AmplifyScience

Harnessing Human Energy

Investigation Notebook with Article Compilation

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Harnessing Human Energy

Investigation Notebook

Table of Contents

Table of Contents (continued)

Chapter 3: Designing an Energy Solution

Safety Guidelines for Science Investigations

1. **Follow instructions.** Listen carefully to your teacher's instructions. Ask questions if you don't know what to do.
2. **Don't taste things.** No tasting anything or putting it near your mouth unless your teacher says it is safe to do so.
3. **Smell substances like a chemist.** When you smell a substance, don't put your nose near it. Instead, gently move the air from above the substance to your nose. This is how chemists smell substances.
4. **Protect your eyes.** Wear safety goggles if something wet could splash into your eyes, if powder or dust might get in your eyes, or if something sharp could fly into your eyes.
5. **Protect your hands.** Wear gloves if you are working with materials or chemicals that could irritate your skin.
6. **Keep your hands away from your face.** Do not touch your face, mouth, ears, eyes, or nose while working with chemicals, plants, or animals.
7. **Tell your teacher if you have allergies.** This will keep you safe and comfortable during science class.
8. **Be calm and careful.** Move carefully and slowly around the classroom. Save your outdoor behavior for recess.
9. **Report all spills, accidents, and injuries to your teacher.** Tell your teacher if something spills, if there is an accident, or if someone gets injured.
10. **Avoid anything that could cause a burn.** Allow your teacher to work with hot water or hot equipment.
11. **Wash your hands after class.** Make sure to wash your hands thoroughly with soap and water after handling plants, animals, or science materials.

Name: _____ Date: _____

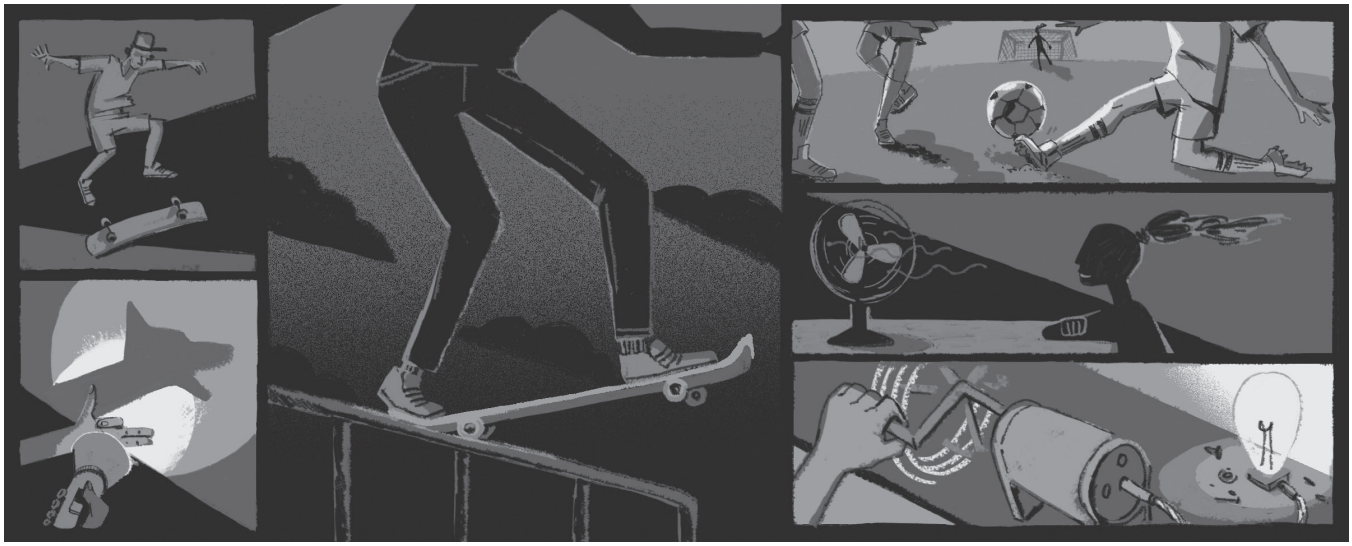
Harnessing Human Energy
Unit Overview

How is it possible to charge electrical devices when the power is out? This is the question that you and your classmates will investigate in your role as student energy scientists. Your challenge is to design a way for rescue workers to get energy to their electrical devices (flashlights, cell phones, and radios), even when they are on rescue missions, far from electrical outlets. To do this, you'll need to learn about possible sources of energy, including energy stored in the bodies of the rescue workers, and figure out a way to capture that human energy. Scientists and engineers have been inventing new ways to solve everyday energy problems; now you and your classmates will have the opportunity to contribute your own valuable ideas.

Name: _____ Date: _____

Chapter 1: What Is Energy?
Chapter Overview

Welcome to the Energy Research Lab! As a student energy scientist, you will learn about what energy is and how you know whether an object has energy. Answering these questions will help you understand why energy matters to a rescue team.



Name: _____ Date: _____

Lesson 1.1: Welcome to the Energy Research Lab

Welcome to your role as a student energy scientist at the Energy Research Lab. A rescue team needs your help: the team needs to use small electrical devices, such as flashlights, on rescue missions, but these devices often run out of energy. The rescue team needs to find a way to get energy to their flashlights and other devices even when the power is out. Today you will explore what energy is, and you will use a digital simulation to find ways to make a light shine. This will help you begin to solve the rescue team's problem.

Unit Question

- How is it possible to charge electrical devices when the power is out?

Chapter 1 Question

- What is energy and why does it matter to the rescue team?

Vocabulary

- energy
- system

Digital Tools

- *Harnessing Human Energy* Sorting Tool activity: What Has Energy?
- *Harnessing Human Energy* Simulation

Name: _____ Date: _____

What Has Energy?

1. Launch the *Harnessing Human Energy* Sorting Tool activity: What Has Energy? and follow the instructions below.
2. When you have finished sorting the objects, press HAND IN. If you worked with a partner, write his or her name here: _____

Goal: Decide whether each object does or does not have energy.

Do:

- Drag objects that you think have energy to the Things That Have Energy bin.
- Drag objects that you think do not have energy to the Things That Don't Have Energy bin.
- Leave objects you are not sure about in the toolbar.

Tips:

- Make sure to read the object descriptions.
- Scroll down on the toolbar to make sure you see all of the objects.
- You can overlap objects if you need to.
- Remember to press HAND IN when you are done.

Name: _____ Date: _____

Using a Simulation to Make the Light Shine

Part 1

Explore the *Harnessing Human Energy* Simulation.

- What can you do in the Sim? What do you observe?
- Share what you notice with a partner.
- Later, your teacher will give you a mission to accomplish in the Sim.

Part 2

1. Return to the Simulation and build a system that makes a light shine.
2. After you build a system that makes a light shine, discuss the question below with your partner, and then record your thinking.

Based on your ideas about energy, where do you see examples of energy in the system you built?

_____

_____

_____

_____

_____

Name: _____ Date: _____

Homework: Reflecting on Energy

1. Do you think a moving skateboard has energy? Why or why not?

_____

_____

_____

_____

2. Do you think people used energy before modern times? Why or why not?

_____

_____

_____

_____

3. How well do you think you understand energy? Use the scale below to rate how well you understand energy (check one).

   ☐ 1: I don't understand energy at all.

   ☐ 2: I know just a little about energy.

   ☐ 3: I know a fair amount about energy, but there is a lot I don't know.

   ☐ 4: I know a lot about energy.

   ☐ 5: I understand everything there is to know about energy!

Name: _____ Date: _____

Lesson 1.2: Investigating Energy Claims

Today you will learn how to tell if an object has energy. To do this, you will build systems that make a fan spin, and you'll think carefully about whether the systems have energy. You will also learn how scientists make arguments, and you'll use the evidence you gathered about energy in systems to support a claim just as a scientist would.

Unit Question

- How is it possible to charge electrical devices when the power is out?

Chapter 1 Question

- What is energy and why does it matter to the rescue team?

Vocabulary

- claim
- energy
- evidence
- reasoning
- scientific argument
- system

Digital Tools

- *Harnessing Human Energy* Sorting Tool activity: What Has Energy?

Name: _____ Date: _____

Warm-Up

ERL Energy Research Lab

Dear student energy scientists,

People use the word *energy* to mean a lot of different things. In an everyday sense, *energy* can mean excitement or having what it takes to run a marathon. In a scientific sense, *energy* has a specific meaning:

Energy is the ability to make things move or change.

Please use this scientific definition of *energy* to revise your thinking about what has energy.

Sincerely,
Morgan Lewis
Lead Energy Scientist, Energy Research Lab

1. Return to the Sorting Tool activity: What Has Energy? from the previous lesson and revise your work.

2. When you have finished sorting the objects, press HAND IN. If you worked with a partner, write his or her name here: _____

3. In the space below, explain what you revised, or why you kept it the same.

_____

_____

_____

_____

_____

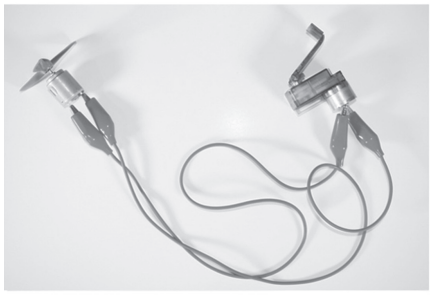
_____

Name: _____ Date: _____

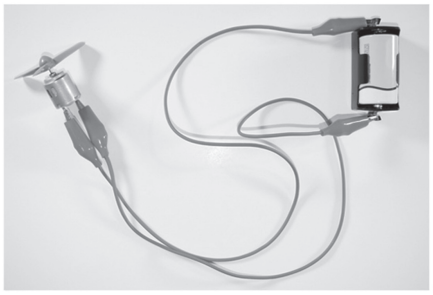
Investigating Energy Systems

Part 1: Do *All* the Systems Have Energy?

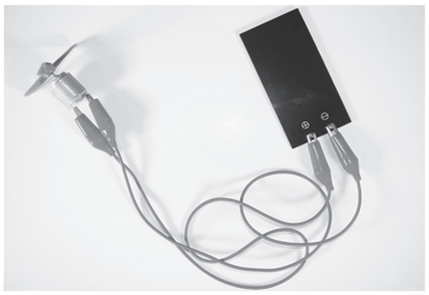
- Use the materials to build each system with your group.
- After you build each system, use the Reasoning Tool on the next page to record evidence about whether or not each system has energy.
- Remember that energy is the ability to make things move or change.



Hand-Crank Generator System



Battery System



Solar Cell System

Name: _____ Date: _____

Investigating Energy Systems (continued)

Part 2: Reasoning Tool

Possible subclaims:

- The Battery System does have energy.
  or
  The Battery System does not have energy.
- The Hand Crank Generator System does have energy.
  or
  The Hand Crank Generator System does not have energy.
- The Solar Cell System does have energy.
  or
  The Solar Cell System does not have energy.

Evidence (observations about whether the system does or does not have energy)	**This matters because . . .** (How does this evidence support the subclaim?)	**Therefore, . . .** (subclaim)

Name: _____ Date: _____

Homework: Do These Objects Have Energy?

- Use what you have learned so far about energy to decide whether each of the objects listed below has energy or not.
- Explain your evidence for why you think each object does or doesn't have energy.

1. Food (check one)

   ☐ has energy

   ☐ does not have energy

What is your evidence for why you think food has energy or does not have energy?

_____

_____

_____

_____

2. Soccer ball flying through the air (check one)

   ☐ has energy

   ☐ does not have energy

What is your evidence for why you think this object has energy or does not have energy?

_____

_____

_____

_____

Name: _____ Date: _____

Homework: Do These Objects Have Energy? (continued)

3. Soccer ball not moving (check one)
   - ☐ has energy
   - ☐ does not have energy

What is your evidence for why you think this object has energy or does not have energy?

_____

_____

_____

_____

4. Fan spinning (check one)
   - ☐ has energy
   - ☐ does not have energy

What is your evidence for why you think this object has energy or does not have energy?

_____

_____

_____

_____

5. Fan not spinning (check one)
   - ☐ has energy
   - ☐ does not have energy

What is your evidence for why you think this object has energy or does not have energy?

_____

_____

_____

_____

Name: _____ Date: _____

Lesson 1.3: Identifying Kinetic Energy and Potential Energy

Welcome back to the Energy Research Lab! In today's lesson, you will continue your research on energy, focusing on how to recognize when things have energy. You will learn about different types of energy today—first through the use of the Sorting Tool, and then through a demonstration by your teacher.

Unit Question

- How is it possible to charge electrical devices when the power is out?

Chapter 1 Question

- What is energy and why does it matter to the rescue team?

Key Concept

- Whenever something moves or changes, it is because of energy.

Vocabulary

- energy
- evidence
- kinetic energy
- potential energy

Digital Tools

- *Harnessing Human Energy* Sorting Tool activity: Evidence of Energy

Name: _____ Date: _____

Warm-Up

The lead energy scientist has forwarded you an email from an Energy Research Lab client. Read the email and decide how you would respond to the client.

ERL Energy Research Lab

Dear student energy scientists,

Now that you have been learning about energy, I would like your help responding to some questions we receive here at the Energy Research Lab. Please see the email I've included below.

Sincerely,
Morgan Lewis
Lead Energy Scientist, Energy Research Lab

Email from client:

Dear Energy Research Lab,
My friend drives around in her electric car, and she has to charge the car's batteries every night. However, I never need to plug in my bike! Therefore, I think I can get from place to place without using energy at all.
What do you think? **Is riding a bike a way to travel that doesn't use energy?**

Sincerely,
Sasha (Energy Research Lab client)

1. Which of the following statements would you include in your response to the client? (check one)

   ☐ Riding a bike doesn't use energy.

   ☐ Riding a bike does use energy.

   ☐ I'm not sure if riding a bike uses energy or not.

2. Explain the statement you selected in the space below.

_____

_____

_____

_____

Name: _____ Date: _____

Evidence of Energy

1. Launch the Sorting Tool activity: Evidence of Energy and follow the instructions below. Talk to a partner about your ideas as you work.
2. When you have finished sorting the objects, press HAND IN. If you worked with a partner, write his or her name here: _____

Goal: Look at each object and decide whether you can see evidence of energy.

Do:

- Think about the definition of *energy* as you look at each object. Do you see evidence of energy?
- If you can't see evidence of energy, drag the object to the bin on the left.
- If you can see evidence of energy, drag the object to the bin on the right.
- Leave objects you are not sure about in the toolbar.

Tips:

- Scroll down on the toolbar to make sure you see all of the objects.
- Remember that energy is the ability to make things move or change.

Name: _____ Date: _____

Kinetic Energy and Potential Energy Demonstration

Before your teacher begins the demonstration, answer the following questions by selecting the option that best completes each sentence.

1. A wind-up toy that is not wound up. . . (check one)
   - ☐ does not have energy.
   - ☐ has kinetic energy.
   - ☐ has potential energy.
   - ☐ has both kinetic and potential energy.

2. A wind-up toy that is wound up but not moving. . . (check one)
   - ☐ does not have energy.
   - ☐ has kinetic energy.
   - ☐ has potential energy.
   - ☐ has both kinetic and potential energy.

3. A wind-up toy that is wound up and moving. . . (check one)
   - ☐ does not have energy.
   - ☐ has kinetic energy.
   - ☐ has potential energy.
   - ☐ has both kinetic and potential energy.

Name: _____ Date: _____

Reflection

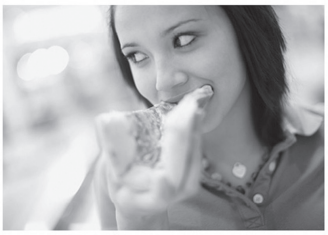
How do you know whether an object has potential energy?

- Circle one object from the choices below that you think has potential energy.
- Explain why you think the object you selected has potential energy.

skateboard at top of ramp

charged battery

food



stretched bow and arrow

Why do you think this object has potential energy?

_____

_____

_____

_____

_____

Name: _____ Date: _____

Homework: Energy and the Rescue Team

You have been investigating why energy matters to the rescue team, and now you've learned about two different categories of energy.

1. What is one way that kinetic energy might be involved in rescue team missions?

_____

_____

_____

_____

2. What is one way that potential energy might be involved in rescue team missions?

_____

_____

_____

_____

Name: _____ Date: _____

Lesson 1.4: "Energy Inventions"

Scientists around the world are working to solve the world's energy problems in creative ways. Some of these solutions were designed by people not much older than you. Today you'll read an article about some of these energy inventions and the scientists who designed them. You will practice reading like a scientist: carefully and actively, making sure that you understand the text and images. You will record your questions and ideas as you read, and you'll have a chance to discuss your thoughts about the article with others.

Unit Question

- How is it possible to charge electrical devices when the power is out?

Chapter 1 Question

- What is energy and why does it matter to the rescue team?

Key Concepts

- Whenever something moves or changes, it is because of energy.
- When something is moving, it has kinetic energy.
- When something has the ability to make things move or change in the future, it has potential energy, even if it is not moving or changing now.

Vocabulary

- energy
- kinetic energy
- potential energy

Digital Tools

- *Harnessing Human Energy* Sorting Tool activity: Kinetic or Potential Energy?

Name: _____ Date: _____

Warm-Up

1. Launch the Sorting Tool activity: Kinetic or Potential Energy? and follow the instructions below.
2. When you have finished sorting the objects, press HAND IN. If you worked with a partner, write his or her name here:_____

Goal: Decide whether each object has kinetic energy or potential energy.

Do:

- If you think an object has potential energy, drag it to the Potential Energy bin.
- If you think an object has kinetic energy, drag it to the Kinetic Energy bin.

Tips:

- Kinetic energy is the energy that an object has because it is moving.
- Potential energy is the energy that is stored in an object or system.

Name: _____ Date: _____

Introducing Active Reading

- What do you notice about this student's annotations?
- How do you know that she was thinking carefully while reading and trying to understand the article?

that are incredibly powerful, and you can't see them, and they're everywhere," says Lynch. "And they dictate, in my book, pretty much everything that goes on on this planet."

They are so tiny, but so important!

Today, at the University of California, San Francisco, Lynch works with many different types of scientists to study the human microbiome and how it affects the body as a system—which requires building bridges between different areas of science. To study the interactions between microorganisms and the body as a whole, scientists have to think and learn about topics outside of their usual areas of study. "In that way, we're kind of like our own little microbiome," she says. "Everybody brings different knowledge and skills to the table."

The crosscutting concept of Systems

How long have scientists studied microbiome?

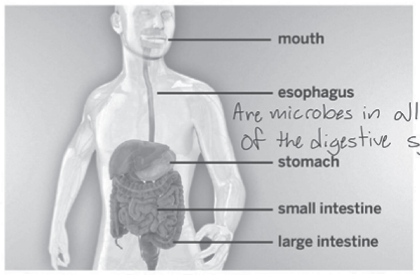
The study of the human microbiome is still in its early stages: scientists are trying to find out and describe the basics of how the microbiome works. Someday, scientists hope to understand exactly what happens during each interaction—and that could open up whole new fields of study.

Interactions seem really important. What does that mean?

What are the challenges?

Studying the human microbiome has its challenges, but Lynch says she loves learning new things—and she encourages young people to find something they love, too. "Go after something that you really enjoy, something that isn't a chore," she says. "I've ended up where I am because I've always gone after things that interest me. I eat, breathe, and sleep this stuff, and I love it."

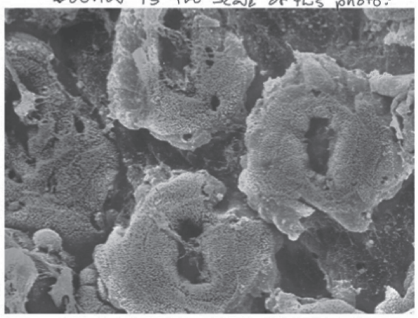
gross



Are microbes in all parts of the digestive system?

Many of the microbes Dr. Susan Lynch studies are found in the human digestive system.

What is the scale of this photo?



This photo, taken with a microscope, shows the wall of a gut infected with ulcerative colitis, a digestive problem that may be caused by the interaction between microorganisms. Lynch's work may someday help heal people with this condition. (Colors were added to the photo to make it easier to see.)

BIG IDEA:
The microbiome interacts with and affects lots of things even though it's not visible

Name: _____ Date: _____

Reading "Energy Inventions"

1. Read and annotate the article "Energy Inventions."
2. Choose and mark annotations to discuss with your partner. Once you have discussed these annotations, mark them as discussed.
3. Now, choose and mark a question or connection, either one you already discussed or a different one you still want to discuss with the class.
4. Answer the reflection question below.

Rate how successful you were at using Active Reading skills by responding to the following statement:

As I read, I paid attention to my own understanding and recorded my thoughts and questions.

- ☐ Never
- ☐ Almost never
- ☐ Sometimes
- ☐ Frequently/often
- ☐ All the time

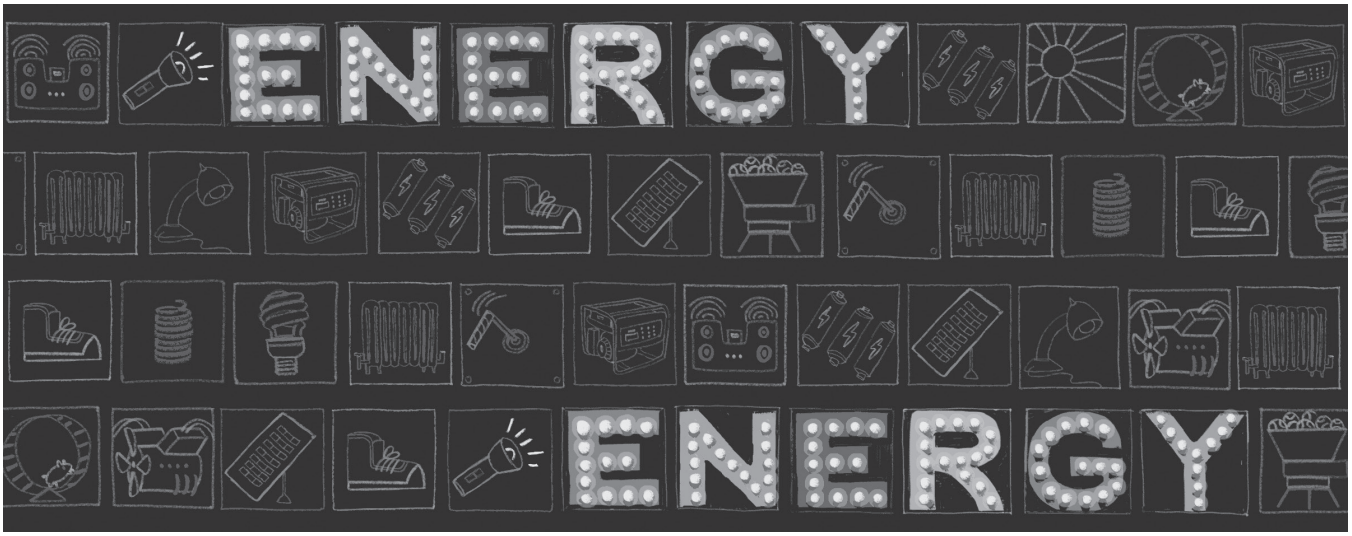
Active Reading Guidelines

1. Think carefully about what you read. Pay attention to your own understanding.
2. As you read, annotate the text to make a record of your thinking. Highlight challenging words and add notes to record questions and make connections to your own experience.
3. Examine all visual representations carefully. Consider how they go together with the text.
4. After you read, discuss what you have read with others to help you better understand the text.

Name: _____ Date: _____

Chapter 2: The Rescue Team's Energy Needs
Chapter Summary

What do you do when your flashlight runs out of energy? What about when the power is out? In Chapter 2, you will investigate how objects get energy. This will help you learn how the rescue team can charge electrical devices, even when the power is out.



Name: _____ Date: _____

Lesson 2.1: Investigating Claims About How Objects Get Energy

The work you've done so far as a student energy scientist has helped you build an understanding of what energy is, and why it matters to the rescue team. You know that the rescue team needs energy to operate electrical devices, but how do devices and other objects get energy? Today you will gather evidence from the Simulation to help answer this question.

Unit Question

- How is it possible to charge electrical devices when the power is out?

Chapter 2 Question

- How can the rescue workers get energy to the batteries in their equipment during rescue missions?

Vocabulary

- energy
- evidence
- kinetic energy
- potential energy
- system
- transfer

Digital Tools

- *Harnessing Human Energy* Simulation

Name: _____ Date: _____

Warm-Up

ERL Energy Research Lab

Dear student energy scientists,

Rescue workers need to have working equipment, such as flashlights, at all times. But they can't always just charge their equipment by plugging it in. As student energy scientists, your assignment is to make sure the rescue team's equipment works in any emergency situation. To prepare to help the rescue team, reflect on these questions and record your ideas.

Sincerely,
Morgan Lewis
Lead Energy Scientist, Energy Research Lab

1. What types of emergency situations could rescue workers be in that would make it difficult for them to get energy to their electrical devices?

_____

_____

_____

_____

2. What's one idea you have about how rescue workers can get energy to their electrical devices in these situations?

_____

_____

_____

_____

Name: _____ Date: _____

Investigating How Objects Get Energy

How do objects get energy?

- With your partner, decide which claim you will investigate in the Simulation, and select it below.
- Talk to your partner about how you plan to get evidence for or against your claim in the Simulation.
- Use the Reasoning Tool below to record your evidence and explain how the evidence supports or goes against the claim you selected.

The claim we are investigating is (check one)

- ☐ **Claim 1:** Objects can make their own energy.
- ☐ **Claim 2:** Objects get energy from other objects that have energy.
- ☐ **Claim 3:** Only living things have energy.

Reasoning Tool

Evidence (observations from the Simulation)	**This matters because . . .** (How does this evidence support or go against the claim)	**Therefore, . . .** (the claim that the evidence supports or goes against) **is/is not supported.**

Name: _____ Date: _____

Investigating How Objects Get Energy (continued)

Describe the energy system you built in the Sim that provided evidence for or against your claim:

_____

_____

_____

_____

Name: _____ Date: _____

Homework: Where Does Energy Come From?

- Use the Simulation to build two *different* systems that can launch a ball.
- Describe each system you built.
- Answer the question about each system.

System 1 description:

_____

_____

_____

_____

In your first system, where did the ball get the energy that it needed in order to move?

_____

_____

_____

System 2 description:

_____

_____

_____

_____

In your second system, where did the ball get the energy that it needed in order to move?

_____

_____

_____

Name: _____ Date: _____

Lesson 2.2: Evaluating Energy Sources

Does everything have energy? And where does it come from anyway? Today you will revisit the "Energy Inventions" article to get more evidence about how objects get energy. You will also learn about and discuss many different energy sources and decide which energy sources are the best and worst options for the rescue team.

Unit Question

- How is it possible to charge electrical devices when the power is out?

Chapter 2 Question

- How can the rescue workers get energy to the batteries in their equipment during rescue missions?

Vocabulary

- convert
- energy
- kinetic energy
- potential energy
- system
- transfer

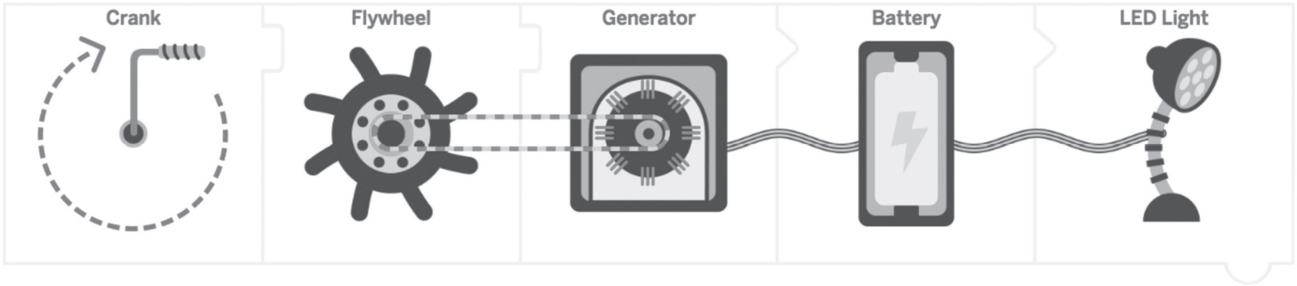
Digital Tools

- *Harnessing Human Energy* Sorting Tool activities: Energy from the Sun, Energy from Gasoline, and Energy from Food
- *Harnessing Human Energy* Simulation

Name: _____ Date: _____

Warm-Up

It's important for energy scientists to be able to understand and describe how energy systems work. Look closely at the energy system below and answer the questions.



1. On the lines below, write where each object gets its energy from: the flywheel, the person turning the crank, the battery, or the generator.

   - The light gets its energy from the _____.
   - The battery gets its energy from the _____.
   - The generator gets its energy from the _____.
   - The flywheel gets its energy from the _____.

2. Someone needs to turn the crank to make the flywheel spin. Is this person creating energy? If not, where do you think the person's energy comes from?

_____

_____

_____

_____

Name: _____ Date: _____

Second Read of "Energy Inventions"

Reread the last two paragraphs of the "Energy Inventions" article and highlight evidence that supports or goes against the claims:

- **Claim 1:** Objects can make their own energy.
- **Claim 2:** Objects get energy from other objects that have energy.

Which claim do you think is most convincing based on the evidence you have gathered so far? (check one)

☐ Claim 1

☐ Claim 2

Name: _____ Date: _____

Evaluating Energy Sources

- Read each Energy Source Card carefully and discuss your questions and ideas about each energy source with your partner.
- Next, arrange the cards in order of best to worst energy source options for the rescue team. Place the cards in a line with the best option on the left and the worst option on the right.
- When you are finished sorting the cards on your desk, answer the questions below.

Energy Sources

nuclear power plant	wind turbine
combustion engine	human-powered generator
hydroelectric power plant	fuel-burning power plant
solar cell	

1. Which energy source did you rank as the best option for the rescue team?

   _____

   Why?

   _____

   _____

   _____

   _____

2. Which energy source did you rank as the worst option for the rescue team?

   _____

   Why?

   _____

   _____

   _____

   _____

Name: _____ Date: _____

Homework: Practice with Energy Transfer Diagrams

Energy from the Sun

1. Launch the Sorting Tool activity: Energy from the Sun, and follow the instructions below.
2. When you are finished, press HAND IN.
3. Optional: Build the system described below in the Simulation.

Goal: Make an Energy Transfer Diagram that shows how energy from the sun can be used to make a flashlight shine.

Do:

- Drag the battery and the sun shining on a solar cell to the correct bins.
- Add more objects and arrows to show how energy from the sun can be transferred and converted to make a flashlight shine.

Tips:

- You can change the direction of the arrow by selecting it and dragging the purple dot.

Energy from Gasoline

1. Launch the Sorting Tool activity: Energy from Gasoline, and follow the instructions below.
2. When you are finished, press HAND IN.
3. Optional: Build the system described below in the Simulation.

Goal: Make an Energy Transfer Diagram that shows how energy from gasoline can be used to make a flashlight shine.

Do:

- Drag the battery and gasoline to the correct bins.
- Add more objects and arrows to show how energy from gasoline can be transferred and converted to make a flashlight shine.

Tips:

- You can change the direction of the arrow by selecting it and dragging the purple dot.

Name: _____ Date: _____

Homework: Practice with Energy Transfer Diagrams (continued)

Energy from Food

1. Launch the Sorting Tool activity: Energy from Food, and follow the instructions below.
2. When you are finished, press HAND IN.
3. Optional: Build the system described below in the Simulation.

Goal: Make an Energy Transfer Diagram that shows how energy from food can be used to make a flashlight shine.

Do:

- Drag the battery and food to the correct bins.
- Add more objects and arrows to show how energy from food can be transferred and converted to make a flashlight shine.

Tips:

- You can change the direction of the arrow by selecting it and dragging the purple dot.

Name: _____ Date: _____

Homework: "How We Store Energy"

In this lesson, you evaluated different energy sources, including renewable energy sources such as solar and wind power. One of the big challenges humans face is how to store energy. To learn more about this challenge, read and annotate the "How We Store Energy" article. Then, answer the questions below.

1. How have batteries gotten better over time?

_____

_____

_____

_____

2. Why is it important for scientists to find better ways to store solar and wind energy?

_____

_____

_____

_____

Active Reading Guidelines

1. Think carefully about what you read. Pay attention to your own understanding.
2. As you read, annotate the text to make a record of your thinking. Highlight challenging words and add notes to record questions and make connections to your own experience.
3. Examine all visual representations carefully. Consider how they go together with the text.
4. After you read, discuss what you have read with others to help you better understand the text.

Name: _____ Date: _____

Lesson 2.3: Writing Scientifc Arguments

The lead energy scientist at the Energy Research Lab is eagerly awaiting your response on how you can solve the rescue team's energy problem. Today you will decide on the best energy source for the rescue team. Once this decision is made, you will work with some of your fellow student energy scientists to develop a detailed explanation of how the rescue workers can use this energy source to get energy to the batteries in their flashlights during rescue missions.

Unit Question

- How is it possible to charge electrical devices when the power is out?

Chapter 2 Question

- How can the rescue workers get energy to the batteries in their equipment during rescue missions?

Vocabulary

- claim
- convert
- energy
- evidence
- generator
- kinetic energy
- potential energy
- reasoning
- system
- transfer

Key Concepts

- Nothing creates energy. If something has energy, the energy must have been transferred from something else.
- Energy can be transferred from one object to another, and energy can be converted from one type to another.

Name: _____ Date: _____

Warm-Up

One of the rescue workers has a special flashlight; it has a crank, and the light shines when the crank is turned. Since the rescue worker has never had to replace the batteries or plug in the flashlight, she thinks this flashlight works without an energy source.
Do you agree or disagree?

☐ I think the flashlight **does** work without an energy source.

☐ I think the flashlight **does not** work without an energy source.

I think this because . . .

_____

_____

_____

_____

_____

_____

Name: _____ Date: _____

Word Relationships

1. With a partner, use the words on the Word Relationships Cards to create sentences that answer the Chapter 2 Question: *How can the rescue workers get energy to the batteries in their equipment during rescue missions?*
2. Use at least two words from the Word Relationships Cards in each sentence. You don't have to use all the words.
3. There are many different ways to answer the Chapter 2 Question, so try to create as many sentences as you can. You can also use multiple sentences to express your ideas.
4. When you have created your sentences, join another pair of students and share your responses

Word Bank

energy	convert	transfer
potential energy	kinetic energy	

Name: _____ Date: _____

Writing a Scientific Argument

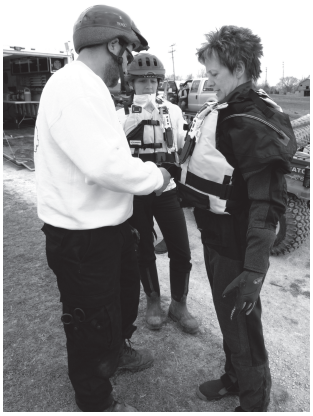
Part 1: Message from the Lead Energy Scientist

Dear student energy scientists,

The rescue team needs to be sure they do not run out of energy in emergency situations. They are choosing between these two energy sources for the batteries in their equipment—the sun (solar cells) or human-powered generators. Please write an argument that will convince the rescue workers which energy source is the best choice for solving this energy problem.

Sincerely,
Morgan Lewis
Lead Energy Scientist, Energy Research Lab

ERL Energy Research Lab



Part 2: Claims and Evidence

Claim 1: The sun (solar cells) is the best energy source for the rescue team.

Claim 2: Human-powered generators are the best energy source for the rescue team.

Evidence 1: Solar cells transfer energy from the sun to a battery.

Evidence 2: Human-powered generators can be used to transfer energy any time someone is there to turn the crank.

Evidence 3: Solar cells only transfer energy when the sun is shining.

Evidence 4: Rescue missions take place both in the daytime and at night, as well as in many different environments.

Evidence 5: Potential energy stored in a battery can be converted to another form of energy at a later time.

Evidence 6: Human-powered generators transfer energy to a battery when a person turns a hand crank.

After reviewing all the evidence, this is the energy source that is best supported for meeting the rescue team's energy needs: (check one)

☐ **Claim 1:** The sun (solar cells) is the best energy source for the rescue team.

☐ **Claim 2:** Human-powered generators are the best energy source for the rescue team.

Name: _____ Date: _____

Writing a Scientific Argument (continued)

Part 3: Arguing for an Energy Source

The rescue team needs to be sure they do not run out of energy in emergency situations. Write an argument that will convince the rescue workers which energy source is the best choice for solving this energy problem.

Claim 1: The sun (solar cells) is the best energy source for the rescue team.

Claim 2: Human-powered generators are the best energy source for the rescue team.

Include the following in your argument:

- the claim you selected,
- evidence that supports your claim, and
- vocabulary from the Word Bank (no need to use all the words).

Word Bank
convert
energy
kinetic energy
potential energy
transfer

Name: _____ Date: _____

Homework: Reading About Hand-Crank Flashlights

ERL Energy Research Lab

Dear student energy scientists,

To help you design a system that solves the rescue team's problem, I would like you to learn about some human-powered devices that already exist. I hope learning about these devices will give you ideas that will help you design an original solution to the rescue team's problem.

Sincerely,
Morgan Lewis
Lead Energy Scientist, Energy Research Lab

1. Read and annotate the "Hand-Crank Flashlight" article. The first time you read, record your questions and connections.
2. Reread the "Hand-Crank Flashlight" article. While reading the article a second time, make highlights and add annotations that help you answer the question: *How does the hand-crank get energy to a battery?*

Name: _____ Date: _____

Chapter 3: Designing an Energy Solution
Chapter Summary

All over the world, energy scientists and engineers are inventing ways to capture energy from the human body's motion to charge electrical devices. In Chapter 3, you will learn about some of these inventions, and you will design a system that captures energy from rescue workers' motion to charge the batteries in their electrical devices.

Name: _____ Date: _____

Lesson 3.1: Reading About Energy Systems

Based on your research and the research of other student energy scientists, the rescue workers have decided that they would like to use kinetic energy from their bodies to power their flashlights. Your task is to design a system that allows them to do this. Before you begin to design your energy system, you will learn about some interesting systems that capture energy from the body's motion.

Unit Question

- How is it possible to charge electrical devices when the power is out?

Chapter 3 Question

- What is the best way for the rescue workers to capture energy from their bodies' motion during rescue missions?

Key Concepts

- Whenever something moves or changes, it is because of energy.
- When something is moving, it has kinetic energy.
- When something has the ability to make things move or change in the future, it has potential energy, even if it is not moving or changing now.
- Nothing creates energy. If something has energy, the energy must have been transferred from something else.
- Energy can be transferred from one object to another, and energy can be converted from one type to another.

Vocabulary

- convert
- energy
- kinetic energy
- potential energy
- system
- transfer

Name: _____ Date: _____

Warm-Up

Based on new evidence you gathered from reading the article, do you think a hand-crank flashlight would be a good energy system for the rescue workers? Why or why not? You can review the "Hand-Crank Flashlight" article, if needed.

_____

_____

_____

_____

_____

_____

Name: _____ Date: _____

Active Reading: *Capturing Human Energy*

Part 1: First Read

- Choose one of the articles from the *Capturing Human Energy* article set. Record the title of the article you selected here: _____
- Read and annotate the article, using your Active Reading strategies. You can refer to the Active Reading Guidelines below.

Part 2: Second Read

- Read the same *Capturing Human Energy* article again. Highlight information and add annotations that help answer these questions:
    - How does the system you read about transfer and convert energy to make a generator move?
    - Do you think this system would be a good solution for the rescue team? Why or why not?
- Be prepared to share what you learned with the members of your group.

Active Reading Guidelines

1. Think carefully about what you read. Pay attention to your own understanding.
2. As you read, annotate the text to make a record of your thinking. Highlight challenging words and add notes to record questions and make connections to your own experience.
3. Examine all visual representations carefully. Consider how they go together with the text.
4. After you read, discuss what you have read with others to help you better understand the text.

Name: _____ Date: _____

Discussing Energy Systems

- Group members should take turns to explain the energy system they read about.
    - How does the system transfer and convert energy to make a generator move?
    - Do you think this system would be a good solution for the rescue team? Why or why not?
- As each group member explains an energy system, record brief notes about that energy system in the table below.

Energy system	**How does this system make a generator move?**	**Would the system be a good solution for the rescue team? Why or why not?**
Hand-crank flashlight	When a person turns the crank, the generator spins.	No, the rescue workers would need to stop what they are doing to turn the crank.
Energy-capturing backpack		
Energy-capturing bike		
Energy-capturing rocking chair		
Energy-capturing knee brace		

Name: _____ Date: _____

Brainstorming Designs for an Energy System

The rescue workers need a way to get energy to their equipment anytime and anywhere. **What is the best way for the rescue workers to capture energy from their bodies' motion during rescue missions?**

Brainstorm some ideas for a system that captures energy from rescue workers' motion. Make sure your energy system

- transfers energy from the body's motion to a battery,
- is easy for the rescue team to use during rescue missions, and
- is original (your group's own design).

Record your ideas for energy systems in the space below.

Name: _____ Date: _____

Lesson 3.2: Designing and Explaining Energy Systems

What do *you* think is the best way for the rescue workers to capture energy from their bodies' motion during rescue missions? Today you will work with your group to design an original energy system to accomplish this important job! You will document your energy system and use physical materials to make a model of your design so that the rescue team can understand how it works.

Unit Question

- How is it possible to charge electrical devices when the power is out?

Chapter 3 Question

- What is the best way for the rescue workers to capture energy from their bodies' motion during rescue missions?

Key Concepts

- Whenever something moves or changes, it is because of energy.
- When something is moving, it has kinetic energy.
- When something has the ability to make things move or change in the future, it has potential energy, even if it is not moving or changing now.
- Nothing creates energy. If something has energy, the energy must have been transferred from something else.
- Energy can be transferred from one object to another, and energy can be converted from one type to another.

Vocabulary

- convert
- energy
- kinetic energy
- potential energy
- system
- transfer

Digital Tools

- *Harnessing Human Energy* Simulation

Name: _____ Date: _____

Warm-Up

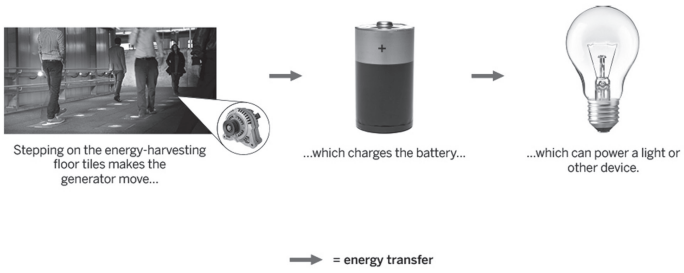
ERL Energy Research Lab

Dear student energy scientists,

I would like you to read about one more system that captures human energy. This might give you more ideas for a system that could work for the rescue team.

Sincerely,
Morgan Lewis
Lead Energy Scientist, Energy Research Lab

How Energy-Harvesting Floor Tiles Work



Energy-harvesting floor tiles work by compressing a tiny amount when stepped on. A special generator converts this squeezing motion to electrical energy. With each footstep, one tile provides enough energy to power a standard lightbulb for just a fraction of a second.

How could the rescue workers use squeezing or compressing to get energy to their flashlights during rescue missions?

_____

_____

_____

_____

_____

_____

Name: _____ Date: _____

Designing Energy Systems

Remember that the rescue workers need a way to easily get energy to their equipment anytime and anywhere. **What is the best way for the rescue workers to capture energy from their bodies' motion during rescue missions?**

1. Work with your group to design an original energy system for the rescue team. All group members should participate in designing the system.
2. Share ideas for energy systems. As a group, decide on one energy system to design.
3. Use the Energy System Sketch sheet on the next page to show what your system might look like.
4. Complete the Energy Transfer Diagram sheet on page 54 to show how your energy system captures energy from the body's motion.
5. Use the provided materials to make a model of your energy system. Your system should include
   - a plastic vial or binder clip to represent a generator, and
   - a penny to represent a battery.

Name: _____ Date: _____

Energy System Sketch

In the space below, sketch your energy system. Add labels and captions that help explain how your energy system works. You can use the Word Bank to help you label your sketch. You do not need to use all of the words.

Word Bank

potential energy	transfer	generator
kinetic energy	convert	

Name: _____ Date: _____

Energy Transfer Diagram

Make an Energy Transfer Diagram, using labels and arrows, to show how your system captured energy from the rescue worker's motion in order to power a flashlight.

Potential Energy

Kinetic Energy

Light Energy

Name: _____ Date: _____

Homework: Report for the Rescue Team

Your homework has two parts. First, write a report to the rescue workers about the energy system you designed for them. Then, read the message from the lead energy scientist about designing a new energy system to solve a different problem.

Part 1

Write a report to the rescue team explaining how your energy system works. Make sure to explain how your system captures energy from rescue workers' bodies to power equipment during rescue missions. Try to use the words in the Word Bank below.

Word Bank

kinetic energy	potential energy	transfer	convert	generator

Name: _____ Date: _____

Homework: Report for the Rescue Team (continued)

ERL Energy Research Lab

Dear student energy scientists,

One of our clients is interested in ways to power lights and other small electronics using energy sources that are available in his environment. This client lives in a sunny, windy, dry environment. I'd like you to use the Simulation to design an energy system for this client and record your ideas below. I look forward to seeing what you come up with!

Sincerely,
Morgan Lewis
Lead Energy Scientist, Energy Research Lab

Part 2

1. Launch the Simulation and create an energy system that can meet the needs of the Energy Research Lab client.
2. In the space below, describe the parts of your energy system and explain how energy is transferred and converted in the system to power lights or small electronics.

_____

_____

_____

_____

_____

_____

Name: _____ Date: _____

Lesson 3.3: Evaluating an Energy Solution

The Energy Research Lab was impressed with your energy system designs for the rescue team and would like your help with another client's energy problem. A school principal is interested in saving money on her school's energy costs by capturing energy from students' physical activities while they are at school. She wants to know whether or not the Ed-You-Swivel chair, a new energy-harnessing product, is a good energy solution for her school. In this lesson, you will evaluate evidence about the Ed-You-Swivel to make a recommendation to the principal.

Unit Question

- How is it possible to charge electrical devices when the power is out?

Chapter 3 Question

- What is the best way for the rescue workers to capture energy from their bodies' motion during rescue missions?

Key Concepts

- Whenever something moves or changes, it is because of energy.
- When something is moving, it has kinetic energy.
- When something has the ability to make things move or change in the future, it has potential energy, even if it is not moving or changing now.
- Nothing creates energy. If something has energy, the energy must have been transferred from something else.
- Energy can be transferred from one object to another, and energy can be converted from one type to another.

Vocabulary

- claim
- energy
- evidence
- kinetic energy
- potential energy
- reasoning
- transfer

Name: _____ Date: _____

Warm-Up

The Energy Research Lab has received a request from a new client. A school principal is interested in saving money on her school's energy costs by capturing energy from students' physical activities while they are at school. She has learned about the Ed-You-Swivel chair, a new energy-harnessing product, and wants to know whether it is a good energy solution for her school.

Read the Ed-You-Swivel brochure below. Use your Active Reading annotation strategies to record questions and connections as you read.

Ed-You-Energy

. . . helping schools save energy since 2013

About our company: At **Ed-You-Energy**, we are in the business of helping students generate electricity for their schools! We design state-of-the-art furniture and other equipment for schools like yours.

At first glance, you can see that our products are designed with comfort and quality in mind. What you can't see is that each and every **Ed-You-Energy** product has a built-in electrical generator! These generators convert energy from students' movements to electrical energy and store it in a battery. Schools can use these batteries to power computers, tablets, lights, and more. Think of how much energy YOUR school could save with **Ed-You-Energy** products!

About the Ed-You-Swivel: The **Ed-You-Swivel** chair is designed so that students can turn in any direction during class. Students can talk to their partners or look at a chalkboard behind them without wasting time dragging their desks across the floor. Every time students swivel their seats, their movements turn a generator. The generator converts kinetic energy to potential energy that is stored in a battery.

Name: _____ Date: _____

Evaluating Ed-You-Swivel Evidence

Part 1: Evaluating Evidence Based on Reliability of Source

Follow the steps below to evaluate the Ed-You-Swivel evidence with your partner.

1. **Discuss each piece of evidence with your partner.**
   - How reliable is the source of the evidence?
   - What makes you think that? You can use the sentence starter below to discuss the evidence.
     I think this evidence source is very reliable / reliable / not reliable because . . .
2. **Place each evidence card on the Evidence Gradient based on how reliable you think the evidence source is.** Make sure that each evidence card is positioned above cards with less reliable sources and below cards with more reliable sources.

Part 2: Deciding Which Claim the Evidence Supports

3. Place the two Claim Cards side by side at the top of your desk.
4. Discuss each piece of evidence with your partner and decide which claim it supports. Place the Evidence Card under that claim.
5. When you have finished sorting the evidence, select the claim below you think is best supported. Be ready to explain how the evidence supports this claim.

   ☐ **Claim 1:** The Ed-You-Swivel chairs will capture enough energy to power the school's small electronics.

   ☐ **Claim 2:** The Ed-You-Swivel chairs will not capture enough energy to power the school's small electronics.

Name: _____ Date: _____

Preparing to Write an Argument

Part 1

The Reasoning Tool will help you organize your evidence so you can write a clear and convincing argument for the principal. Select the evidence you want to include, and write it in the left-hand column of the table on page 61. Then, in the middle column, explain why this evidence matters. In the right-hand column, you can write the claim or you can explain in more detail what aspect of the claim is supported.

Evidence

- **Evidence Card A:** A commercial paid for by Ed-You-Energy says that the Ed-You-Swivel "creates" enough energy to power an entire school.
- **Evidence Card B:** Data from the electric company shows that the school uses about 15 million (15,000,000) joules of energy every hour.
- **Evidence Card C:** A magazine called *Future-Tech Today* published an article about the Ed-You-Swivel. The article said that after a few minutes of use, the product would be able to fully charge one tablet. *Future-Tech Today* also published an article about a car that "makes more energy than it uses."
- **Evidence Card D:** Engineers at Product Testing Lab, Inc. found that the Ed-You-Swivel harnesses 4,000 joules in one day of typical use. It would take an Ed-You-Swivel 20 days to charge one tablet. Product Testing Lab, Inc. is a company used by many businesses, schools, and government agencies to make choices about what to buy.
- **Evidence Card E:** Your friend said that his dad uses the Ed-You-Swivel at work, and it captures enough energy to charge his cell phone.
- **Evidence Card F:** Someone who knows the owner of a company that sells basketballs that harness human energy says that the Ed-You-Swivel will not capture enough energy to charge a cell phone, even if it is used for an entire day.
- **Evidence Card G:** For hundreds of years, scientists have observed that energy cannot be created. If something has energy, the energy must have been transferred from something else.
- **Evidence Card H:** The Ed-You-Swivel developers state that the product can save schools money.

Name: _____ Date: _____

Preparing to Write an Argument (continued)

Part 2

Question: *Can the Ed-You-Swivel chairs capture enough energy to power the school's small electronics?*

Select the claim the evidence supports:

- ☐ **Claim 1:** The Ed-You-Swivel chairs will capture enough energy to power the school's small electronics.
- ☐ **Claim 2:** The Ed-You-Swivel chairs will not capture enough energy to power the school's small electronics.

Evidence	**This matters because . . .** (How does this evidence support the claim?)	**Therefore, . . .** (claim)

Name: _____ Date: _____

Homework: Writing an Argument for the School Principal

Write an argument that explains to the school principal why you think the Ed-You-Swivel chairs will or will not help the school save money on energy costs. You can use one or more of the Argumentation Sentence Starters as you write. Include the following:

- the claim you selected,
- an explanation of how the Ed-You-Swivel works,
- evidence from the Reasoning Tool that supports your claim, and
- vocabulary from the Word Bank.

Claim 1: The Ed-You-Swivel chairs will capture enough energy to power the school's small electronics.

Claim 2: The Ed-You-Swivel chairs will not capture enough energy to power the school's small electronics.

Word Bank

kinetic energy

convert

potential energy

evidence

transfer

harness

Argumentation Sentence Starters

- I think this piece of information supports this claim because . . .
- I don't think this piece of information supports this claim because . . .
- I agree because . . .
- I disagree because . . .
- Why do you think that?

Harnessing Human Energy Glossary

claim: a proposed answer to a question about the natural world

afirmación: una respuesta propuesta a una pregunta sobre el mundo natural

convert: to change from one type to another

convertir: cambiar de un tipo a otro

energy: the ability to make things move or change

energía: la capacidad de hacer que las cosas se muevan o cambien

evidence: information about the natural world that is used to support or go against (refute) a claim

evidencia: información sobre el mundo natural que se utiliza para respaldar o rechazar (refutar) una afirmación

generator: a machine that can convert kinetic energy into electrical energy

generador: una máquina que puede convertir energía cinética en energía eléctrica

kinetic energy: the energy that an object has because it is moving

energía cinética: la energía que tiene un objeto porque se está moviendo

model: an object, diagram, or computer program that helps us understand something by making it simpler or easier to see

modelo: un objeto, diagrama o programa de computadora que nos ayuda a entender algo haciéndolo más simple o fácil de ver

potential energy: the energy that is stored in an object or system

energía potencial: la energía que está almacenada en un objeto o sistema

reasoning: the process of making clear how your evidence supports your claim

razonamiento: el proceso de aclarar cómo tu evidencia respalda tu afirmación

scientific argument: a claim supported by evidence

argumento científico: una afirmación respaldada por evidencia

system: a set of interacting parts forming a complex whole

sistema: un conjunto de partes que interactúan formando un todo complejo

transfer: to move from one object to another or one place to another

transferir: mover de un objeto a otro o de un lugar a otro

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Credits:

Illustrations: Cover: Tory Novikova; Page 39, 46: Shutterstock
Photographs: Page 41: Jocelyn Augustino/FEMA; Page 51: (l) www.pavegen.com; Pages 51 (m, r), 58: Shutterstock

Harnessing Human Energy

Article Compilation

Table of Contents: Articles

The Little Sun lamp has a light bulb on the front and a solar panel on the back.

Energy Inventions

Many people around the world don't have easy access to the energy they need to power lights, phones, and other electrical devices. There may not be an electrical grid nearby, or they may not have electrical wires to bring power from the electrical grid to their homes—or they may have electrical wires, but the nearest power plant may only provide energy part of the time, leaving people in the dark when it doesn't work. These people may not have much money, so they can't just buy lots of batteries to power their lights. They face an energy problem: they need access to cheap, reliable electricity. All over the world, people from professional engineers and energy scientists to students, makers, and inventors are working to solve this problem. They have designed ways to provide portable light in places where electrical power isn't always available. In this article, you'll read about a few of them.

Gathering Energy from the Sun

When Olafur Eliasson and Frederik Ottesen heard that more than 1 billion people on Earth don't have access to electricity, they wanted to help. In many places, lack of electricity means students can't study after dark and families can't cook after the sun goes down. It's also harder for doctors and nurses to treat patients without good lighting. Some people light their homes by burning a type of oil called kerosene, but kerosene is expensive and produces thick, black smoke that causes lung disease—and it can cause houses to catch fire. Eliasson and Ottesen decided to invent a solar lamp that would provide light without costing a lot of money, polluting the air, or causing fires. Their solution? The Little Sun lamp, a sun-shaped light with a light bulb on one side and a solar panel on the other.

The Little Sun lamp uses energy to provide light to people who need it, but the Little Sun doesn't make its own energy. To run, the lamp needs to get energy from somewhere else. In this case, that source of energy is the sun. The solar panel on the back of the lamp converts light energy

from the sun into potential energy that can be stored in a battery and used later to make the light bulb shine. Little Sun lamps charge in the sun during the day and provide light at night, allowing people to study, cook, work, and take care of other things even after the sun sets. They're inexpensive, don't pollute, and don't cause fires. Eliasson and Ottesen's plan turned out to be a good one—since 2012, their company has sold 200,000 lamps to people who don't have electricity.

The Little Sun lamp allows people with no electricity in their homes to work when it's dark outside.

Gathering Energy from the Human Body

The sun is one source of energy in places where there's no electrical grid; another source may be closer than you think—the human body! The human body contains energy. Most of that energy is used to keep us alive and active, but some of it can be captured and used for other things. Just ask Ann Makosinski, a young inventor from British Columbia, Canada. At the age of 15, after hearing of a friend in the Philippines who was failing her classes because her home didn't have light to study by, Makosinski invented a flashlight that uses the heat of the human hand to power a light bulb. Her flashlight, called the Hollow Flashlight, has a handle made of special tiles and nothing but air inside. The tiles get energy from the human hand and convert it into electrical energy, which powers a light bulb. The Hollow Flashlight doesn't have a battery, or even an on/off switch—it lights up as soon as the user picks it up. That makes it lightweight, reliable, and cheap to own: users of the Hollow Flashlight never have to buy flashlight batteries or worry about their old batteries running out of power.

When she was only 15, Ann Makosinski invented a flashlight that uses the heat of the human hand for power.

Comparing Solutions

Using solar energy and capturing energy from humans are just some of the exciting ways people are using science to solve energy problems. There is no perfect solution, however. Solar energy relies on the sun and doesn't work as

well in the dark or on cloudy days. For example, if you were using your Little Sun to read at night and it ran out of energy, you would need to wait for the sun to come up so that more energy could be captured and transferred to the battery in your light. Just imagine if the next day was very cloudy! Your energy system would not be able to capture very much energy from the sun, so your light would not stay on for long.

The Little Sun lamp and the Hollow Flashlight have something in common: they get energy from somewhere else instead of making it themselves. In fact, that's true of every object in the universe. Engineers must think about energy sources as they design their inventions. They must find an energy source that will do a good job of transferring energy to the object. The Little Sun lamp gets energy from the sun, while the Hollow Flashlight gets energy from the human body. There are many other possible energy sources to consider. For example, some devices transfer kinetic energy (energy of motion) from wind, water, or even people to power devices! There isn't a single right way to provide energy when there's no electrical grid available, and each source has its strengths and drawbacks. Which energy source would YOU choose?

Solar panels don't work as well at night or on cloudy days.

Scientists are still looking for ways to store energy from sources like wind and the sun.

How We Store Energy

Humans have always been good at transferring energy from place to place—long ago, we figured out how to transfer energy from fire to cook our food, how to use sails to harness the wind and take us where we want to go, and how to use tools that transfer energy from our bodies to get a job done. We found plenty of ways to transfer energy that we could use right away. Storing energy for later, however, has never been easy. For thousands of years, scientists have tried to find better ways to store energy—and the search continues today as we look for better ways to store renewable energy from sources like the sun and the wind.

There's one way of storing energy that you're probably pretty familiar with: batteries power all kinds of devices, from phones to cars, even when they're not plugged into a source of electricity. Batteries store energy using chemicals. The first batteries were invented back in 1800 by an Italian scientist named Alessandro Volta, and they were big and messy—they contained liquid that could leak out. Today's batteries are neater and can store much more energy for their size. However, the batteries we need to produce a lot of power still don't work as well as scientists would like. These batteries can be heavy and expensive, and getting the materials to make them often means digging mines that can harm the environment.

One of the most common ways to store energy without using batteries is by converting it to kinetic energy, or motion energy. For thousands of years, people have stored energy by using it to spin wheels called flywheels. Ancient people used basic flywheels to store energy thousands of years before they began using electricity! The process of storing energy in a flywheel starts when energy is used to make the wheel spin, either by pushing on it or by using a motor. As long as the flywheel keeps spinning, the energy that made it spin is stored as kinetic energy. When it's time to use the stored energy, the spinning flywheel can transfer its energy to something else. Today,

we connect flywheels to generators and use the energy they store to produce electricity.

Another way people have been storing energy for hundreds of years is by moving water around. These systems use two human-made lakes, one located at the top of a hill and one located at the bottom of the hill. The two lakes are connected by a pipe with a turbine at the bottom. When it's time to store energy, the turbine pumps the water uphill from the lower lake to the upper lake. When it's time to use some of the energy that's been stored, water from the upper lake flows downhill through the pipe, turning the turbine as it goes and converting the stored energy into kinetic energy, which can then be converted into electrical or other types of energy. This kind of energy storage is reliable, but it only works in places where it's possible to build two lakes with an elevation difference between them. This type of system can also have serious effects on nearby plants and animals.

Today, we still use batteries, flywheels, water-pump systems, and other methods to store energy, but scientists are still looking for easier, cheaper, and better energy storage methods. For example, scientists are working on iron-air batteries that use the rusting process to store large amounts of energy for cities and towns. These batteries are made of iron, which is much cheaper and easier to get than the usual materials for making batteries. Innovations like these are bringing down the cost of storing energy produced by renewable sources like wind and the sun.

One common way of storing energy is by moving water around.

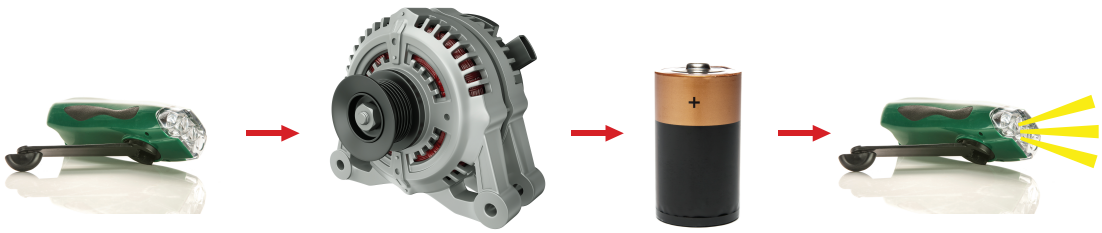
Capturing Human Energy

Chapter 1: Hand-Crank Flashlight

Have you ever used a hand-crank flashlight? You turn a crank on the outside of the flashlight and the crank turns a generator inside the flashlight. A generator is a machine that stores energy by charging a battery. When the generator turns, it converts kinetic energy to electrical energy and then stores it in a battery as potential energy. The potential energy stored in the battery can be used right away or saved for later. The energy that powers the light comes from the battery—but before that, it came from you. When you use a hand-crank flashlight, you are using your body's energy to power a light!

Hand-crank flashlights are powered by energy from the human body, so they never need new batteries.

How a Hand-Crank Flashlight Works



Turning the crank... ...turns the generator... ...which charges the battery... ...and powers the light.

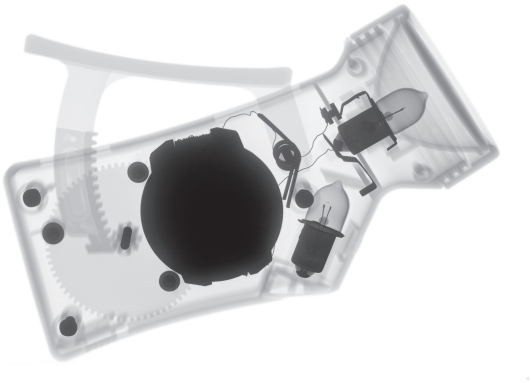
= energy transfer

When you turn the crank on a hand-crank flashlight, kinetic energy from your body turns the generator inside the flashlight. That kinetic energy is converted into potential energy and stored in the battery, which can then make the light bulb work.

The disadvantage of a hand-crank flashlight is that you have to turn the crank in order to charge the battery. The longer you plan to use the flashlight, the more energy you need to store and the more cranking you have to do.

However, turning a crank isn't the only way to store energy in a generator. There are lots of other ways to release kinetic energy: bouncing, stretching, compressing, and other forms of motion all involve kinetic energy, which means they can be used to turn a generator and store electrical energy in a battery. Now imagine if those motions allowed you to charge that battery just by doing everyday activities—things you have to do anyway, like walking.

Some people have invented devices that do just that: convert kinetic energy from everyday activities into electrical energy, storing the energy in batteries as potential energy that can be used to power flashlights, cell phones, and other devices. Students, business people, engineers, and even hobbyists have come up with ideas for inventions like this. You can read one or more of the chapters that follow to find out about a few of them.



Squeeze-lever flashlights are similar to hand-crank flashlights: both convert kinetic energy from the motion of the human hand. To make a squeeze-lever flashlight work, you squeeze the handle.

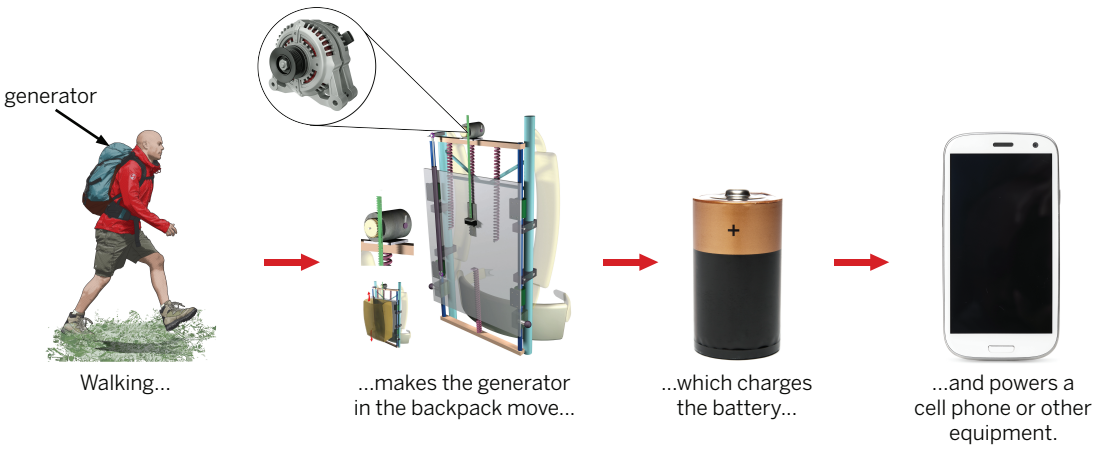
Chapter 2: Energy-Capturing Backpack

When you wear a backpack, the backpack moves up and down a bit as you walk. Like all motion, this up-and-down movement is a form of kinetic energy. An energy-capturing backpack uses that kinetic energy to charge a battery.

One way that an energy-capturing backpack can work is by hanging the heavy part of the backpack from springs, allowing it to bounce up and down as you walk. The bouncing turns the wheel of a generator. When the generator turns, it converts kinetic energy to electrical energy and then stores it in a battery as potential energy. The potential energy stored in the battery can be used to power a cell phone or other electrical device.

Walking produces an up-and-down motion that hikers can use to power small devices like cell phones.

How an Energy-Capturing Backpack Works



When you use an energy-capturing backpack, the motion of walking powers a generator that charges a battery. You can use the energy in that battery to charge small devices.

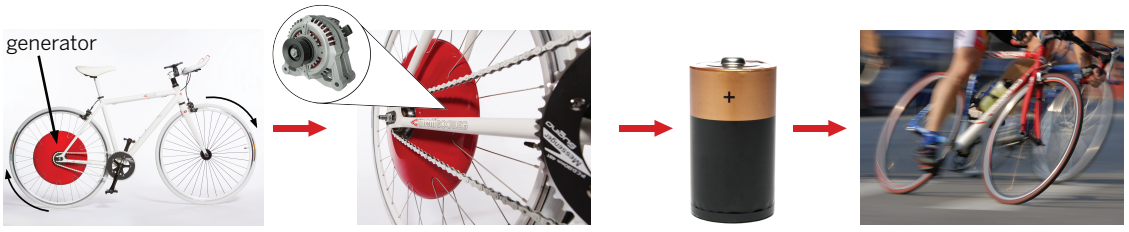
Chapter 3: Energy-Capturing Bike

A spinning bicycle wheel has lots of kinetic energy. The kinetic energy provided by the rider's pedaling makes bicycles a good way to capture energy from the human body. When you use the brakes on an energy-capturing bicycle to slow down, the kinetic energy of the spinning wheel is converted to electrical energy and stored in a battery as potential energy. That potential energy could be used to power all kinds of electrical devices. Some energy-capturing bicycles use the potential energy stored in the battery to run a motor that helps turn the wheel and gives the rider an extra boost. This can be a big help when riding up steep hills! Using a motor might sound like getting a free ride from the energy stored in your bicycle. However, if you trace it back, that energy first came from you, the rider.

The Copenhagen Wheel fits into a bicycle wheel and stores some of the rider's energy for later use.

It was your kinetic energy that was transferred to the bicycle wheel, then transferred to the generator and converted into electrical energy, then stored as potential energy in the battery, then used to power the motor that gave you a boost when you needed it most.

How an Energy-Capturing Bicycle Works



The spinning wheel...

...makes the generator in the wheel move...

...which charges the battery...

...which can power a motor that helps turn the wheel when the rider wants an extra boost.

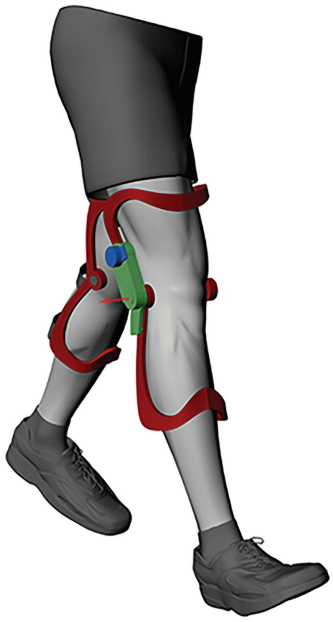
= energy transfer

On a bike with the Copenhagen Wheel, kinetic energy from the rider turns a generator that charges a battery, which can help power the bike when the rider needs some extra help.

Chapter 4: Energy-Capturing Knee Brace

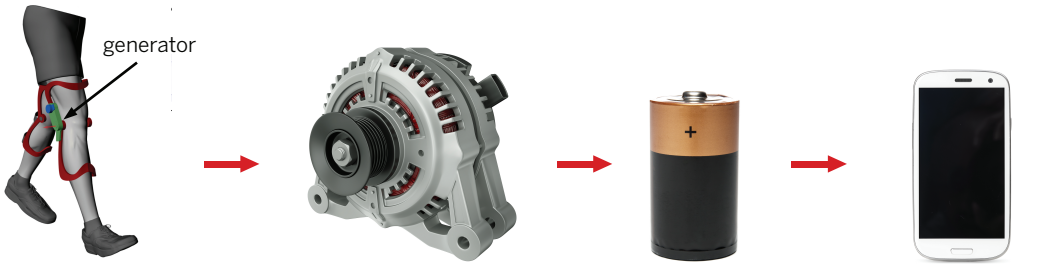
An energy-capturing knee brace uses the kinetic energy of your moving leg to charge a battery. The knee brace has a generator inside it. You bend your knee with each step, and as you straighten it again, the movement makes the generator spin. The kinetic energy in the spinning generator is converted to electrical energy, then stored in a battery as potential energy. You can use that potential energy to power a cell phone or other device.

The knee brace spins the generator when you're straightening your knee instead of when you're bending it. That's because your muscles don't have to work as hard to straighten your knee as they do to bend it. This makes the knee brace easier to use—you don't have to work very hard to spin the generator.



An energy-capturing knee brace harvests energy with the bending and straightening of the leg.

How an Energy-Capturing Knee Brace Works



Taking a step... ...makes the generator in the knee brace move... ...which charges the battery... ...which can power a cell phone or other equipment.

= energy transfer

When you use an energy-capturing knee brace, the motion of your steps turns a generator in the knee brace. That energy is converted to potential energy and transferred to a battery. The energy in the battery can be used to power a small device, like a cell phone.

Chapter 5: Energy-Capturing Rocking Chair

Most chairs can't convert energy from the body into electrical energy. However, an energy-capturing rocking chair can! Energy-capturing rocking chairs use the motion of rocking to power electronic devices—a lamp attached to the chair or a charger for phones and other electronic devices. The process begins with the kinetic energy your body uses to rock the chair, usually by pushing your foot against the floor. That kinetic energy makes the chair rock back and forth and spins a generator built into the rockers (the parts of the chair that rest on the floor). The kinetic energy in the spinning generator is converted into potential energy and stored in a battery built into the body of the chair. The energy can be used right away to power the lamp or the device charger, or it can be stored for later. When using stored energy to power the lamp or the device charger, you don't need to rock to keep them working.

An energy-capturing rocking chair uses the motion of rocking to power electronic devices.

How an Energy-Capturing Rocking Chair Works

When you rock an energy-capturing rocking chair, kinetic energy is transferred to a generator on the back of the chair. The generator transfers energy to a battery. Energy from the battery can be used to power electrical devices.

Harnessing Human Energy

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