: ❑ African American ❑ American Indian or Alaska Native ❑ Asian, Native Hawaiian, or Other Pacific Islander

❑ White ❑ Two or More Races ❑ Other/Unidentified

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