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Fueling Our Future: Exploring Sustainable Energy Use - An Interdisciplinary Curriculum Recommended for Grades 3-5

Facing the Future, Western Washington University

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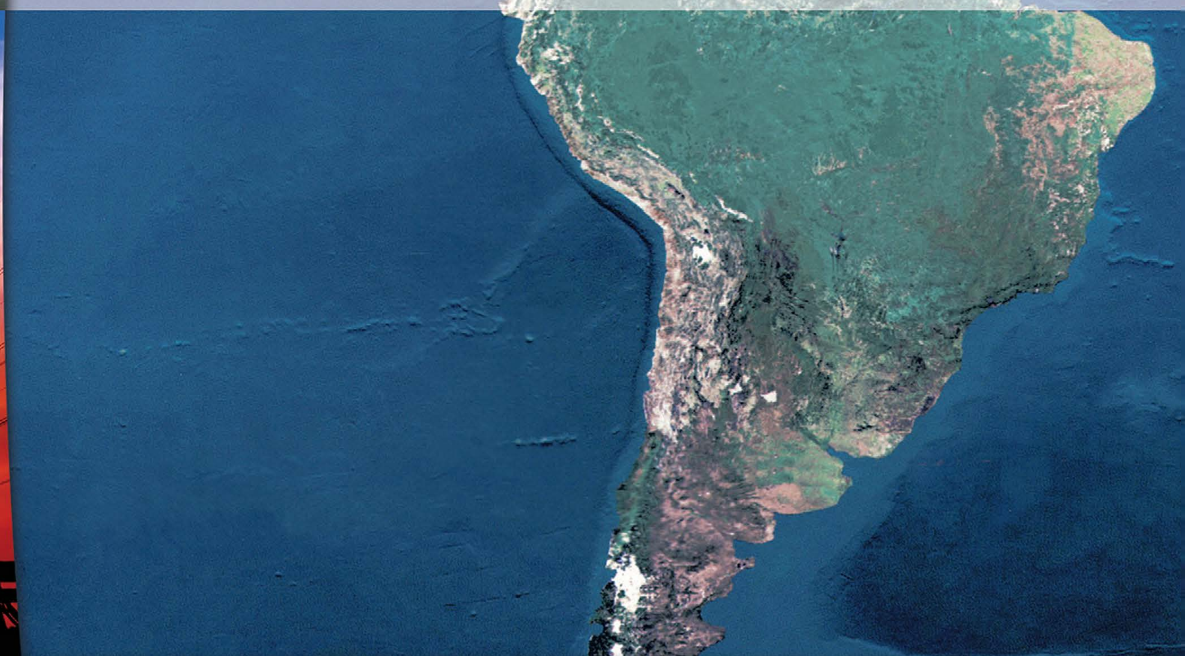

6–Lesson Curriculum Unit

Facing the Future

Western Washington University

Facing the Future is an independent program of Western Washington University.

Fueling Our Future:
Exploring Sustainable Energy Use

An Interdisciplinary Curriculum
Recommended for Grades 3–5

Facing the Future
Critical Thinking. Global Perspective. Informed Action.

Fueling Our Future:
Exploring Sustainable Energy Use

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About Facing The Future

Facing the Future is an independent program of Western Washington University whose mission is to create tools for educators that equip and motivate students to develop critical thinking skills, build global awareness, and engage in positive solutions for a sustainable future.

We develop and deliver standards-based hands-on lessons, student texts, curriculum units, and professional development opportunities for educators. Facing the Future curriculum is in use in all 50 U.S. states and over 140 countries by teachers and students in grades K-12, in undergraduate and graduate classes, and across multiple subject areas. Facing the Future reaches over 1.5 million students through its programming.

For more information, visit www.facingthefuture.org.

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NARA
Northwest Advanced Renewables Alliance

USDA United States Department of Agriculture National Institute of Food and Agriculture

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Introduction

Energy fuels our lives—it sustains our bodies, powers our industries, lights our cities, charges our cell phones, and moves our cars. Energy is also connected to a range of global concerns such as climate change, economic inequities, and resource scarcity. Taking a close look at this significant and timely issue is a key part of working toward a sustainable world.

Why energy education?

Energy is an engaging, generative topic that is relevant to students' lives inside and outside the classroom. On an academic level, energy concepts are connected to big ideas in science, math, civics, history, economics, and other disciplines. Energy-related issues also provide an opportunity for students to learn 21st century skills such as critical thinking, creative problem solving, statistical analysis, and collaboration. On a personal level, all of us—no matter what age or location—make countless energy-related decisions each day that have individual, local, and global consequences. Helping young people learn basic energy science, develop an awareness of their personal energy consumption, and think critically about where their energy comes from can therefore empower them to make informed energy decisions now and in the future.

Human energy use is inextricably linked with many other global issues. For instance, petroleum has been the primary source of energy for the world in the 21st century.[1] Our dependence on this nonrenewable resource has environmental, social, and economic impacts that grow larger every day. The Intergovernmental Panel on Climate Change has stated that the burning of fossil fuels is the main contributor to increased atmospheric concentrations of carbon dioxide in the past century, leading to global climate change.[2] At the same time, one in five people around the globe, or 1.3 billion people, lack access to electricity.[3] Lack of access to electricity significantly restricts people's ability to study after dark, keep food and medicines such as vaccines refrigerated, or pump water to crops.[4]

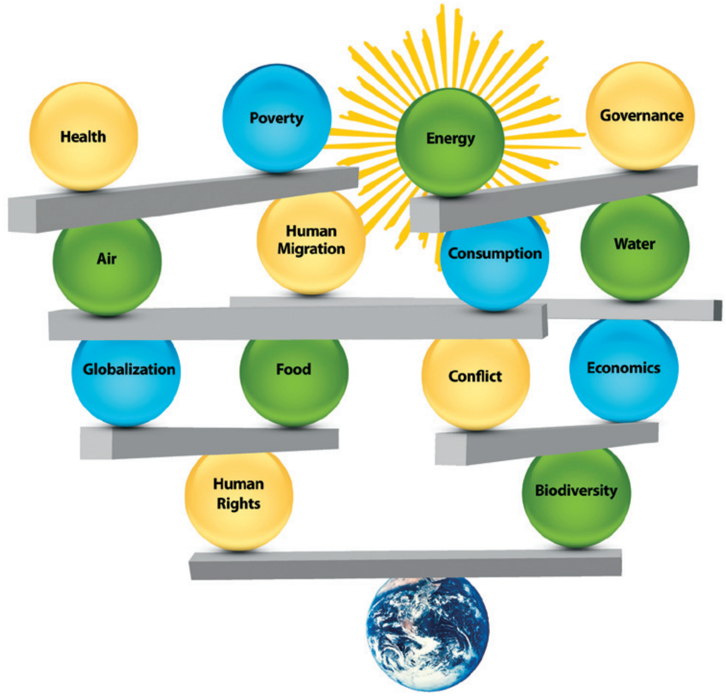
Because energy consumption is so deeply rooted in a multitude of interconnected local and global issues, the choices we make about energy can be part of sustainable solutions to the world's most critical challenges. Such solutions can range from promoting home energy efficiency and conservation in order to lower household energy bills, to helping developing communities access energy through readily available renewable resources.

Why this unit?

Facing the Future's *Fueling Our Future: Exploring Sustainable Energy Use* presents an opportunity for you to engage your students in a relevant and authentic exploration of sustainable energy use. This unit contains six student-centered lessons that cover important energy concepts from basic energy science, to the economics of oil, to the characteristics of a successful energy conservation project.

Just as energy is an interdisciplinary topic, *Fueling Our Future* presents energy concepts from multiple academic perspectives. Throughout these 6 lessons, students explore content from different disciplines and have the opportunity to demonstrate understanding in many different ways. In the first two lessons, students learn foundational energy science. They design a Rube Goldberg machine to observe energy transfer and transformation, create an energy flow diagram to show that the sun is our primary source of energy, and analyze patterns in different food chains to draw conclusions about energy flow through ecosystems. In Lessons 3 and 4, students observe how they use energy in their daily lives and learn about the natural resources used to provide us with energy. They distinguish between human wants and needs, create a visual representation of their personal energy use, and read nonfiction texts to learn about and compare renewable and nonrenewable energy sources.

Lesson 5 hones in on one of the primary energy resources used to supply the world with energy—oil. In this lesson, students journey through the supply chain of gasoline from oil well to gas station. Students identify countries with oil reserves on a map, summarize each step of the supply chain, calculate the number of miles a petroleum product may travel from well to wheel, and discuss how supply and demand relates to gasoline



production. By learning the steps of this supply chain, students gain a more complete mental model of where fuel comes from and our current energy context. With a more accurate understanding of this context, students will be better able to evaluate the sustainability of this energy system.

In the culminating lesson, students analyze case studies that showcase young people from around the world implementing energy conservation strategies in their homes, schools, communities and beyond. Students read advice from these young people about how to make a difference and learn how perseverance, collaboration, and a sense of responsibility are related to successful action projects. This lesson provides a launchpad for a class or school energy action project.

In addition to 6 fully planned lessons, *Fueling Our Future* includes formative and summative assessments, lesson extensions, and resources for a comprehensive service learning project. Each lesson is guided by inquiry and critical thinking questions and concludes with discussion questions. This unit includes a pre and post assessment designed to show students' growth in content knowledge, ability to analyze energy concepts, and personal energy-related attitudes and behaviors toward energy consumption and energy resources.

Additionally, each lesson in this unit has been aligned to the fundamental concepts presented in The U.S. Department of Energy's *Energy Literacy: Essential Principles and Fundamental Concepts for Energy Education.* This framework presents seven energy principles and concepts that, if understood and applied, will help individuals and communities make informed energy decisions. This framework was developed through a peer-review network of 13 federal agencies that comprise the U.S. Global Change Research Program Partner agencies and 20 recognized educational partners including the American Association for the Advancement of Science.[5] For more information on DOE's Energy Literacy efforts visit the Energy Literacy Framework website:

http://energy.gov/eere/education/energy-literacy-essential-principles-and-fundamental-concepts-energy-education

The unit guides students to reflect on how energy is connected to their own lives and to investigate paths toward energy consumption that ensure access to energy for all people for generations to come. By engaging youth with authentic and relevant activities to explore energy issues, we foster the understanding and critical thinking skills needed to make thoughtful personal and collective decisions about energy. We hope that *Fueling Our Future* will prepare students to navigate the complex real-world issues of energy resources and consumption and will motivate students to participate in positive energy solutions for a sustainable world.

Unit Overview

Fueling Our Future: Exploring Sustainable Energy Use begins by introducing students to foundational energy science. The lessons then shift to focus on personal energy use, energy sources and their impacts, and transportation fuels. The unit culminates with an energy conservation lesson that showcases young people from around the world implementing energy conservation strategies in their homes, schools, communities and beyond. This lesson can be used as a launching pad for a classroom action or service project. This unit was designed to contribute to the Northwest Advanced Renewables Alliance Education Team's goal of strengthening overall science literacy of students in areas particular to the biofuels. The pre and post assessment can be administered before and after this unit to measure student growth in content knowledge, personal attitudes, and personal behaviors about energy.

Lesson Features

Every lesson in this unit includes:

- Additional resources
- Background information for educators
- Connections to the Fundamental Concepts in *Energy Literacy: Essential Principles and Fundamental Concepts for Energy Education*[6]
- Discussion questions
- Inquiry/critical thinking questions
- Key concepts
- Lesson extensions
- Student objectives
- U.S. standards correlation

Key Concepts

Each lesson includes a short reading for teachers that provides background information on the key concepts covered in this unit.

- biodiesel
- biome
- British thermal unit (Btu)
- case study
- collaboration
- community organization
- consume
- consumer
- consumption
- crude oil
- decomposers
- economy
- ecosystem
- electricity
- embodied energy
- energy
- energy conservation
- energy efficiency
- energy transfer
- energy transformation
- engineering
- evaluate
- export
- food chain
- fossil fuel
- heat
- import
- landfill
- law of conservation of energy
- light
- motion
- natural resource
- nonrenewable resource
- perseverance
- perspective
- producer
- renewable resource
- responsibility
- Rube Goldberg machine/contraption
- sound
- supply and demand
- supply chain
- sustainability
- system
- technology
- transportation
- watt

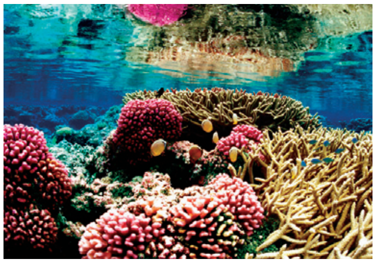
Standards Correlations

Fueling Our Future: Exploring Sustainable Energy Use correlates to standards in all 50 U.S. states, including Common Core State Standards. Visit our standards correlation tool to see how this unit and individual lessons correlate to state standards: www.facingthefuture.org/CurriculaFreeUnits/StandardsCorrelations.

Suggested Scope and Sequence

Lesson 1: Energy in Action
(Activity 1: 60 min | Activity 2: 60 min)

Students use observations of domino chains and Rube Goldberg machines to learn about different forms of energy, energy transfer and transformation, and energy flow through systems.



Lesson 2: Mystery Dinner—Energy in Ecosystems
(60 min)

The class uses an energy flow diagram to represent transfer of energy from the sun to food to people. Then small groups create dinner menus to represent energy flow through particular food chains and analyze the roles of the sun, producers, consumers, and decomposers in ecosystems.

Lesson 3: Mapping My Energy Use
(Activity 1: 20 min | Activity 2: 60 min)

After learning electrical safety tips and observing their energy use for 24 hours, students design an energy map to visually represent and categorize their personal energy use.

Lesson 4: Where Does My Energy Come From?
(60 min)

Small groups read nonfiction text to learn about a natural resource used to provide people with energy. They classify their source as nonrenewable or renewable, present their research to the class, and design a trading card to represent the unique characteristics of their energy source.

Lesson 5: Oil Takes a Trip
(Activity 1: 80 min | Activity 2: 60 min)

Students move through the supply chain of gasoline from oil wells around the world to gas stations in the United States. Along the way, they track their mileage and summarize each step in the supply chain. In a follow-up activity, students reflect on this supply chain using systems thinking and economics.

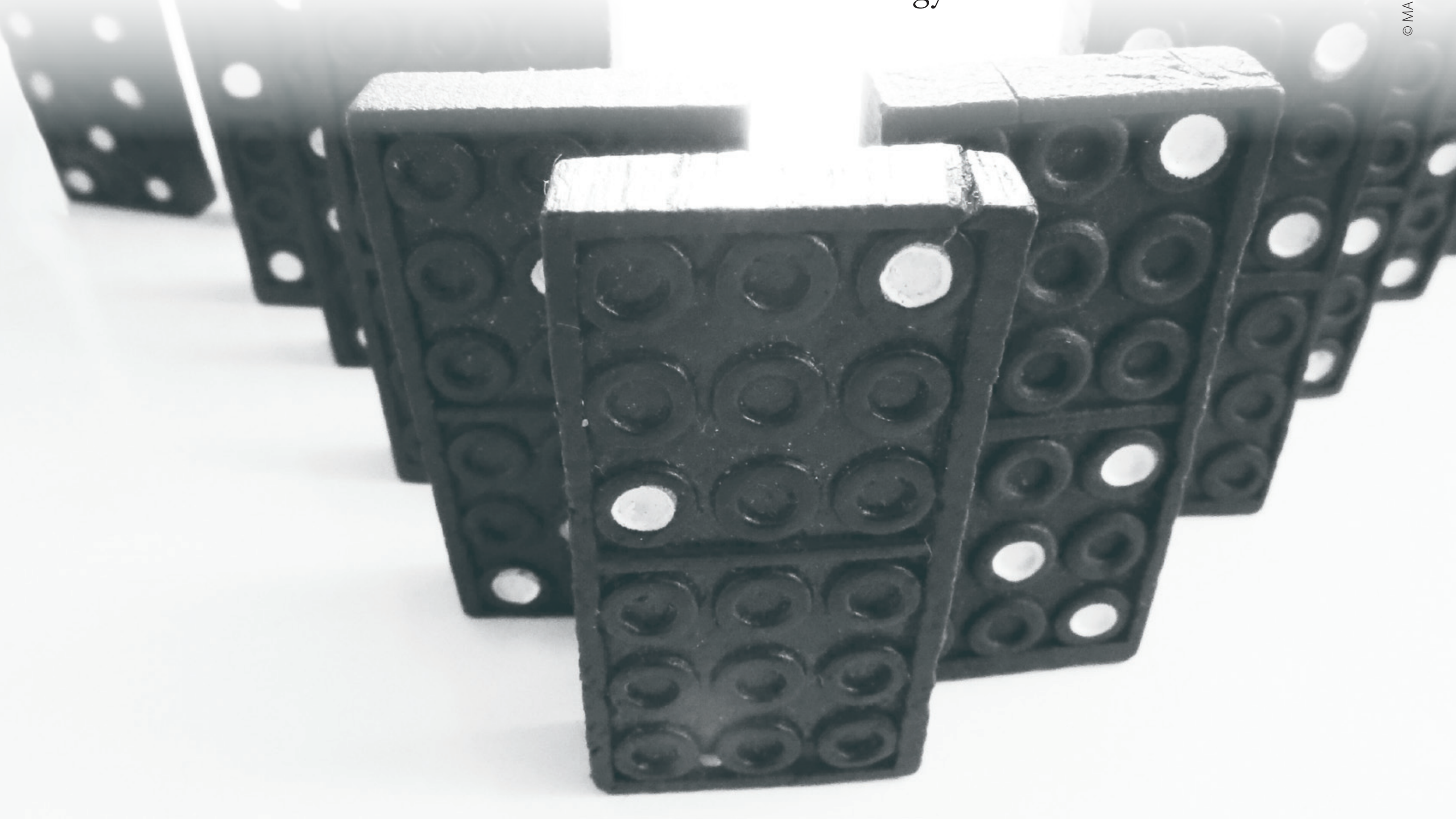
Lesson 6: Energy for All
(60 min)

Students review what they have learned about energy and brainstorm reasons to use energy sustainably. Small groups then read and analyze case studies about youth around the world to learn 4 different strategies to conserve energy and nonrenewable resources.

Lesson 1

Energy in Action

During Activity 1, students connect their observations of domino chains with the definitions of energy and systems. In small groups, students learn more about different forms of energy and practice identifying these forms of energy in everyday situations. During Activity 2, students use their online or in-class observations of Rube Goldberg machines to learn about energy transfer, transformation, and the law of conservation of energy.



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Objectives

Students will:

- Observe and describe how energy can be transferred from place to place and transformed into different forms.
- Read about different forms of energy and apply this information to everyday situations.
- Build a small Rube Goldberg machine and consider how this system relates to energy.
- Use observations and evidence to support the law of conservation of energy.

Inquiry/Critical Thinking Questions

- What is energy?
- How can one tell if energy is present?
- How can energy flow throughout a system?
- What are everyday examples of energy transfer and transformation?

Time Required

Activity 1: 60 minutes
Activity 2: 60 minutes

Key Concepts

- **energy**—The ability of a system to do work or cause change.
- **energy transfer**—The movement of energy from one object to another. For example, when a falling domino hits a stationary second domino, the second domino starts moving because motion energy has been transferred from the first domino to the second one.
- **energy transformation**—When energy is changed from one type to another. For example, the light that hits a solar cell (also called photovoltaic cell) is changed, or converted, into electrical and heat energy.
- **heat**—Also called thermal energy, heat is the random motion or vibration of particles in a substance.
- **law of conservation of energy**—Energy cannot be created or destroyed, but it can be transferred or transformed.
- **light**—Energy that travels in transverse waves (waves that move perpendicular to the forward motion) and can travel in a vacuum or through a substance such as water. Light energy is a visible form of electromagnetic radiant energy. However, radiant energy includes forms that are not visible, such as infrared, ultraviolet, x-ray, gamma ray, and radio waves.
- **motion**—Energy of a moving object. The faster an object moves, the more motion energy it has.
- **Rube Goldberg machine** (or **Rube Goldberg contraption**)—A silly and complicated invention designed to perform a simple task.
- **sound**—Energy that moves through substances such as air or water in a back-and-forth motion (longitudinal waves). Sound travels in a similar way to a slinky that has been pulled straight out and released.
- **system**—A collection of many interconnected parts that work together; changing one part affects other parts.

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Energy Literacy: Essential Principles and Fundamental Concepts for Energy Education

1.1 Energy is a quantity that is transferred from system to system.

1.2 The energy of a system or object that results in its temperature is called thermal energy.

1.3 Energy is neither created nor destroyed.

1.4 Energy available to do useful work decreases as it is transferred from system to system.

1.5 Energy comes in different forms and can be divided into categories.

U.S. Standards Correlation

- **State and national standards:** Visit our Standards Correlation Tool at www.facingthefuture.org/CurriculaFreeUnits/StandardsCorrelations

Materials/Preparation

Activity 1

☐ **Cards:** *Energy Cards,*[1] 1 set per student

☐ **Handout:** *Evidence of Energy,* 1 per student

☐ **Obtain a set of dominoes** and prepare to provide several to each student group, keeping some for demonstration as well.

☐ **Obtain several marbles** and prepare to provide 2 per student group, keeping 2 for demonstration as well.

Activity 2

☐ **Cards:** *Energy Cards,* 1 set per student

☐ **Handout:** *Energy in Action,* 1 per person

☐ **Obtain materials for mini–Rube Goldberg machines** for each small group, such as dominoes, blocks, a marble track or paper towel rolls (or PVC pipe cut in half the long way), marbles, balls, and safety goggles, as needed.

Option: If your students need more support, create 1 system or Rube Goldberg contraption as a class.

☐ **Obtain materials for a Rube Goldberg class demonstration or video.** Set up a small Rube Goldberg machine using the materials listed above, or show one of the following videos.

- **Video:** *Honda Commercial with Rube Goldberg*
  This 2-minute video shows a Rube Goldberg machine that has been made out of Honda car parts: www.teachertube.com/viewVideo.php?video_id=15955
- **Video:** *Joseph Herscher on Sesame Street*
  This 3-minute video shows the kinetic artist Joseph Herscher creating a plant-watering Rube Goldberg machine: www.josephherscher.com

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Background Information for Educators

Energy is a rich and complex concept addressed in a variety of academic and professional fields, such as science, social studies, and economics. While the word "energy" is used in everyday vernacular to describe mood, sports drinks, electricity, and so on, energy is generally defined in the sciences as the ability of a system to do work or cause change. For example, energy is required to move, generate light, or perform any other action.

The law of conservation of energy states that energy cannot be created or destroyed. However, energy can be changed, or transformed, into different forms, and energy can be transferred from one object to another. For example, the gasoline put into a car is a form of chemical energy. While it may seem like energy is disappearing because the gasoline eventually runs out, in fact, this chemical energy is simply being changed into heat energy and motion energy. There are many additional forms of energy, such as light, sound, and nuclear energy. Not all of these forms of energy are easily observable, which can make the law of conservation of energy difficult to observe and learn.

One fun way to help students observe how energy is transferred and transformed is by using domino chains and Rube Goldberg machines. The term "Rube Goldberg machine" refers to a complicated, humorous contraption made of everyday items placed in sequence to do a very simple task. These machines are named after the Pulitzer Prize-winning artist Reuben (Rube) Goldberg, whose cartoons depicting overly complicated "inventions" gained great popularity in the early and mid-20th century.[2] These modern-day Rube Goldberg machines can help students better understand energy transfer and transformation and are a great way to introduce systems (a collection of many interconnected parts that work together; in a system, changing one part affects other parts).

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Activity 1

Introduction

1. Stand a domino on its short edge several inches away from a marble and ask students how you could make the marble move without touching it.
2. Fill in the distance between the domino and the marble by creating an evenly spaced domino chain.
3. Invite a student to set off the row of dominoes.
4. In Think-Pair-Share format, have students describe what happened after the first domino was pushed over and why they think this happened. Encourage students to distinguish between their observations and explanations.
5. Share with students the following definition of energy:
   - **energy**—The ability of a system to do work or cause change.
6. Ask students how the definition of energy might relate to the domino demonstration. Use the following questions to guide this discussion:
   - What "work" was done, or what happened after the first domino was pushed?
   - What changes occurred?
   - What sounds did you observe?
   - Why did the marble stop rolling?

   Note: You do not necessarily have to correct students' ideas. Encouraging guesses at this point is a good way to assess students' prior knowledge.
7. Recreate the domino and marble chain and ask students how this set up is an example of a system. Share with students the following definition of a system:
   - **system**—A collection of many interconnected parts that work together; changing one part affects other parts.
8. In Think-Pair-Share format, have students discuss the following questions:
   - What are the parts of this system?
   - Where are the boundaries?
   - How do the parts interact with each other?
   - What input of energy was needed in order to set off the row of dominoes?
   - How did energy flow throughout this system?

   Option: Have students draw the answers to the questions.

Steps

1. Tell the class that energy can take on many different forms.
2. Ask students to name some different forms of energy. *(Some forms of energy include chemical, elastic, electrical, gravitational potential, heat or thermal, light or radiant, magnetic, motion or kinetic, nuclear, and sound.)*


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3. Share with students that they are going to explore a few different forms of energy in small groups.
4. Divide the class into groups of 3–4.
5. Give each student 1 set of *Energy Cards* and the handout *Evidence of Energy*.
6. Discuss the directions and give small groups time to complete the handout.
7. Once groups are finished, discuss correct answers for the handout *Evidence of Energy* and have students correct their handout as needed.
8. Collect student handouts and have students put away their *Energy Cards*.
9. Conclude this activity with the following discussion questions.

Discussion Questions

1. How does energy move from one place to another? What evidence or examples do you have to support your answer?
2. What forms of energy are the easiest to observe? What forms of energy can be difficult to observe? Why?
3. How is the scientific meaning of energy different than the way people use the word energy in everyday settings? How could this affect people's understanding of energy?
4. What similarities do you notice among the different forms of energy? What differences do you notice?
5. How does energy play a role in your daily life?

Activity 2

Introduction

1. In popcorn style, have students name different forms that energy can take. *(Some forms of energy include chemical, elastic, electrical, gravitational or potential, heat or thermal, light or radiant, magnetic, motion or kinetic, nuclear, and sound.)*
2. Have students take out their *Energy Cards* from yesterday to check their answers.
3. Share with students the definition of a Rube Goldberg machine:
   - **Rube Goldberg machine** (or **Rube Goldberg contraption**)—A silly and complicated invention designed to perform a simple task.
4. Set off a Rube Goldberg contraption that you have created or show students one of the following videos. Have students silently hold up the appropriate energy card as they watch the video to indicate the form of energy they are observing. They should see more than one form of energy in each video.
   - **Video:** *Honda Commercial with Rube Goldberg:* www.teachertube.com/viewVideo.php?video_id=15955
   - **Video:** *Joseph Herscher on Sesame Street:* www.josephherscher.com

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5. Share with students the law of conservation of energy.
    - **law of conservation of energy**—Energy cannot be created or destroyed, but it can be transferred or transformed.
6. Push a marble down a track or on a table so that it collides with another marble.
7. Ask students what form of energy the first marble had. *(Motion energy.)*
8. Ask students what form of energy the second marble gained once the first marble hit it. *(Motion energy.)*
9. Tell students that this demonstration shows energy transfer. Share with students the following definition of energy transfer:
    - **energy transfer**—The movement of energy from one object to another. For example, when a falling domino hits a stationary second domino, the second domino starts moving because motion energy has gone from the first domino to the second one.
10. Ask students how the demonstration with the marbles shows this concept. *(Motion energy from the first marble was transferred to the second marble.)*
11. Have students quickly rub their hands together. Ask if they can tell how the motion energy of their hands is being changed into another form of energy with this activity. Share with students the following definition of energy transformation:
    - **energy transformation**—When energy is changed from one type to another. For example, the light that hits a solar cell (also called photovoltaic cell) gets changed into electrical energy.
12. Ask students how rubbing their hands together shows this concept. *(Some motion energy is changed into heat energy, which you may feel with your hands.)*
13. Repeat your Rube Goldberg demonstration or the Rube Goldberg video. Ask students to continue to think about energy transfer and energy transformation as they watch the demonstration or video.
14. After the demonstration or video has finished, ask volunteers to share examples of energy transfer and energy transformation they observed.
15. Ask students: If energy cannot be destroyed or disappear, then why did the last object in the demonstration or video stop?
16. Share with students that though the final object stopped, this does not mean that energy was destroyed. Energy was changed into a form that is more difficult for us to see and observe (like heat) and it was spread out into the surrounding environment. For example, a lamp converts electrical energy to light *and* heat. While it may be easy for us to see and notice the light, we may not realize that some of the electrical energy is turning into heat, too.

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17. In Think-Pair-Share format, ask students how this demonstration provides support for the law of conservation of energy.

Steps

1. Tell students that you would like them to build their own small system that—with one gentle touch on one end—will make some change take place at the other end of the system. This system should also demonstrate energy transfer and transformation.

Option: Review the definition of a system:

- **system**—A collection of many interconnected parts that work together; changing one part affects other parts.

2. Give each student the handout *Energy in Action* and discuss the directions.

3. Divide students into groups of 3 or 4 and discuss group expectations and roles.

Option: If your students need more support, create 1 system or Rube Goldberg contraption as a class.

4. Give each group a set of materials (e.g. dominoes, marbles, paper towel rolls, and safety goggles as needed) and 10–20 minutes to first build a Rube Goldberg contraption and then complete the handout *Energy in Action.*

Note: Remind students of your classroom safety rules.

5. When students are finished exploring their contraptions and have completed the handout *Energy in Action,* invite each group to report on their experience to the class.

Option: Have each group set off the system for the rest of the class to see. Before each presentation, have observers make a prediction about the energy changes they think will take place.

7. Once all groups have presented, have them put away their materials.

8. Collect student diagrams as a way to assess students' understanding of energy forms, transfer, and transformation.

9. Conclude this activity with the following discussion questions.

Discussion Questions

1. What are some everyday examples of energy transfer and transformation?

2. What characteristics of a Rube Goldberg machine make it a helpful model for demonstrating the law of conservation of energy? What characteristics of a Rube Goldberg machine are not helpful for teaching people about the law of conservation of energy?

3. What are some other systems that provide evidence for the law of conservation of energy, or the idea that energy is never created or destroyed?

4. Can you think of any toys, appliances, or machines that transfer or transform energy in order to function?

Lesson Extensions

Language Arts Extension

Remind students that the word "energy" is used differently in different situations or contexts. Invite students to brainstorm other words that have different meanings in different contexts (for example, the words "mean" and "average"). Write the following headings on the board: Soccer Practice, Science Lab, Lunch Room, Home. Have students divide a piece of paper into 4 even parts, copy the headings from the board into the boxes, and write their name at the top of the page. Under each heading, have students write a sentence they might hear in each situation that includes the word "energy." When students are finished, ask volunteers to share some of their answers and write these ideas on the board. Or, have students crumple up their papers and toss them into the center of the room. Have each student grab 1 paper and share examples from this piece of paper.

Conclude with the following questions:

- What are some problems that might occur because the word energy is used in so many different ways?
- How could it be helpful to make sure we are all using the same definition before we begin to explore energy?
- How does this activity help you explain why people in the fields of science and math use standardized units of measurement and symbols for equations?
- Can you think of other words that are used differently in different fields or jobs?

Music/Science Extension

To further explore sound energy, have students learn how the different parts of the ear all contribute to hearing. Then have students choose an instrument to research and either compare it to the anatomy of the ear or determine how its use creates sound energy. For the latter suggestion, students can draw the path of sound energy from the instrument to the ear; advanced students can draw the energy transfer and transformations that take place from the musician to the listener.


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Additional Resources

- **Audio Clip:** *"Trimpin's Latest 'YOU ARE HEAR' At Seattle's Olympic Sculpture Park"*
  This 2-minute KPLU news story describes a temporary art installation created in Seattle by sound sculpture artist Trimpin. The art piece, which consists of a seat and precisely placed large orange headphones, is meant to prompt reflection about the sounds we hear around us: **www.kplu.org/post/seattle-sound-artist-trimpin-s-latest-work-be-unveiled-olympic-sculpture-park**
- **Website:** *Energy Kids*
  The U.S. Energy Information Administration has a website just for kids. Students can click under the tab "What is Energy?" to learn more about energy and its different forms: **www.eia.gov/kids**
- **Website:** *U.S. Energy Information Administration*
  The U.S. Energy Information Administration website is a wealth of information for teachers as well. From the homepage, click on the tab "Learn About Energy" for an in-depth explanation of energy and lesson plans: **www.eia.gov**
- **Interactive:** *What is Energy?*
  In this interactive lesson from The Children's University of Manchester, students match images with different forms of energy and learn more about each during a ride on a virtual bicycle. To access the animation, click on the "Energy and the Environment" tab and then the "What is Energy?" link: **www.childrensuniversity.manchester.ac.uk/interactives/science**

Evidence of Energy, Answer Key (page 20)

Lamp: light energy and electrical energy; answers could also include heat energy since some heat is produced in the wires and by the bulb.

Swing: motion energy; answers could also include sound energy and heat energy since the swing's chain will most likely produce sound and friction which will produce heat.

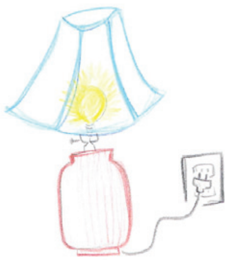
Guitar: sound energy; answers could also include motion energy since the strings are moved in order to produce sound.

Fire: light and heat energy; answers could also include sound since burning wood often creates noise.

Name ____ Date ______________________

Evidence of Energy

Directions: Take turns reading each one of the Energy Cards. Then use the information from the cards to complete this handout. In each box, write down the form of energy best represented by each picture. Then explain your answer. There may be more than one answer for each box.



Form(s) of Energy:

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Explanation:

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Form(s) of Energy:

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Explanation:

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Form(s) of Energy:

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Explanation:

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Form(s) of Energy:

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Explanation:

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Energy Cards, page 1

MOTION ENERGY

Motion energy is the energy of a moving object. The faster an object moves, the more motion energy it has. A bike speeding down the street and ball flying through the air are examples of motion energy.

Take turns sharing answers to these questions: What is the fastest thing you have ever seen? What is the slowest thing you have ever seen?

SOUND ENERGY

Sound energy is a type of energy that moves through particles of air or water in waves. Sound waves move like a slinky that has been pulled straight out and then released. When this energy reaches your eardrums, it causes the eardrums to vibrate and helps you to hear sound.

Place your hand lightly on your throat and hum a tune. Describe to your group what you feel.

ELECTRICAL ENERGY

Electrical energy is energy carried by moving electrons (negatively charged particles in an atom). This energy can move through wires and other materials that conduct electricity, and it can move through air, as in the case of lightning.

Share with your group an example of how electrical energy is moved from one place to another.

LIGHT ENERGY

Light energy is energy that travels in waves. Light waves move like a rope that has been lifted quickly off the floor and dropped back down. Light can travel through an area with no matter (a vacuum) or through a substance such as water.

How could you use a flashlight to move light from one place to another? Think about this on your own, then discuss your ideas with your group.

HEAT ENERGY

Heat energy refers to the random motion or vibration of particles in a substance or object. As a substance or object heats up, its particles move faster. Even the particles in solids are moving—they just shake or vibrate in place.

When 2 objects rub against each other, heat energy is often produced. Rub your hands together for 10 seconds. Share with your group members what you feel.

CHEMICAL ENERGY

Chemical energy is energy stored in the bonds of chemicals. Food and fuels are examples of chemical energy. In our bodies, this energy is used to help us grow, move, and think. Other things with chemical energy include batteries, corn, petroleum, and wood.

What form of chemical energy is put into the tank of a car? Think about this on your own, then discuss your ideas with your group.

X To create double-sided cards, match these X's and place both pages into the copy machine face up.

Energy Cards, page 2

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© RØLF KAENTEA | FLICKR.COM

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X To create double-sided cards, match these X's and place both pages into the copy machine face up.

Name Date

Energy in Action, page 1

Directions: Use the materials given to you by your teacher to design a Rube Goldberg contraption. Follow the directions and answer the questions below.

Part 1. Design

1. Draw your Rube Goldberg contraption.

2. Label the different parts of this system.

3. Write a prediction about how this system will transfer or transform energy.

Name Date

Energy in Action, page 2

Part 2. Observe

1. Set off your contraption. Draw or write your observations below. If you draw your observations, you can use arrows or labels to show direction of motion or sound.

2. Describe an example where the energy was **transferred** from one object to another object, but kept its same form.

3. Describe an example where one type of energy was **transformed** into a different type of energy.

4. What different types of energy did you observe in this demonstration?

Name Date

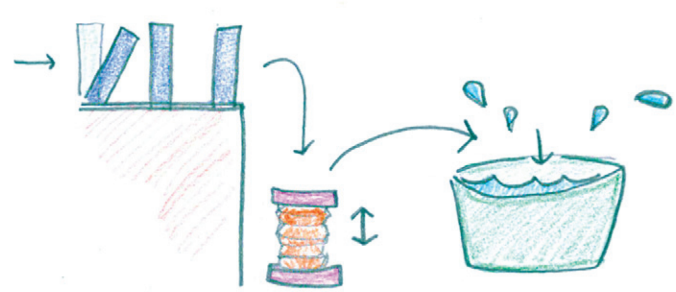
Energy in Action, page 3

Part 3. Analysis

1. How did your observations compare to your prediction?

2. How did this activity provide evidence to show that energy can be **transferred** from one object to another?

3. How did this activity provide evidence to show that energy can be **transformed** from one form to another?



Lesson 2

Mystery Dinner—Energy in Ecosystems

After brainstorming the connection between energy and food, the class creates an energy flow diagram to represent the transfer of energy from the sun to food to people. Students then attend a mystery dinner party where they gather as organisms into their respective ecosystems, create a dinner menu to represent energy flow through a food chain, identify patterns among different food chains and ecosystems, and guess the mystery host.

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Objectives

Students will:

- Trace energy flow throughout an ecosystem.
- Identify patterns among different food chains and ecosystems.
- Draw conclusions about the roles of the sun, producers, consumers, and decomposers in ecosystems.

Inquiry/Critical Thinking Questions

- How is my life linked to the sun?
- How does energy flow through living systems?
- How do different food chains and ecosystems compare?
- What roles do producers, consumers, and decomposers play in an ecosystem?

Time Required

60 minutes

Key Concepts

- **biome**—A specific region of Earth that has similar climate, plants, and animals; a biome may be made of many different ecosystems.[1]
- **consumer**—An organism that does not make its own food (i.e., is not a producer). There are different types of consumers: *primary consumers,* or herbivores, eat producers (such as plants or algae); *secondary consumers* eat primary consumers; and *tertiary consumers* eat secondary consumers.
- **decomposers**—Organisms such as fungi or bacteria that use dead organisms or waste as food and in this process return nutrients to the ecosystem.
- **ecosystem**—A community of organisms (plant, animal, and other living organisms) that interact with one another and with the nonliving factors in their environment.
- **food chain**—A series of organisms through which energy is transferred. Each organism feeds on the one before it (except for producers which get their energy from the sun) and is eaten by the organism following it.
- **producer**—An organism that is able to make its own food (e.g., plants and algae).
- **system**—A collection of many interconnected parts that work together; changing one part affects other parts.

Energy Literacy: Essential Principles and Fundamental Concepts for Energy Education

3.1 The Sun is the major source of energy for organisms and the ecosystems of which they are a part.

3.2 Food is a biofuel used by organisms to acquire energy for internal living processes.

3.4 Energy flows through food webs in one direction, from producers to consumers and decomposers.

3.5 Ecosystems are affected by changes in the availability of energy and matter.

3.6 Humans are part of Earth's ecosystems and influence energy flow through these systems.

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U.S. Standards Correlation

- **State and national standards:** Visit our Standards Correlation Tool at www.facingthefuture.org/CurriculaFreeUnits/StandardsCorrelations

Materials/Preparation

- ☐ **Display Copy:** *Mystery Dinner*
- ☐ **Handout:** *Mystery Dinner Menu,* 1 per group of 5 students
- ☐ **Create 4 ecosystem stations** by hanging signs with each ecosystem/biome name around the room and placing the corresponding *Ecosystem Card* at each station.
- ☐ **Cards:** *Ecosystem Cards,* 1 per station
- ☐ **Cards:** *Organism Role Cards,* copied and cut such that there is 1 per person OR, for classes greater than 20, 1 per partnered pair

Background Information for Educators

All living things need energy in order to survive and function. We humans get our energy from the chemical energy stored in food, but if we trace our path of energy back far enough, we will find that ultimately we get our energy from the sun. In fact, the sun is the main source of energy for most food chains and ecosystems on Earth.[2] Like other consumers, humans are dependent upon producers such as plants and algae. Through the process of photosynthesis, producers use the sun's energy to turn carbon dioxide and water into their food—sugars, a form of chemical energy. This food helps them function and survive, just as it helps us to function and survive when we eat them. (Not all producers use sunlight to make their food: autotrophs are organisms that make their food using chemicals. They typically live in harsh environments devoid of sunlight, such as in hot springs or near vents in the ocean floor.[3])

When we eat plants and animals, we gain both matter and energy that we need to survive. Energy always flows through a food chain or ecosystem in the same direction; energy travels from the sun to producers to consumers to decomposers. However, the amount of energy that is available at a particular level in a food chain decreases over the course of this process. This is because while an organism uses some of the energy consumed to survive and function, most of it is lost as heat to the surrounding environment. In fact, only about 10 percent of the energy available at one level of the food chain is passed on to the next.[4]

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Activity 1

Introduction

1. Tell students that this morning you received an invitation in your mailbox to a mystery dinner.
2. In Think-Pair-Share format, ask students how food is related to energy.
3. Share with the class that food contains energy. We eat food in order to get the energy our bodies need to function and survive (e.g., to help our bodies grow, move, think, and stay warm). In fact, all living things need energy in order to function and survive.

   Option: Ask students to identify what form of energy is stored in food. *(Chemical energy.)*
4. Draw a person on the board or write the word "person."
5. Ask students to imagine they ate a hamburger for lunch. Ask the class to name the main ingredients for the bun and meat patty. *(Wheat and beef.)*

   Option: Invite students to name another food and use that for steps 5–13.
6. Draw an image of wheat and an image of a cow on the board, or write the words.
7. Ask students in which direction energy is moving when a person eats a hamburger: from the cow and wheat to the human, or from the human to the cow and wheat. *(Energy is flowing from the cow/wheat to the human.)*
8. Connect the cow and the wheat on the board to the person using arrows moving in the direction of the person.

   Note: Arrows in energy flow diagrams such as this one point in the direction that energy is moving, not in the direction of who is eating whom.

   cow ↘
   wheat ⟶ person
9. Remind students that all living organisms require energy to function, and ask the class where the cow gets its energy. *(Grass.)*
10. Draw an image of grass or write the word on the board. Connect the grass to the cow using an arrow pointing toward the cow.

    grass ⟶ cow ↘
    wheat ⟶ person
11. Ask the class where the grass gets its energy. *(It makes its own food using energy from the sun.)*
12. Ask the class where the wheat gets its energy. *(It makes its own food using energy from the sun.)*
13. Draw an image of the sun or write the word and connect the sun to the grass and wheat using arrows pointing toward the grass and wheat.

    sun ↗ grass ⟶ cow ↘
    sun ↘ wheat ⟶ person

    Option: Challenge students to draw an energy flow diagram that shows the energy transformations that take place in this food chain. (Answer is as follows:)

    light energy ⟶ chemical energy ⟶ heat and movement (in our bodies)

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14. In Think-Pair-Share format, have students create a short summary that describes how the energy, or food, people need to survive is connected to the sun.

Steps

1. Project the display copy *Mystery Dinner* on the board and read the following information to students:

   A mystery host has invited you and your classmates to a dinner party. The purpose of this dinner party is to help you learn about ***food chains*** *and* ***ecosystems*** *around the world. While at this party, each one of you will receive a card that describes an organism from a specific ecosystem. You will work together to complete the following tasks:*

   a. Find other "guests" that live in the same ecosystem.

   b. Gather at the appropriate ecosystem station.

   c. Create a dinner menu to represent energy flow through your food chain.

   d. Identify the mystery host.

2. Share with students the following definition and ask students how a dinner menu could be similar to a food chain.
   - **food chain—**A series of organisms through which energy is transferred. Each organism feeds on the one before it (except for producers) and is eaten by the organism following it.
3. Share with students the definition of ecosystem and ask students to name some nonliving things in an environment. *(Answers may include air, sunlight, soil, and water.)*
   - **ecosystem—**A community of organisms (plant, animal, and other living organisms) that interact with one another and with the nonliving factors in their environment.
4. Pass out an *Organism Role Card* to each student or student pair.
5. Give students a couple of minutes to read their card.
6. Announce the beginning of the dinner party and tell students they will have about 3 minutes to walk around the room, find other organisms in their ecosystems, and gather as a group at the corresponding station.
7. Once students have accurately located their stations, give each group the handout *Mystery Dinner Menu* and review the directions together. Explain that students should use the information on their *Organism Role Cards* to complete this handout and tell groups that they will be reporting their results to the class.
8. While students are working, write the following labels on the left side of the board: Appetizer, First Course, Second Course, Third Course, Dessert.
9. Once all groups have completed the handout *Mystery Dinner Menu*, invite a student from each group to write or draw their food chain on the board next to these labels. (Answers are as follows:)

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Appetizer	Douglas Fir	Kelp	Avocado Tree	Big Sagebrush
First Course	Bushy-Tailed Woodrat	Hermit Crab	Red-Rumped Agouti	Black-Tailed Jackrabbit
Second Course	Spotted Owl	Blue-Ringed Octopus	Anaconda	Western Rattlesnake
Third Course	Great Horned Owl	Moray Eel	Jaguar	Golden Eagle
Dessert	Orange Jelly Fungus (Witch's Butter)	Sea Cucumber	Termite	Heterotrophic Bacteria

10. Give small groups a few minutes to examine the data on the board and look for patterns among the different food chains. Use the following questions to guide student analysis:

- In which direction does energy flow through these food chains?
- What similarities do you notice between these different food chains?
- What differences do you notice between these different food chains?

11. Have students raise their hands if the organism they represented feeds off more than 1 organism in their ecosystem. Ask students how this might be beneficial to the survival of that organism.

12. Have students raise their hands if the organisms listed in their assigned ecosystems could feed in a different order, and ask volunteers to give examples. *(Answers may include that great horned owls eat rodents, eels eat pink anemonefish, and golden eagles eat jackrabbits.)*

13. Share with students the following definitions:

- **producer**—An organism that is able to make its own food (e.g., plants and algae). Typically, these are organisms that convert sunlight into chemical energy that animals can eat.
- **consumer**—An organism that does not make its own food (i.e., not a producer).

Note: If desired, share the following information about different types of consumers:

- *Primary consumers* eat producers.
- *Secondary consumers* eat primary consumers.
- *Tertiary consumers* eat secondary consumers.

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- **decomposers**—Organisms such as fungi or bacteria that use dead organisms or waste as food and in this process return nutrients to the ecosystem.
- **system**—A collection of many interconnected parts that work together; changing one part affects other parts.

14. Have students work in their groups to identify the producers, consumers, and decomposers in the diagrams on the board. If desired, have them start by labeling the producers and consumers on their handout *Mystery Dinner Menu.*

15. Invite students to share their answers with the class.

Option: Add arrows to show how energy flow through these ecosystems may not be as linear as the menu suggests.

16. In small groups, have the class examine the information on the board and answer the following questions:

- Is the dinner menu a helpful comparison to use for learning about energy flow through ecosystems? Why or why not?
- What are the different parts and boundaries inputs of these ecosystems? How do the different parts of these systems interact?
- What input of energy is needed in each ecosystem in order for organisms to survive?
- When you compare all of these food chains, do you notice any patterns that relate to producers, consumers, and decomposers?
- **Note:** Be sure that students see how each food chain begins with a producer that captures sunlight and converts it to food, or chemical energy, that consumers can eat.
- What is the role of the sun in a food chain?
- What might happen if there were no producers in an ecosystem? Consumers? Decomposers?

18. Tell students it is time to reveal the mystery host. Reread the hint on the student handout *Mystery Dinner Menu* and have groups raise their hands if they think they know "who" it is.

19. Share that the mystery host is the sun. Ask students how the sun plays a role in every one of the food chains they researched. *(The sun was the original source of energy in each food chain.)*

20. Collect *Mystery Dinner Menu* handouts and *Organism Role Cards* and have students return to their seats.

21. Conclude with the following discussion questions.

Discussion Questions

1. How is your life linked to the sun?
2. Why are producers such as plants and algae so important for an ecosystem?
3. What are some conclusions you can draw about energy flow through food chains and ecosystems?

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4. How could humans impact energy flow through ecosystems?
5. How are ecosystems examples of systems?
6. How is energy transferred in a food chain? How does energy change forms in an ecosystem?
7. How does the flow of energy through a food chain system compare to the flow of energy through a physical system such as a Rube Goldberg machine (Lesson 1)?
8. Why is it important to take care of the ecosystems in our world?

Lesson Extensions

Scientific Models Extension

Write the words "food chain" and "food web" on the board and ask students to think of an image for each one. Share with students that we often use models to help us to understand complex ideas such as food chains and food webs. List some types of models on the board (e.g., diagrams, physical models, mathematical representations, analogies, and simulations).[5] Share examples of diagrams and flowcharts. Explain to the class that each student will be creating a model to represent energy flow through an ecosystem, and that each model should meet the following requirements: show the original source of energy in their ecosystem; include the words "producers," "consumers," and "decomposers;" and show the direction of energy flow. Students can use media such as computer simulations, paper and markers, or yarn to create their models, and models can be image- or word-based. Once students have created their models, have a class discussion about the benefits and limitations of each model, including which phrase, "food chain" or "food web," more accurately describes feeding relationships in an ecosystem.

Literature/Geography Extension

Read to the class *Horseshoe Crabs and Shorebirds: The Story of a Food Web* by Victoria Crenson, and ask students to locate Delaware Bay on a map. Have students pay close attention to the shorebirds' journey from the tip of South America to the Arctic Circle. Create a map of this journey, including the stopover in Delaware Bay.

Additional Resources

- **Book:** *Pass the Energy Please*
  This picture book by Barbara Shaw McKinney and illustrated by Chad Wallace describes how energy is passed throughout a food chain.
- **Interactive:** *Energy Flow*
  In this NOVA animation, students follow the path that energy takes from the sun to a hamburger and answer questions along the way: **www.pbslearningmedia.org/resource/tdc02.sci.life.oate.energyflow/energy-flow**
- **Website:** *National Geographic Kids*
  This website has kid-friendly information and interactives about animals, ecosystems, and more:
  http://kids.nationalgeographic.com/

Mystery Dinner

You Are Invited!

A mystery host has invited you and your classmates to a dinner party. The purpose of this dinner party is to help you learn about **food chains** and **ecosystems** around the world.

Solve A Mystery.

While at this party, each one of you will receive a card that describes an organism from a specific ecosystem. You will work together to complete the following tasks:

1. Find other "guests" that live in the same ecosystem.
2. Gather at the appropriate ecosystem station.
3. Create a dinner menu to represent energy flow through your food chain.
4. Identify the mystery host.

Name _______________________________ Date _______________________________

Mystery Dinner Menu

Location

1. What is the name of the biome where your organisms live?

____

2. What are 2 to 3 characteristics of this biome?

____

____

Menu

Use your Organism Role Cards to figure out who eats whom in this ecosystem. Under each heading below, write the name of an organism from your ecosystem that matches the feeding habit listed.

Appetizers (Makes its own food.)

____

First Course (Eats organisms that make their own food.)

____

Second Course (Eats other organisms.)

____

Third Course (Eats other organisms.)

____

Dessert (Eats waste or dead organisms.)

____

Observations

3. What are some observations you can make about the food chain above?

____

____

Mystery Host: Who do you think the mystery host is?

Hint: The host is a nonliving source of energy and the foundation for most food chains on Earth.

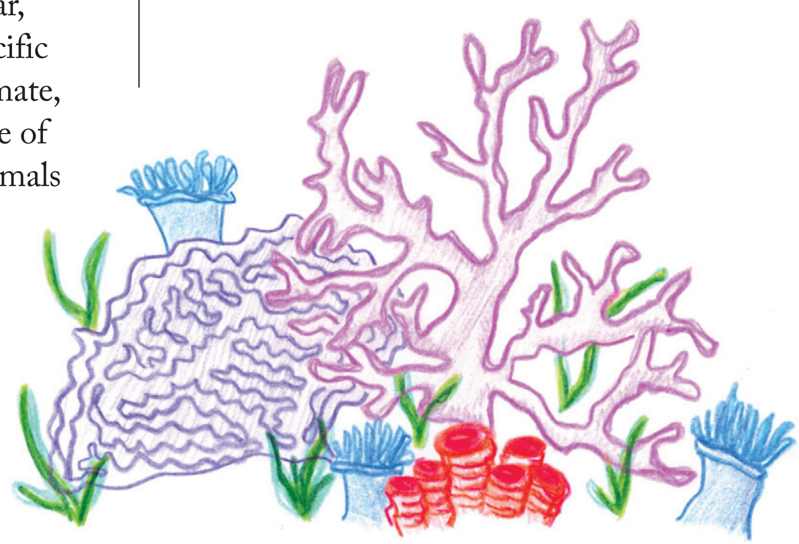
Ecosystem Cards, page 1

Ecosystem 1: Amazon Rainforest

The organisms in your ecosystem can be found in the Amazon Rainforest. The Amazon Rainforest is a biome named after the Amazon River. Biomes are specific regions of Earth that have similar climate, plants, and animals; they may be made of many different ecosystems.[6] Tropical rainforests, like the Amazon rainforest, are hot, humid, and have lots of rainfall.[7] Since the Amazon rainforest provides about 20% of the oxygen on Earth, it is one of our most important natural resources.[8] Scientists estimate that the canopy of this rainforest may contain half of the world's species![9] The rainforest is made up of four distinct layers: emergent layer, canopy, understory, and forest floor.[10] Each of these layers has unique ecosystems with plants and animals that have adapted to those conditions.[11]

Ecosystem 2: Coral Reef

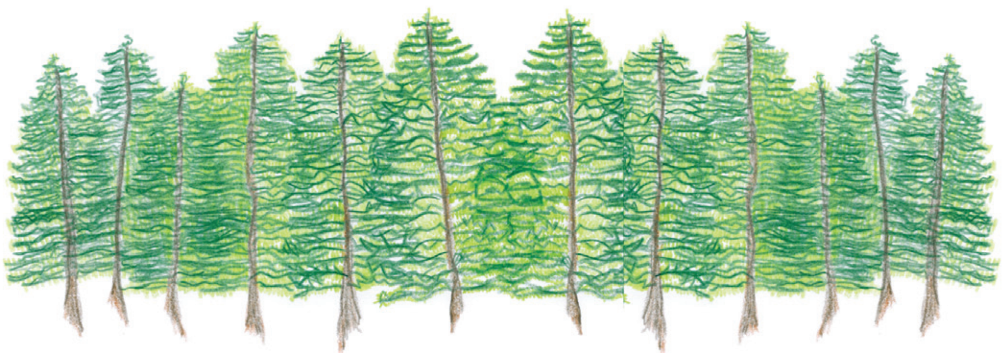
The organisms in your ecosystem can be found in a coral reef. Coral reefs are biomes that are most commonly found in clear, tropical ocean waters. Biomes are specific regions of Earth that have similar climate, plants, and animals; they may be made of many different ecosystems.[12] Tiny animals called corals create brightly colored underwater ridges called reefs. These reefs serve as a home to other marine plants and animals, too. Coral reefs are usually in areas with a lot of wind and wave action. The organisms here rely on the wind and waves to carry nutrients into the reef.[13]



Ecosystem Cards, page 2

Ecosystem 3: Temperate Coniferous Forest

The organisms in your ecosystem can be found in a temperate coniferous forest. Temperate coniferous forests are biomes located in coastal or mountainous regions with mild climates. Biomes are specific regions of Earth that have similar climate, plants, and animals; they may be made of many different ecosystems.[14] The temperatures in this biome do not change much throughout the year and there is lots of precipitation, or rain (50–200 inches per year). Because of the rainfall and moderate temperatures, evergreen conifers (trees) can grow very tall.[15]



Ecosystem 4: Temperate Grassland—Steppe

The organisms in your ecosystem can be found in a type temperate grassland called a steppe. The primary feature of temperate grasslands is—you guessed it—lots of grass. Grasslands are a type of biome. Biomes are specific regions of Earth that have similar climate, plants, and animals; they may be made of many different ecosystems.[16] Many different types of grasses and shrubs grow in grasslands, but almost no trees or large plants grow there. Steppes, a type of temperate (non-tropical) grassland, are dry and have hot summers and cold winters. Overuse of steppe land for grazing livestock can put a steppe biome at risk, because the wind picks up loosened soil and brings about dust storms.[17]

Organism Role Cards: Amazon Rainforest, page 1

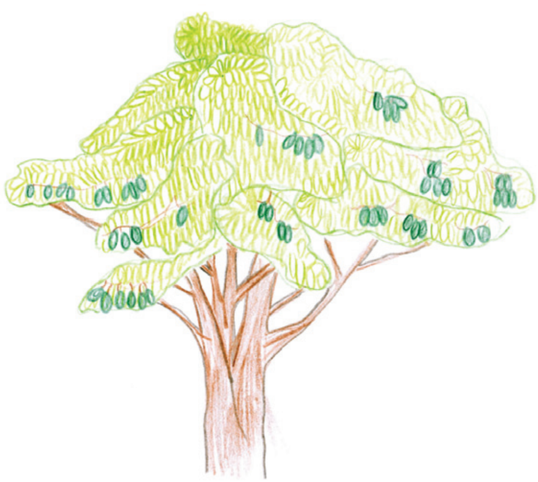
Avocado Tree

Who I am: A tree with evergreen leaves that grows 35-40 feet tall. I produce oval shaped fruits that many people eat.[18]

Where I live: In the Amazon Rainforest.[19]

Where I get energy: From the sun.

Who depends on me as an energy source: Agoutis (rodents),[20] leaf-katydids (insects),[21] and resplendent quetzals (birds).[22]



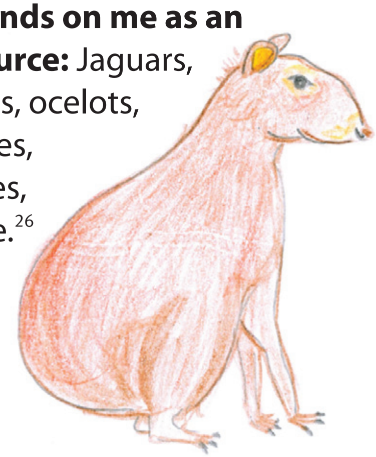
Red-Rumped Agouti

Who I am: A small, brown, fast-running rodent with a short tail. I have a white stripe running down my underside.[23] I can grow up 24 inches long and weigh up to 9 pounds.[24]

Where I live: In the Amazon Rainforest. I hide in thick brush near rivers, streams, and swamps.

Where I get energy: I love to eat the seeds, pulp, leaves, and roots of most fruit trees, including avocados. When food is scarce, I will eat insect larvae.[25]

Who depends on me as an energy source: Jaguars, jaguarundis, ocelots, harpy eagles, large snakes, and people.[26]



Anaconda

Who I am: I am one of the largest snakes in the world. I can grow up to 30 feet long and weigh as much as 400 pounds![27]

Where I live: The tropical rain forests of the Amazon. I am often found in the water and in trees.[28]

Where I get energy: Agouti, capybaras, crocodiles, and other snakes.[29]

Who depends on me for energy: Jaguars and large black caimans (a reptile from the alligator family).[30]

Organism Role Cards: Amazon Rainforest, page 2

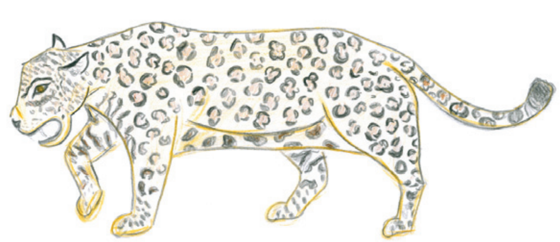
Jaguar

Who I am: The largest big cat in South America.

Where I live: Remote regions of South and Central America.[31] I am most commonly found near the Amazon River in the rainforest.[32]

Where I get energy: Anacondas, caimans (a reptile from the alligator family), capybaras, deer, fish, peccaries (a pig-like mammal), tapirs, and turtles.[33]

Who depends on me for energy: Humans sometimes hunt me for fur or to protect their livestock.[34]



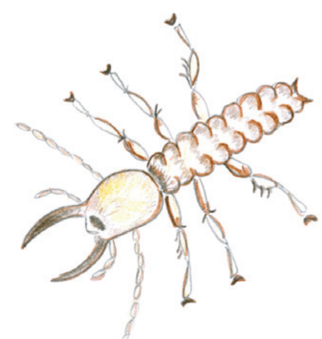
Termite

Who I am: A soft-bodied, light-colored insect that grows up to 0.59 inches in length.[35]

Where I live: Most termite species live in tropical and subtropical regions of the world.[36] Some tropical species build giant nests made from termite feces, soil, and fungi.[37]

Where I get energy: I eat dead wood. I use fungi or bacteria to help digest the wood.[38]

Who depends on me as an energy source: In tropical regions, birds, frogs, and giant anteaters are my primary predators.[39] Ants, beetles, and centipedes will also eat me.[40]



Organism Role Cards: Coral Reef, page 1

Kelp

Who I am: A large type of brown seaweed (algae). Patches of kelp growing near each other are called "forests," but I am not a tree![41]

Where I live: Coral reefs and other marine environments.

Where I get energy: From the sun.

Who depends on me as an energy source: Pink anenomefish, other fish and invertebrates.[42]

Hermit Crab

Who I am: I am a small crustacean, and not a true crab. I carry a shell on my back to protect my soft under-body.[43]

Where I live: In oceans around the world, including coral reefs.[44]

Where I get energy: I eat both animals and plants like algae, or kelp.[45]

Who depends on me as an energy source: Fish, sharks, and octopuses.[46]

Blue-Ringed Octopus

Who I am: A small marine mollusk. I get my name from the bright blue ring patterns that cover my body and all eight of my arms. I produce powerful poisons in my body to help me catch my prey.[47]

Where I live: Coral reefs all over the South Pacific Ocean.[48]

Where I get energy: Mollusks, crabs, and small or injured fish.[49]

Who depends on me for energy: Moray eels, large fish, and sharks.[50]

Organism Role Cards: Coral Reef, page 2

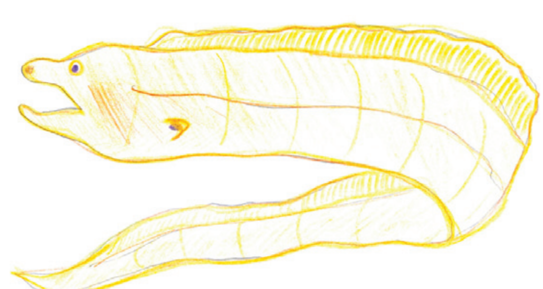
Moray Eel

Who I am: A large species of eel that can live in either deep or shallow waters. I can grow up to 2 meters in length. Although I look like a snake, I am actually a type of fish.[51]

Where I live: Coral reefs in warm and temperate waters all over the world.[52]

Where I get energy: Blue-ringed octopuses and other mollusks, crustaceans such as crabs, and fish.[53]

Who depends on me for energy: Larger fish such as sharks, and sometimes humans![54]



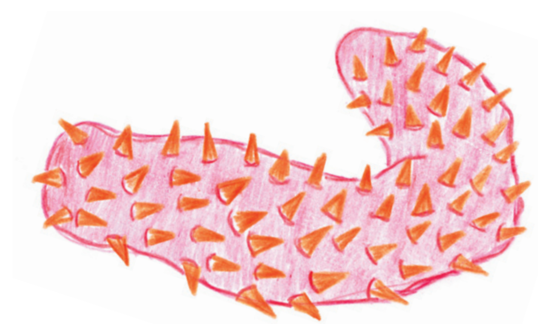
Sea Cucumber

Who I am: A tube-shaped creature with a soft body and between 8 and 30 tube-shaped feet. I can grow to be over six feet long! I am an echinoderm, like starfish or sea urchins.[55]

Where I live: On the ocean floor in coral reefs and other marine environments.

Where I get energy: Algae and particles of waste material.

Who depends on me as an energy source: Fish, other marine predators, and bacteria eat the waste I have broken up into tiny pieces.[56]



Organism Role Cards: Temperate Coniferous Forest, page 1

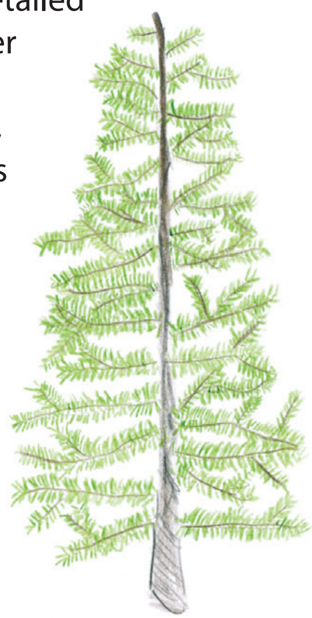
Douglas Fir

Who I am: A large evergreen tree with cones and yellow-green needles; I can grow to be 200 feet tall.[57]

Where I live: Temperate coniferous forests.

Where I get energy: From the sun.

Who depends on me as an energy source: Bushy-tailed woodrats, other small rodents, birds, deer, elk, and even bears can be found eating my seeds, leaves, or sap.[58]



Bushy-Tailed Woodrat

Who I am: A grayish-brown mammal with a bushy tail, often called a packrat because of the things I store near my nest.[59]

Where I live: Temperate coniferous forests.

Where I get energy: Berries and the leaves of Douglas fir and other trees.[60]

Who depends on me as an energy source: Owls, bobcats, and martens.[61]

Spotted Owl

Who I am: A brown owl with white spots who hunts at night. I can grow to be 1.5 feet long with a wingspan of 4 feet.[62] Some species are near threatened or threatened due to habitat loss.

Where I live: Temperate coniferous forests.

Where I get energy: Woodrats, birds, flying squirrels, and reptiles.[63]

Who depends on me for energy: Great horned owls, red-tailed hawks, and ravens.[64]

Organism Role Cards: Temperate Coniferous Forest, page 2

Great Horned Owl[65]

Who I am: An owl with yellow eyes and feathers on the top of my head that look like horns.

Where I live: Many different habitats, including temperate coniferous forests.

Where I get energy: Rodents, insects, fish, and other birds such as young spotted owls.[66]

Who depends on me for energy: I have no natural predators, but sometimes other organisms eat my eggs.

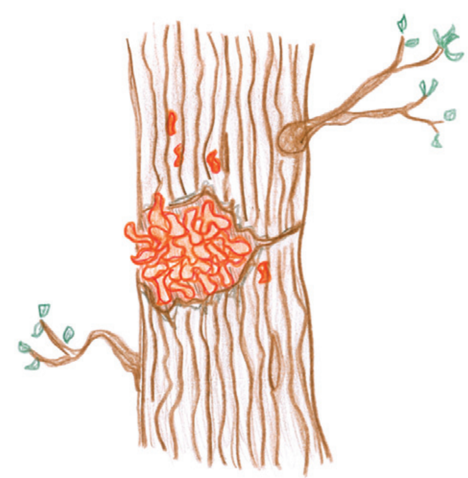
Orange Jelly Fungus or Witch's Buttter[67]

Who I am: A shiny yellow fungus that looks like a brain and grows in clusters on dead trees.

Where I live: Temperate coniferous forests.

Where I get energy: I feed off dead pine trees that no longer have bark.

Who depends on me as an energy source: Soil animals such as worms, mites, and insects often feed on fungi and bacteria like me.[68]



Organism Role Cards: Temperate Grassland—Steppe, page 1

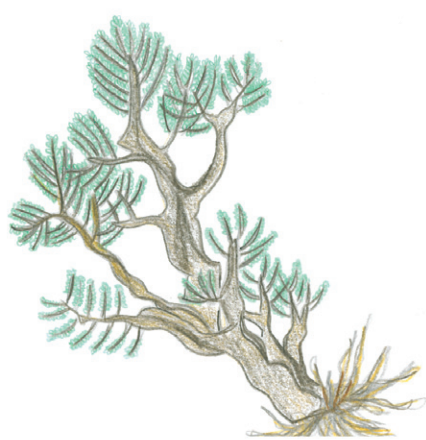
Big Sagebrush

Who I am: A grey-green shrub, usually growing to 2–4 feet tall (but sometimes up to 10). My leaves are covered with tiny hairs to prevent me from drying out in hot, dry weather.[69]

Where I live: Grasslands, such as those found all over the western United States and Canada.[70]

Where I get energy: From the sun.

Who depends on me as an energy source: White- and black-tailed jackrabbits, ground squirrels and other rodents, and insects.



Black-Tailed Jackrabbit

Who I am: I am known as the most widely distributed jackrabbit in North America,[71] but I am not really a rabbit; I am a hare. My long ears have black tips, and I have a long black stripe running down my back and tail.[72]

Where I live: Grasslands and forests across North America. I hide and nest in shrubs and small conifers.[73]

Where I get energy: Shrubs and grasses, including big sagebrush.[74]

Who depends on me as an energy source: Eagles, hawks, and other birds of prey; rattlesnakes and garter snakes; and bobcats, coyotes, and other predators.[75]

Western Rattlesnake

Who am I: A medium-sized snake, usually greenish brown or gray, with a flat head and a "rattle" at the end of my tail. I am very poisonous but I don't bother people unless I am stepped on or harassed.[76]

Where I live: Warm, dry deserts, grasslands, or forests. I like to live in rocky areas where I can hide.[77]

Where I get energy: Rodents, ground dwelling birds, lizards, and other small animals.[78]

Who depends on me for energy: Eagles, hawks, bobcats, coyotes, foxes, and other large predators.[79]

Organism Role Cards: Temperate Grassland—Steppe, page 2

Golden Eagle

Who I am: One of the largest birds in North America! My feathers are mostly dark brown but my head and neck have a golden sheen.[80]

Where I live: Throughout most of North America, including grasslands. I like open areas near mountains or hills.[81]

Where I get energy: Mainly small mammals like jackrabbits, mice, and squirrels, but I also eat snakes and lizards, or even larger animals like domestic livestock![82]

Who depends on me for energy: I don't have any natural predators, although in rare cases bears or wolverines might try to eat my nestlings.[83]

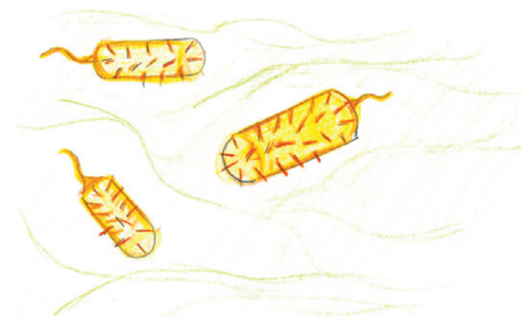
Heterotrophic Bacteria

Who I am: A microscopic, single celled organism. I'm one of the smallest life forms on earth.[84]

Where I live: Almost everywhere, including grasslands! I often make my home in soil and water, although some bacteria might live on plants, and on or inside animals—even you![85]

Where I get energy: I break down and "eat" the bodies of animals or plants that have died.

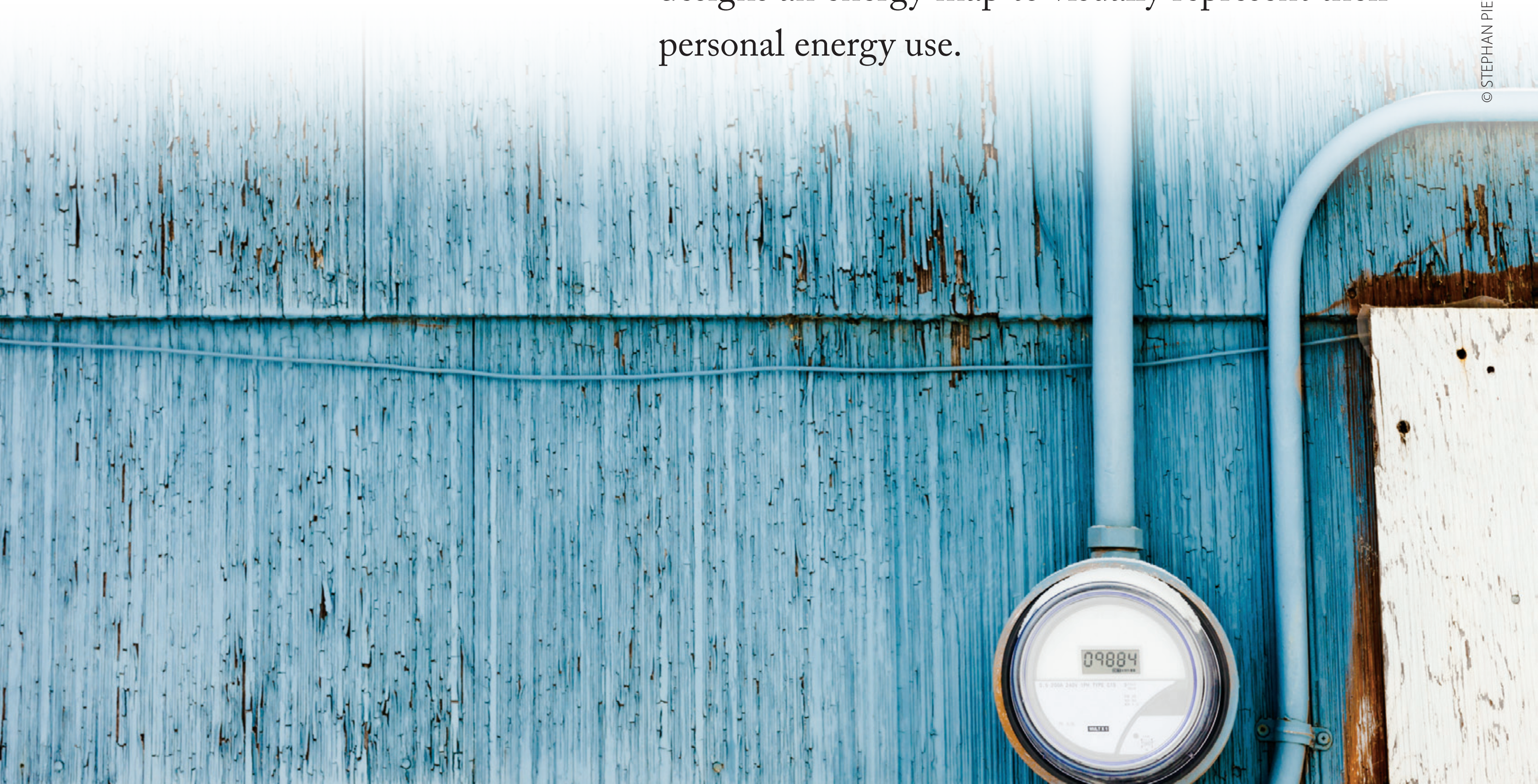
Who depends on me as an energy source: Plants need the carbon and nitrogen I release into the soil, air, or water when I break down organic matter for energy.[86]



Lesson 3

Mapping My Energy Use

In preparation for an energy awareness activity, students brainstorm the different ways that they use energy. Students learn electrical safety tips and then record their personal energy use over 24 hours. During Activity 2, they use these observations to categorize the different ways they use energy. The class then reads Sara Fanelli's *My Map Book* and each student designs an energy map to visually represent their personal energy use.



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Objectives

Students will:

- Articulate electrical safety tips.
- Analyze and categorize human energy use.
- Observe and record their daily energy use.
- Distinguish between energy needs and wants.
- Visually represent their personal energy use with art and labels.

Inquiry/Critical Thinking Questions

- How do we use electricity safely?
- How do I use energy to meet and exceed my needs?
- How can I represent my energy use with art?
- What are some benefits of being aware of my energy use?

Time Required

Activity 1: 20 minutes
Activity 2: 60 minutes

Key Concepts

- **British thermal unit (Btu)**—The amount of heat required to raise the temperature of a pound of water by 1 degree Fahrenheit.
- **consumption**—The process of using natural resources or manufactured products to satisfy human wants or needs.
- **electricity**—A form of energy associated with the movement of charged particles; generally produced as a secondary form of energy by converting other sources of energy, such as coal or wind, into electricity.

Energy Literacy: Essential Principles and Fundamental Concepts for Energy Education

5.1 Decisions concerning the use of energy resources are made at many levels.

6.2 One way to manage energy resources is through conservation.

6.7 Products and services carry with them embedded energy.

6.8 The amount of energy used can be calculated and monitored.

U.S. Standards Correlation

- **State and national standards:** Visit our Standards Correlation Tool at www.facingthefuture.org/CurriculaFreeUnits/StandardsCorrelations

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Materials/Preparation

Activity 1

- ☐ **Handout:** *24 Hours of Energy,* 1 per student
- ☐ **Download** the Electrical Safety Foundation International's *Family Information Sheet* or the *Safety and Activity Guide,* 1 per student.
  - Family Information Sheet: kids.esfi.org/system/teaching_guide_items/guide_attachment_englishes/000/000/013/original/Family_Information_Sheet_Its_Electric.pdf?1397425323
  - Safety and Activity Guide: kids.esfi.org/system/teaching_guide_items/guide_attachment_englishes/000/000/010/original/Safety_and_Activity_Guide-Its_Electric.pdf?1397424275
- ☐ **Internet access and projector** to show the Electrical Safety Foundation International's 3-minute cartoon video *Home Safety:* kids.esfi.org/cartoon/6

Activity 2

- ☐ **Handout:** *24 Hours of Energy,* completed in Activity 1
- ☐ **Book:** Obtain a copy of *My Map Book,* by Sara Fanelli. If you want more than one copy, ask a librarian to help you secure them through inter-school loans.
- ☐ **Paper and colored pencils/markers** or other art supplies

Optional

- ☐ **Gather visual representations** of information, such as different types of maps and infographics.
- ☐ **Create a class poster** with a concept map that shows different categories of human energy use. Consider keeping this poster as students continue to study energy.

Background Information for Educators

Energy fuels our lives. We eat food to sustain our bodies, use electricity to charge our cell phones and computers, and burn fuel to transport people and goods. Every time we buy a product or service, we also use a certain amount of embodied energy, or embedded energy. Embodied energy is the energy that is used throughout the entire lifecycle of a product or service.[1] For example, energy is required to fertilize, irrigate, and harvest crops before they become food; then, that food requires energy to be processed, refrigerated, packaged, and transported to consumers.[2] The way we dispose of products also has an impact on the amount of energy we consume. By creating products from recycled materials instead of raw materials, we save the energy needed for the growth or extraction—or both—of natural resources. For example, manufacturing aluminum cans with recycled aluminum uses 95% less energy than making aluminum cans from raw materials![3]

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According to the U.S. Energy Information Administration, the world consumed about 524 quadrillion British thermal units (Btus) in 2011. A Btu is a unit of energy equivalent to the amount of heat required to raise the temperature of a pound of water by 1 degree Fahrenheit. For frame of reference, a 1200-calorie burrito contains about the same amount of energy as 4750 Btus.[4] Energy consumption in the U.S. is often categorized into 4 main sectors: commercial, industrial, residential, and transportation.[5] In the residential sector (homes and apartments), people use energy for appliances, electronics, heating and air conditioning, lighting, refrigeration, and water. The amount of energy used in each home depends on the area's climate, the amount and types of energy-consuming devices in that home, and, importantly, the access one has to energy sources.[6] About 1.3 billion people around the globe lack access to electricity and 2.6 billion people rely upon biomass (vegetation and animal waste) for cooking and heating.[7]

The amount and type of energy we use affects our environment, economy, and society. Thus, taking a close look at the ways we use energy lays important groundwork for sustainable energy use.

Activity 1

Introduction

1. Remind students that we measure things using specific units.
2. Ask the class to name some units that might be used to measure the following:
   - A person's weight. *(Pounds in the US, kilograms using the metric system.)*
   - The distance you travel to school. *(Miles, kilometers, or meters.)*
   - The speed you travel in a car. *(Miles per hour or kilometers per hour.)*
   - The amount of energy in food. *(Calories.)*
3. Share with students that the British thermal unit is also a unit of energy and a 1200-calorie burrito contains about the same amount of energy as 4750 Btus.[8]
4. Ask students how many Btus of energy they think they used this year in their daily lives.
5. Share with students that, on average, every person in the U.S. used 148.6 million Btus in 2012 for his or her house and travel needs. Ask how many burritos they think this is. Reveal that this is about the same amount of energy as contained in 31,226 burritos, 165,033 sticks of dynamite, or 15,370 pounds of coal.[9]

   Option: Show students the U.S. Department of Energy interactive graphic "How Much Energy Do You Use?" which compares the amount of energy used by the average person in a particular state

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to the energy potential in burritos, coal, dynamite, and jet fuel: http://www.energy.gov/maps/how-much-do-you-consume-0

6. In Think-Pair-Share format, have students brainstorm a list of the different ways they think they use energy in a 24-hour period. Challenge students to think of indirect energy uses they might not be aware of, such as making their sandwich with cheese that had been cooled in the refrigerator or eating an apple that had been transported by a truck using diesel.
7. Give each student the handout *24 Hours of Energy* and discuss the directions for this assignment.

Steps

1. Share with students that while they are observing their energy use, they should first be concerned with safety. Remind students that electricity is dangerous because it can cause shocks and fires.
2. Invite students to share some safety tips they know about electricity and other sources of energy such as natural gas or wood fires.
3. Show students the Electrical Safety Foundation International's 3-minute video *Home Safety,* where Private I. Plug investigates a home filled with common household electrical dangers: http://kids.esfi.org/cartoon/6
8. Have students recall the safety tips in the video after viewing it (or pause after each safety tip is revealed) and write these on the board.
9. The following tips are from the Electrical Safety Foundation International:[10]
    - Be careful with electrical cords. Always have an adult unplug a cord using the plug and not the cord. Tell an adult if you notice cracks, bends or frayed wires in a cord. Tell an adult if too many things are plugged into 1 outlet.
    - Water and electricity do not mix. Keep liquids away from electrical outlets or cords and keep appliances such as hair dryers away from water or liquids.
    - Don't touch outlets even if they are not in use.
    - Prevent fires. Tell an adult if an object is too close to a lamp, heater, or any other hot surface. Tell an adult if cords are frayed, broken, or smoking.
    - Know your escape route in case of fires and call 9-1-1 if you need help.
10. Hand each student a copy of the handout *Family Information Sheet* or the handout *Safety and Activity Guide.* Encourage students to share these with their families.
11. Remind students that for this activity they are only making observations; they should not touch any wires or plugs. Remind them too that they should always tell an adult if they see anything dangerous or have questions about any appliances, electronics, or plugs.

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Activity 2

Introduction

1. Ask students to briefly look over their completed handout *24 hours of Energy*.
2. In Think-Pair-Share format, ask students to describe some of the different ways they used energy in the last 24 hours. List these uses on one side of the board.
3. In Think-Pair-Share format, have students describe the difference between needs and wants.
4. Lead students in categorizing the list on the board as a need or a want using the following questions to guide student discussion:
   - What are some of our body's energy needs?
   - Would you consider activities such as playing video games needs or wants?
   - Is it necessary to have lights on in a room when no one is in the room?
   - Would you consider it a need or want to use lights to help you study?
5. Invite students to analyze the list on the board and think about other ways—besides needs and wants—to categorize these uses of energy. Use the following questions to guide your discussion, as needed:
   - Could you sort these uses of energy by time of day? *(Answers may include alarm clock, hot water, and toaster in the morning, and lights, oven, and TV at night.)*
   - Are there different places/locations that you use energy? *(Answers may include home and school, or kitchen, bedroom, and bathroom.)*
   - Could you categorize energy use by the different reasons or purposes for using energy? *(Answers may include staying a comfortable temperature, doing chores, eating, playing, seeing, and studying.)*
   - Could you categorize these activities based on the source of energy used? *(Answers may include that transportation often uses gasoline and lights and appliances often use electricity.)*

   Option: Have students create a circle graph to represent their own answers to one of the questions above. For example, students could estimate the percentage of their total energy use in various locations and then turn this into a circle graph. Remind students that a circle graph represents a whole, or 100 percent.
6. Share with the class some of the graphs listed below to show them how others have categorized human energy use.
   - **Pie Graph:** *How electricity is used by the U.S. residential sector, 2012:* http://www.eia.gov/energyexplained/index.cfm?page=electricity_use
   - **Pie Graph:** *Share of total energy consumed by major sectors of the economy, 2013:* http://www.eia.gov/kids/energy.cfm?page=us_energy_use-basics

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- **Interactive Graphic:** *ENERGY@home:* http://www.energystar.gov/index.cfm?fuseaction=popuptool.atHome

Steps

1. In Think-Pair-Share format, ask students: what are some of the benefits, or advantages, of being aware of our energy use? *(Answers might include that energy costs money, we use natural resources to produce it, and knowing how we use energy can help us to use it more wisely.)*
2. Share with students that today they are going to create a map of their energy use in order to represent and become more aware of how they use energy in their lives.
3. Read Sara Fanelli's *My Map Book,* taking time to admire and discuss the different types of maps presented. Invite students to identify the different elements of each map such as labels, pictures, and symbols. As you proceed, you might have students try to predict what type of map will come next.

   Note: Sara Fanelli was born in Italy and lived in London when she wrote *My Map Book.* She uses maps as a metaphor to explore personal identity, mapping her face, neighborhood, family, dog, and even her heart. The book is primarily visual with labels rather than narrative text.
4. Discuss some of the questions below as a class or assign small groups different questions and have them report their answers back to the class.
   - What is a map?
   - How does information come across differently with a map than with words or numbers?
   - What kinds of maps did Sara paint?
   - How do the labels on these maps help you better understand each map?
   - How much text, as opposed to image, is on each map?
   - What have we learned about Sara from her maps?
   - How are the pages of "Map of my Family" and "Map of my Heart" different from the other maps? *(They are not mapping physical places like her bedroom and school, but people, favorites, and feelings.)*
   - How could you create a map like this to represent your energy use?
5. Tell the class that they will have about 20 minutes to create a map of their energy use. Encourage students to refer to their handout *24 Hours of Energy* and the categorizing activity they did in the beginning of class to help them develop the map. If desired, model this mapmaking process by creating one as a class to represent the class's energy use at school.

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Use the following questions to guide student mapmaking:

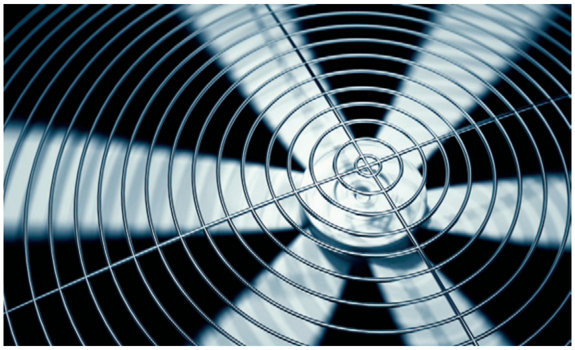
- How will you categorize the different ways you use energy in your life?
- What types of pictures will you use to represent the different ways you use energy?
- How could you use color to communicate information about your energy use?
- How could you use picture sizes and placement to communicate information about your energy use?
- How will you include words or labels in your map?
- How will you make use of the entire piece of paper?
- How can you create a draft before your final design? *(Ideas could include use a pencil or a different piece of paper first.)*

6. Hand out paper and colored pencils or markers to each student.
7. When students are finished, have students do a silent gallery walk.

   Option: Hang student maps in the hallway or another public space at school.
8. Conclude this activity with the following discussion questions.

Discussion Questions

1. What is one thing you learned about electrical safety?
2. What is one thing you learned about your energy use? What most surprised you about your energy use?
3. How did visually representing your energy use with a map help you better understand your energy use?
4. How do people use energy to **meet** their needs? How do people use energy to **exceed** their needs or to meet their wants?
5. How might one's energy use change during different seasons?
6. How might the place where people live affect how they use energy?
7. What are some reasons we might want to be aware of our energy use?
8. What actions could you take to reduce the amount of energy you use?



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Lesson Extensions

History Extension

How did people living in your region use energy in the past? Have students research historical energy use in your region and then summarize their findings by creating another energy map. Students could then compare this to their own map and reflect on similarities and differences.

Science & Geography Extension

Have students research climates around the world and consider how climate affects the way people use energy. Students can communicate their results to the rest of the class and draw conclusions about climate and energy use.

Additional Resources

- **Energy Map:** *How much energy do you use?*
  This U.S. Department of Energy graphic shows users the average amount of energy used by people in different states and compares this amount of energy to the energy in burritos, dynamite, coal, and flights: http://www.energy.gov/maps/how-much-do-you-consume-0
- **Toolkit:** *4 Seasons of Safety Toolkit*
  The Electrical Safety Foundation International is a nonprofit organization dedicated to promoting electrical safety. This toolkit includes lessons and take-home resources focused on helping students learn fire and electricity concepts and safety tips for every season: files.esfi.org/file/4-Seasons-of-Safety-Tool-Kit.pdf
- **Lessons:** *What is Electricity?*
  The Electrical Safety Foundation International is a nonprofit organization dedicated to promoting electrical safety. This resource includes a teacher's guide and student printouts covering the basics of electricity and electrical safety: www.esfi.org/resource/what-is-electricity-an-introductory-program-236#
- **Website:** *Energy Kids*
  The U.S. Energy Information Administration has a website just for kids. Students can click under the tab "Using & Saving Energy" to learn more about how we use energy: www.eia.gov/kids

Name Date

24 Hours of Energy, page 1

Directions: List the different ways you use energy in your daily life. Pause what you are doing at least three 3 times in the next 24 hours to fill this out, so you do not forget all the different ways you use energy. **Be safe!** Stay away from electric cords and outlets during this activity. If you need help or see something that looks dangerous, tell an adult.

Appliances and Electronics 	Almost one third of the energy used in homes is for appliances and electronics such as game systems, refrigerators, televisions.[11] **What types of appliances and electronics did you use at school and at home today?**
Food 	Energy is used to grow, ship, process, and package the foods we eat. It also takes energy to cool and cook food. **What kinds of food did you eat today? Or, how was the food you ate kept cold or cooked?**
Lights 	Electricity powers the lights in our homes and different light bulbs use different amounts of energy. **How and when did you use lights at home and at school today? Did you turn off light switches when you left a room?**
Heating and Cooling 	It takes energy to make our homes a comfortable temperature. We might use electric or gas furnaces, wood-burning stoves, or radiant floor heating to heat our homes. Many people cool their homes with air conditioning. **How did you keep your home or classroom a comfortable temperature today?**

Name Date

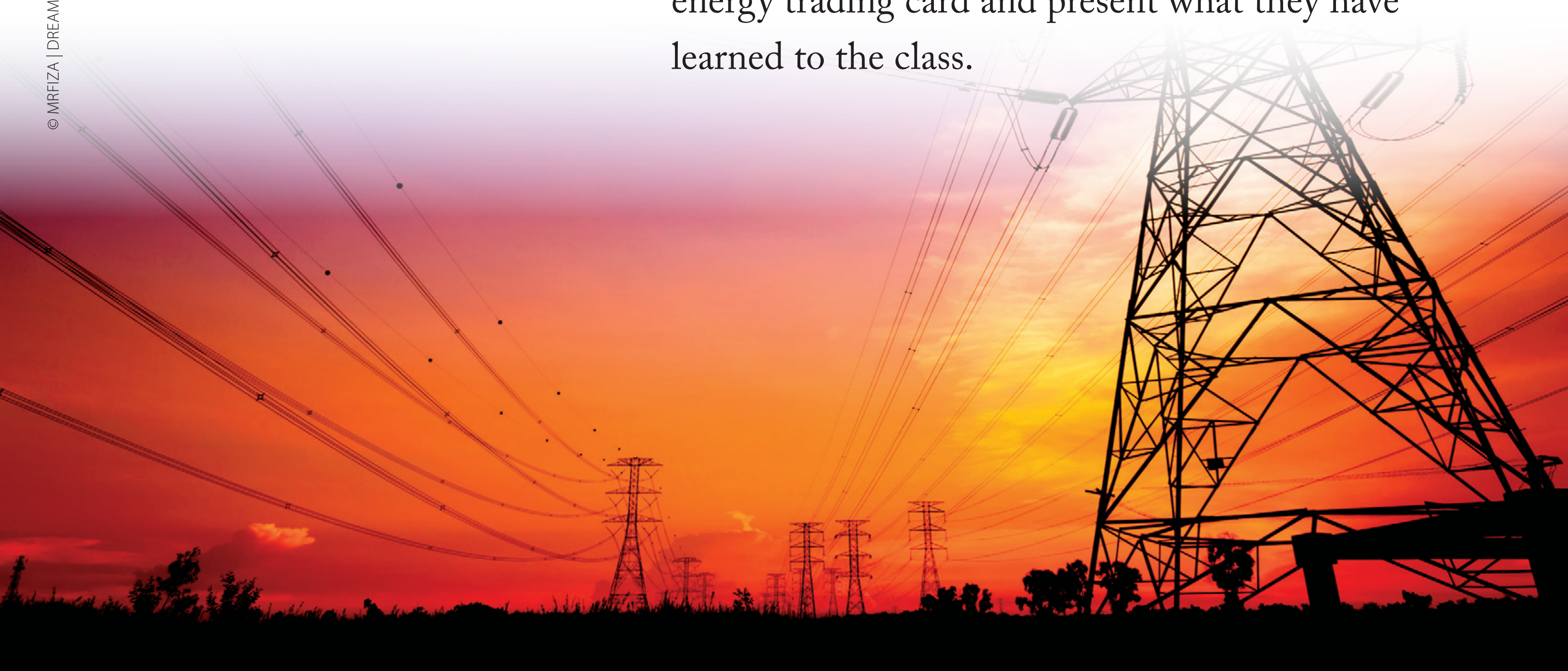
24 Hours of Energy, page 2

Transportation 	Cars, trucks, buses, trains, motorcycles, and even your own feet require energy in order to move. **How did you get from place to place today?**
Waste 	Recycling and composting your waste can use less energy than throwing your waste out. Making something with recycled materials often uses less energy than using new materials.[12] **What did you do with your trash today?**
Water 	We use water for brushing our teeth, washing clothes and dishes, flushing toilets, and much more. It takes energy to pump, heat and clean the water that we use. **How did you use cold and warm water today?**
Other 	What else would you like to record about your energy use today?

Lesson 4

Where Does My Energy Come From?

The class brainstorms the different natural resources used to provide people with energy, then predicts which resources are renewable or nonrenewable. After reading nonfiction text about a particular energy source, small groups classify that source as renewable or nonrenewable and identify the impacts of using this energy source. Students then design an energy trading card and present what they have learned to the class.



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Objectives

Students will:

- Know the natural resources used to produce energy.
- Use information from nonfiction texts to describe an energy source and the positive and negative consequences of its use.
- Classify different energy resources as renewable or nonrenewable.
- Create icons and nicknames to represent an energy source.

Inquiry/Critical Thinking Questions

- Where does my energy come from?
- What is the difference between a renewable and a nonrenewable resource?
- What are the effects of using natural resources to supply our energy?
- How do different energy sources compare?

Time Required

60 minutes

Key Concepts

- **fossil fuel**—A nonrenewable energy source created when dead plants and animals are exposed to heat and pressure over millions of years.
- **natural resource**—Something from nature that people can use.
- **nonrenewable resource**—A limited resource, such as coal, natural gas, or oil, that cannot be replaced in a short amount of time.
- **renewable resource**—A resource, such as biomass, sunlight, water, or wind, that can be replaced quickly and naturally.
- **technology**—The use of scientific knowledge to create tools or solve problems.

Energy Literacy: Essential Principles and Fundamental Concepts for Energy Education

4.1 Humans transfer and transform energy from the environment into forms useful for human endeavors.

4.2 Human use of energy is subject to limits and constraints.

4.3 Fossil and biofuels are organic matter that contain energy captured from sunlight.

4.4 Humans transport energy from place to place.

4.5 Humans generate electricity in multiple ways.

4.6 Humans intentionally store energy for later use in a number of different ways.

4.7 Different sources of energy and the different ways energy can be transformed, transported, and stored each have different benefits and drawbacks.

6.4 Earth has limited energy resources.

7.3 Environmental quality is impacted by energy choices.

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U.S. Standards Correlation

- **State and national standards:** Visit our Standards Correlation Tool at www.facingthefuture.org/CurriculaFreeUnits/StandardsCorrelations

Materials/Preparation

- ☐ **Select nonfiction texts** you would like students to use to learn about different energy sources. Consider giving each group a couple of different readings about the same energy source for practice using multiple texts. The following websites provide some possible resources:
  - **Fact Sheets:** *Elementary Energy Infobook*
    The National Energy Education Development Project has created energy infobooks for different grade levels. You can download and print the energy sources you would like students to read about or let them read online: www.need.org/content.asp?contentid=197
  - **Website:** *Energy Kids*
    Students can use the U.S. Energy Information Administration's online resource to learn about different energy sources under the Energy Sources tab: www.eia.gov/kids/
- ☐ **Internet access and projector** to use one of the following websites to show students the resources used to produce energy in your region:
  - **Website:** *Power Profiler*
    This U.S. Environmental Protection Agency resource allows you to enter your zip code to learn about the fuel mix and resulting emissions for your region. http://oaspub.epa.gov/powpro/ept_pack.charts
  - **Website:** *U.S. States: State Profiles and Energy Estimates*
    This U.S. Energy Information Administration resource allows you to click on a particular state to access regional energy profiles. http://www.eia.gov/state/
- ☐ **Handout:** *Energy Investigation,* 1 per student
- ☐ **Handout:** *Energy Trading Card,* 1 per student

Optional

- ☐ **Internet access** for student research
- ☐ **Art materials** for creating an energy card

Background Information for Educators

Many natural resources are used to meet our demand for energy. Some of these energy sources, such as biomass, geothermal energy, sunlight, water, and wind, are renewable resources. Other energy sources—nonrenewable resources—have only a limited supply or can take millions of years to form. Nonrenewable energy sources include coal, natural gas,

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oil, and uranium. Some resources could be considered both renewable and nonrenewable, depending on how they are harvested, extracted, and regenerated. For instance, while trees can be replanted, it can take generations for a forest to have old-growth trees again, so old-growth trees may be considered nonrenewable.[1]

While we may use some natural resources directly to meet our energy needs (e.g. wind propelling a sailboat), we often use technology to change them into a more usable or convenient form of energy such as electricity or gasoline. Power plants, solar cells (photovoltaic cells), and wind turbines are some technologies we use to change these sources of energy into more usable forms.

Every energy source has environmental, social, and economic costs and benefits. For instance, renewable resources like the sun, wind, and water might pollute less than fossil fuels, but sunlight and wind can be less reliable than other forms of energy and cannot be stored for later use without additional technology. Knowing the pros and cons of each energy source can help us make more informed decisions about our energy production and consumption.

Activity

Introduction

1. Ask the class to name some ways that people use energy. *(Answers may include appliances and electronics, growing and cooking food, heating and cooling buildings, heating water, lighting, managing waste, and transportation.)*

   Option: If students completed Lesson 3, you could have them refer to their energy maps.

2. Ask students where they think the energy we use comes from.
3. Share with students that **natural resources** are used to supply us with energy.
4. Write the following definition on the board:
   - **natural resource**—Something from nature that people can use.
5. Write the following heading on the board:

   Natural Resource

6. In Think-Pair-Share, have students brainstorm a list of natural resources used to produce energy and write these on the board under the heading "Natural Resource." *(Answers include biomass (e.g. animal waste, switchgrass, wood), coal, geothermal (hot water or steam from Earth's crust), water, natural gas, uranium (for nuclear energy), petroleum (oil), the sun, and wind.)*

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Option: Show students pictures of energy technologies such as dams, power plants, solar panels, and wind turbines to help them brainstorm the different natural resources these technologies have been designed to use. Share with students that while some natural resources could be used directly as an energy source (such as wind pushing the sails of a boat), natural resources are often converted, or changed, into more usable forms of energy with technology.

7. Use one of the following resources to show students the fuel mix for your region and compare to the list on the board:
   - **Website:** *Power Profiler* http://oaspub.epa.gov/powpro/ept_pack.charts
   - **Website:** *U.S. States: State Profiles and Energy Estimates* http://www.eia.gov/state/

Steps

1. Share with students that today they will be working in small groups to learn more about a particular natural resource that is used to provide us with energy.
2. Tell students that some groups will be learning about renewable resources while other groups will be learning about nonrenewable resources.
3. Share the following definitions with students:
   - **nonrenewable resource**—A limited resource that cannot be replaced within a short amount of time.
   - **renewable resource**—A resource that can be replaced quickly and naturally.
4. Write the following heading on the board next to the heading Natural Resource:

   Natural Resource **NonRenewable or Renewable?**

5. Ask students to predict whether each natural energy resource listed on the board is renewable or nonrenewable and record their answers on the board.
6. Share the definition of fossil fuel with students and have them guess which 3 natural resources are fossil fuels. Circle their predictions on the board. *(Coal, natural gas, and petroleum (oil))*
   - **fossil fuel**—A nonrenewable energy source created when dead plants and animals are exposed to heat and pressure over millions of years.

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7. Divide the class into groups of 2–3.
8. Assign each group 1 of the following sources of energy: biomass, coal, geothermal, hydropower, natural gas, petroleum (oil), solar, uranium, or wind. Depending on your class size, you may have more than 1 group researching the same energy source.
9. Give each student a copy of the handout *Energy Investigation.*
10. Show students how to use the handout *Energy Investigation* to record information from their research, and how to then use this research to complete the handout *Energy Trading Card.*

    Option: Students can create their own energy trading cards using a computer or other art materials instead of the handout template.
11. Provide each group with the corresponding nonfiction texts or access to the Internet to conduct their research.
12. Give groups about 20 minutes to read their texts and complete the handout *Energy Investigation.*
13. Have each group check in with you after they finish the handout *Energy Investigation.* If the handout looks accurate and complete, give each student in the group the handout *Energy Trading Card,* to complete using the group's research.
14. When groups are finished, bring the class back together so groups can share their research with the rest of the class. Consider having groups share everything about their energy source except whether it is renewable or nonrenewable. Students that are in the audience can then return to the predictions they made about whether the energy source is renewable or nonrenewable and either confirm or revise their prediction. The group that is presenting can then reveal the correct classification. *(Answers include:)*

Natural Resource	Nonrenewable or Renewable?
Biomass	Renewable
Coal	Nonrenewable
Geothermal	Renewable
Hydropower	Renewable
Natural gas	Nonrenewable
Petroleum (oil)	Nonrenewable
Solar	Renewable
Uranium (nuclear)	Nonrenewable
Wind	Renewable

15. Remind students of the predictions they made about fossil fuels. Reveal to the class that coal, natural gas, and petroleum (oil) are all fossil fuels.
16. Conclude this activity with the following discussion questions.

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Discussion Questions

1. How are renewable resources different from nonrenewable resources? How are they similar?
2. How can energy use impact the environment?
3. Which energy sources would you want used in your community? Why?
4. Why might we want to save or conserve energy?
5. Do most people know where their energy comes from? Do you think it is important for people to know? Why or why not?
6. How might the location or geography of a community affect which natural resources are used to produce energy?
7. Other than solar energy, how does the sun play a role in sources of energy? *(Answers may include: trees require solar energy to grow, millions of years ago plants that eventually were transformed into coal, natural gas, and oil absorbed sunlight, and sunlight heats Earth unevenly creating wind.)*
8. How does the law of conservation of energy apply to energy production?

Lesson Extensions

Geography Extension

Does where you live influence the sources of energy you use? Ask students how geography might affect the resources that are used for energy production. Invite students to predict which energy sources they think are used to generate energy in your state or region and to explain why. Then show your class the actual energy sources using one of the resources listed below. Have small groups use an online map to select the type of energy source they need to observe and to create a map showing the actual distribution of resources in your region/state. Be sure that students include a map key and labels where appropriate. Have groups present their maps when finished. Conclude with a class discussion or an essay that invites students to make a claim about the influence of geography the type of energy sources a region uses. The following resources may be helpful for students:

- **Graphic:** *Visualizing the U.S. Electric Grid* This graphic created by National Public Radio is an interactive map of the United States that shows major transmission lines, the percentages of different sources of power used in different states, solar and wind power transmission lines, and the location of different power plants: **www.npr.org/templates/story/story.php?storyId=110997398**

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- **Website:** *Clean Energy*
  This U.S. Environmental Protection Agency website allows you to enter your zip code to learn about the fuel mix used to generate electricity in your region and compares this to the national fuel mix: http://oaspub.epa.gov/powpro/ept_pack.charts
- **Online Maps:**
  U.S. Energy Information Administration:
  The U.S. Energy Information Administration provides state energy profiles which include information about consumption by source and sector, production, electricity, and price. www.eia.gov/state

  National Energy Education Development Project (NEED):
  These U.S. Energy Geography maps are interactive and show where different energy resources are located. www.need.org/maps

  National Renewable Energy Laboratory:
  This website has many different interactive tools that provide information about renewable energy data and technologies deployed around the United States. www.nrel.gov/tech_deployment/tools.html

Graphic Design Extension

Have students create a digital version of their energy trading card and print it. In small groups, have students design a trading game that uses what they have learned about natural resources and nonrenewable/renewable energy sources. Small groups should write up and turn in the rules and goals of this game. You can select the best game for students to play during the next class. The following resource could be used for students to create digital versions of their energy cards:

- **Interactive:** *Trading Card Creator*
  ReadWriteThink's Trading Card Creator provides a template for students to use to design a trading card with an uploaded image: www.readwritethink.org/classroom-resources/student-interactives/trading-card-creator-30056.html

Additional Resources

- **Interactive Mapping Tools:** *MapMaker Interactive*
  National Geographic Education has many accessible interactive mapping tools that allow students to manipulate layers and draw onto maps that can be saved or printed: http://education.nationalgeographic.com/education/mapping
- **Website:** *The Children's University of Manchester*
  This website provides a brief overview of renewable and nonrenewable resources and a variety of related interactive activities: www.childrensuniversity.manchester.ac.uk/interactives/science/energy/renewable

Name Date

Energy Investigation, page 1

Directions: Use the information from your research to answer the questions below.

1. Natural Resource:

Describe how this energy source is formed or created. You may use sketches or drawings to help you.

2. Renewable or Nonrenewable

Circle the word below that best describes your energy source.

Renewable or **Nonrenewable**

Write a fact to show why your energy source is renewable or nonrenewable.

Write a fact to show why your energy source is renewable or nonrenewable.

Name Date

Energy Investigation, page 2

Directions: Use the information from your research to answer the questions below.

3. Energy Source
Describe how humans use this natural resource as a source of energy. You may use sketches or drawings to help you.

4. Impacts
List 2–3 effects or consequences of using this source of energy.

5. Fun Facts
Describe 2 interesting things you learned about this natural resource.

6. Sources
List the sources you used for research.

Name Date

Energy Trading Card

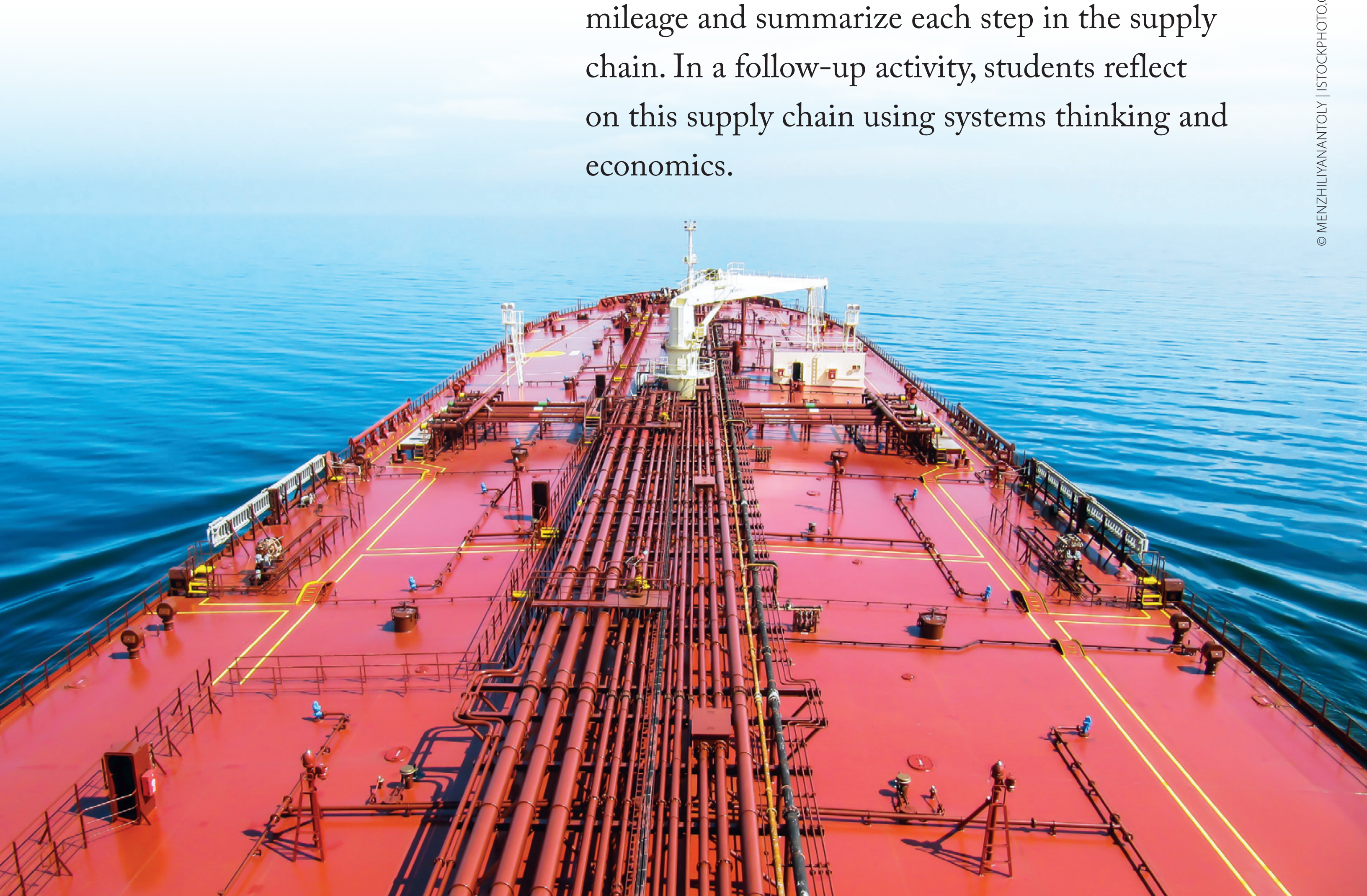
Directions: Use the information gathered during your research to create a trading card that represents your source of energy.

Natural Resource:	**Nickname:**
Drawing/Image that represents this energy source:	
Advantages:	Disadvantages:
How does this natural resource compare to other natural resources as a source of energy? You can use a ranking system or an explanation to answer.	

Lesson 5

Oil Takes a Trip

Working backward from a gas pump, students brainstorm the steps involved in producing gasoline, including the formation of crude oil and the steps in the gasoline supply chain. Students move through the supply chain from oil wells around the world to gas stations in the United States. Along the way, they track their mileage and summarize each step in the supply chain. In a follow-up activity, students reflect on this supply chain using systems thinking and economics.



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Objectives

Students will:

- Move through different stations to learn about the steps of a gasoline supply chain.
- Understand that crude oil is found in and traded between different areas around the world.
- Summarize each step of the gasoline supply chain.
- Calculate the total number of miles a petroleum product may travel in a supply chain.
- Analyze the supply chain using systems thinking and economics.

Inquiry/Critical Thinking Questions

- Where does my gasoline come from?
- How are petroleum products transported from place to place?
- How does energy flow throughout a system?
- What are the impacts of the fuel supply chain?

Time Required

Activity 1: 80 minutes
Activity 2: 60 minutes

Key Concepts

- **consumption**—The process of using natural resources or manufactured products to satisfy human wants and needs.
- **crude oil**—A liquid fossil fuel found deep within the Earth; the raw material for petroleum products such as gasoline and plastics.
- **economy**—The system of production, distribution, and consumption of goods and services.
- **export**—To send a product or service to another country to be sold.
- **fossil fuel**—A nonrenewable energy source created when dead plants and animals are exposed to heat and pressure over millions of years.
- **import**—To bring a product or service into a country to be sold.
- **supply and demand**—The amount of a product that is available (supply) and the amount of a product that is wanted by customers (demand).
- **supply chain**—All the steps, resources, people, and businesses it takes to get a product or service from supplier to customer.
- **system**—A collection of many interconnected parts that work together; changing one part affects other parts.
- **transportation**—The carrying of people, animals, or goods from one place to another.

Supporting Vocabulary

These definitions are provided to help expand class discussions and provide additional background information for you and your class. Not all of these vocabulary words are used explicitly in this lesson.

- **co-product**—A useful product that is made in a step required for the manufacture of another product.

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- **extraction**—The process of obtaining natural resources from the land or the oceans.
- **infrastructure**—The basic facilities, services, and installations needed for the functioning of a community or society, such as transportation and communication systems, roads, water, power lines, and public institutions such as schools, post offices, and libraries.
- **natural resource**—Something from nature that people can use.
- **nonrenewable resource**—A limited resource, such as coal, natural gas, or oil, that cannot be replaced in a short amount of time.
- **renewable resource**—A resource, such as biomass, sunlight, water, or wind, that can be replaced quickly and naturally.

Energy Literacy: Essential Principles and Fundamental Concepts for Energy Education

4.1 Humans transfer and transform energy from the environment into forms useful for human endeavors.

4.2 Human use of energy is subject to limits and constraints.

4.3 Fossil and biofuels are organic matter that contain energy captured from sunlight.

4.4 Humans transport energy from place to place.

4.6 Humans intentionally store energy for later use in a number of different ways.

4.7 Different sources of energy and the different ways energy can be transformed, transported, and stored each have different benefits and drawbacks.

5.2 Energy infrastructure has inertia.

6.4 Earth has limited energy resources.

6.7 Products and services carry with them embedded energy.

7.4 Increasing demand for and limited supplies of fossil fuels affects quality of life.

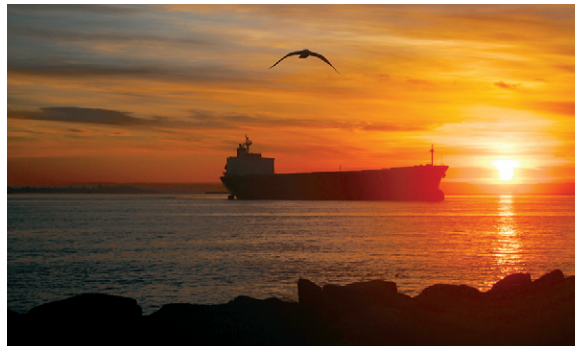
U.S. Standards Correlation

- **State and national standards:** Visit our Standards Correlation Tool at www.facingthefuture.org/CurriculaFreeUnits/StandardsCorrelations

Materials/Preparation

Activity 1

- ☐ **Display Copy:** *The Supply Chain of Gasoline*
- ☐ **Display a large world map** for the class to view.
- ☐ **Obtain string or markers** to trace the journey of crude oil on the world map.
- ☐ **Handout:** *The Supply Chain of Fuel,* 1 per student or student pair
- ☐ **Cards:** *Step 1: Oil Well,*[1] 1 per student, distributed randomly among your students. There are 9 different Oil Well cards; make enough copies so that each student in your class receives one.
- ☐ **Cards:** *Step 2: Refinery,*[2] 4-6 copies of each region. **Note:** The number of copies needed for each region will depend on your class size



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and how your students will be traveling through the stations (e.g., individually, in partners, or as a small group). Ideally, there will be enough *Refinery* cards at each station for students to read comfortably at their own pace.

- ☐ **Cards:** *Step 3: Storage Terminal,*[3] 4-6 copies of each region. **Note:** The number of copies needed for each region will depend on your class size and how your students will be traveling through the stations (e.g., individually, in partners, or as a small group). Ideally, there will be enough *Storage Terminal* cards at each station for students to read comfortably at their own pace.
- ☐ **Cards:** *Step 4: Gas Station,* 20-30 copies. **Note:** The number of copies needed for each region will depend on your class size and how your students will be traveling through the stations (e.g., individually, in partners, or as a small group). Ideally, there will be enough *Gas Station* cards at each station for students to read comfortably at their own pace.
- ☐ **Create 5 signs:** East Coast, Gulf Coast, Midwest, Rocky Mountains, and West Coast.
- ☐ **Stations:** Post each of the 5 signs described above around the room or on tables where students can work in groups. Place *Step 2: Refinery, Step 3: Storage Terminal,* and *Step 4: Gas Station* cards at each station. Note that the cards vary by geographic region and should be placed at the corresponding station:

Station:	**East Coast**	**Gulf Coast**	**Midwest**	**Rocky Mtn Region**	**West Coast**
Cards:	*Refinery on the East Coast* (4-6 copies)	*Refinery on the Gulf Coast* (4-6 copies)	*Refinery in the Midwest* (4-6 copies)	*Refinery in the Rocky Mountain Region* (4-6 copies)	*Refinery on the West Coast* (4-6 copies)
	Storage Terminal on the East Coast (4-6 copies)	*Storage Terminal on the Gulf Coast* (4-6 copies)	*Storage Terminal in the Midwest* (4-6 copies)	*Storage Terminal in the Rocky Mountain Region* (4-6 copies)	*Storage Terminal on the West Coast* (4-6 copies)
	Gas Station (4-6 copies)	*Gas Station* (4-6 copies)	*Gas Station* (4-6 copies)	*Gas Station* (4-6 copies)	*Gas Station* (4-6 copies)

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Options

- **Set up the 5 stations to geographically represent** the 5 different regions of the U.S. if you can move to a spacious location such as a gym or large classroom. Then, within each region, spread out the Step 2: *Refinery, Step 3: Storage Terminal,* and *Step 4: Gas Station* cards so students can physically move from step to step to mimic the real supply chain.
- Provide a computer at each station, cued to videos to show the different steps of the supply chain or other resources that might be helpful. Possible resources include:
    - **Animation:** *Petroleum Products Batching*
      This animation shows how different petroleum products move through the same pipelines in batches and could provide a nice visual for the *Step 2: Refinery* cards:
      www.pipeline101.com/how-do-pipelines-work/what-is-batching
    - **Interactive Website:** *Adventures in Energy*
      This interactive website uses animations and sound to demonstrate the different steps of oil production from exploration and production to pump. The American Petroleum Institute created this interactive website: www.adventuresinenergy.org
    - **Model:** *Oil and Water*
      Pour oil and water into a plastic bottle and close it with a lid. This model can serve as an analogy for the way different chemicals in crude oil have different properties and can be separated out at a refinery.
    - **Model:** *A Container Measuring 1 Gallon*
      Place a container such as a milk jug that measures 1 gallon so students can have a visual of this unit of measurement when they read the *Step 3: Terminal Storage* cards. This can help students understand how big a 10,000 gallon tanker truck is.

Activity 2

☐ **Display Copy:** *The Supply Chain of Gasoline*

☐ **Handout:** *Supply and Demand,* 1 per student

Background Information for Educators

Oil has been the primary source of energy for the world in the 21st century.[4] Crude oil is a liquid fossil fuel found underground in many different regions around the world. It takes millions of years to form and, therefore, is classified as a nonrenewable resource. Oil is formed when dead plants and animals are exposed to heat and pressure over millions of years. The result is an energy dense hydrocarbon (a compound of hydrogen and carbon) that, when burned, releases carbon dioxide, carbon monoxide, and other pollutants that are harmful to the environment and to human health.[5]

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In 2013, almost three quarters of the oil used in the U.S. was for transportation.[6] Yet, before crude oil can be used in the tanks of our cars, trucks, and jets, it travels through a complicated supply chain and often across national borders. A supply chain includes all the steps, resources, people, and businesses it takes to get a product or service from supplier to customer.

In this lesson, students trace a simplified fuel supply chain from an oil well to a refinery, a storage terminal, and a gas station. During production, oil is extracted from the ground then transported to a refinery. At refineries, oil is separated into different petroleum products. Most of these products end up as fuel such as gasoline and diesel. Petroleum products are also used to produce plastics, medical equipment, crayons, and other everyday goods.[7] Fuel is then stored at storage terminals before it goes to a gas station. At each step of the supply chain, as well as for transport between steps, a significant amount of energy and other resources are used. To truly understand and evaluate the sustainability of gasoline, it is important to understand and consider the entire supply chain.

Activity 1

Introduction

1. Share with students the following definition of **transportation** and give students a few seconds to brainstorm different types of transportation. *(Answers may include bicycles, boats, buses, cars, hot air balloons, trains, trucks, etc.)*
    - **transportation**—The carrying of people, animals, or goods from one place to another.
2. Have students identify what common element is required to move these people, cars, and animals. *(Energy.)*
3. Ask students where they would get the energy required to power a car or truck. *(For most cars and trucks, a gas station; all-electric vehicles require recharging stations, however.)*
4. Show students a picture of a gas pump or a gas station and have them make a sketch of this on the right side of a piece of paper.
5. Ask students to raise their hands if they know where this gasoline comes from or how it is made.
6. Have students work backwards from the gas pump or station, sketching the different steps they think are involved in making gasoline. Assure students that this sketch is a brainstorm and encourage them to make guesses.

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7. As students draw, circulate around the room to get a sense of students' prior knowledge about the supply chain of fuel.
8. In Think-Pair-Share format, have students explain their sketches and discuss which parts of this path were most difficult to imagine.
9. Project the display copy *The Supply Chain of Gasoline* and have students compare it with their sketch.
10. Tell students that these steps represent the supply chain of gasoline.
11. Have a student read aloud the definition of **supply chain**.
    - **supply chain**—All the steps, resources, people, and businesses it takes to get a product or service from supplier to customer.
12. In Think-Pair-Share format, ask students why they think the phrase "supply chain" is used to describe this process.

Steps

1. Tell students that today they are going to learn more about the steps of this supply chain, and they will start by learning about the natural resource that is used to produce gasoline.
2. Read each one of the following statements and have students give you a thumbs up (yes/true) or thumbs down (no/false) in response. Share the information in italics and the definitions before moving on to the next statement.
    - I know what natural resource gasoline is made from. *(Gasoline is made from crude oil, which is often called petroleum.)*
        - **crude oil**—A liquid fossil fuel found deep within the Earth; the raw material for petroleum products such as gasoline and plastics.[8]
    - True or false: crude oil or petroleum is a renewable resource. *(False; crude oil is a nonrenewable resource.)*
    - True or false: crude oil or petroleum is a fossil fuel. *(True; crude oil is a fossil fuel.)*
    - True or false: fossil fuels take about 100 years to form. *(False; it takes millions of years for fossil fuels to form!)*
        - **fossil fuel**—A nonrenewable energy source created when dead plants and animals are exposed to heat and pressure over millions of years.

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Option: Use 1 or more of the following resources to help students learn about the formation of crude oil.

- **Image:** *Petroleum and natural gas formation* This image from the U.S. Energy Information Administration shows how oil and gas were formed over millions of years: www.eia.gov/energyexplained/images/OILGASFORMATION.gif
- **Video:** *Oil and Gas Formation* This 3-minute video supported by Woodside and Earth Science Western Australia gives a fast-paced explanation of how oil and gas are formed: www.youtube.com/watch?v=8YHsxXEVB1M
- **Video:** *Fossil Fuel Formation* This 9-minute video thoroughly explains the conditions necessary for fossil fuel formation: www.youtube.com/watch?v=pvH-h7TzSsE

3. Display the world map for the class to see and explain that crude oil is a natural resource found in many—but not all—places around the world.

Option: Invite a student to locate your state or province on the map and place a pin or other marker on this location.

4. Share with students that in 2013 about 50% of the crude oil processed in U.S. refineries was from the United States and the rest was imported.[9] Tell them that for today's activity, students will begin their supply chain in a country other than the United States. For statistics on oil production and consumption in other countries, see: www.eia.gov/countries

Option: Share the following definition with students:

- **import**—To bring a product or service into a country to be sold.

5. Refer back to the display copy *The Supply Chain of Gasoline.*

6. Give each student a copy of the handout *The Supply Chain of Fuel* and ask students to review both sides of the handout. If desired, the following questions could be used to guide a class discussion about the elements of the graphic on the handout:

- Which part(s) of this graphic represents movement? *(The arrows.)*
- Which part(s) of this graphic represents one step? *(The boxes.)*
- What is the first step of this supply chain? *(Oil well.)*
- How do you know? *(The number 1 is written by the heading and there is no arrow to the left of this step.)*

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- After which step do things move in 2 different directions? *(After Step 2: Refinery.)*
- How do you know? *(There are 2 arrows leaving the Refinery box.)*
- What is the final step in this supply chain? *(The final step is Step 4: Gas Station.)*
- How do you know? *(There are no arrows leaving this step.)*
- What products or objects do you think move from each step to the next?

7. Hand each student an *Oil Well* card and give them a few minutes to read their card to find out where in the world their oil supply chain begins. There are nine different *Oil Well* cards, representing different regions of the world.

8. Point out (or have a student point out) Angola on the map and invite students who begin their oil supply chain in Angola to raise their hands. Place a pin or other marker on this country.

9. Share with students the following definitions and ask students which country is importing crude oil and which country is exporting crude oil. *(Angola is exporting crude oil to the US, and the U.S. is importing crude oil from Angola.)*

- **export**—To send a product or service to another country to be sold.
- **import**—To bring a product or service into a country to be sold.

10. Repeat steps 8 and 9 for the other regions mentioned on the Oil Well cards (Canada [1], Canada [2], Ecuador, Iraq, Mexico, Nigeria, Saudi Arabia, and Venezuela).

Option: Share with students that oil is found in many other places in the world, not just the countries they will study today.

11. Have students reread their *Oil Well* card to themselves.

12. As a class, write a 1–2 sentence summary of what happens during this step. Record this summary on the board. *(Scientists find oil. Then a hole is drilled and a well is made. Oil is pushed out of the ground by pressure.)* **Note:** You may wish to point out that the reading includes more than just information about oil production, so students should identify which information should be included and which should not.

13. Have each student record the class summary in the first box on their handouts, "Step 1," and explain that they will be writing their own summaries for Steps 2–4.

14. Invite students to refer to their handouts and ask them where the crude oil will go next. *(To a refinery.)*

15. Share with students that while oil refineries are found in many places around the world, today all students will follow their supply chain to an oil refinery in the United States.

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16. Invite a student whose supply chain begins in Angola up to the map.

17. Have this student trace the path crude oil might travel to get to East Coast of the United States, first with a finger, then with a marker or string. Have the student read from his or her card the type of transportation used to transport this crude oil. *(Oil tankers or barges.)*

18. Repeat this process with students from each of the following countries listed. *(Answers follow below.)*

Angola → East Coast
(Tankers or barges.)

Canada [1] → Midwest
(Rail or pipelines.)

Canada [2] → Rocky Mountain Region
(Pipelines.)

Ecuador → West Coast
(Tankers or barges.)

Iraq → West Coast
(Tankers or barges.)

Mexico → Gulf Coast
(Tankers or barges.)

Nigeria → East Coast
(Tankers or barges.)

Saudi Arabia → Midwest
(Tankers or barges, and probably also pipelines.)

Venezuela → Gulf Coast
(Tankers or barges.)

19. Ask students why different types of transportation might be used to move crude oil.

20. Have students record both the distance crude oil traveled and the type of transportation used to transport crude oil from Step 1 to Step 2 in the first arrow on their handout *The Supply Chain of Fuel*. Remind students to include units (miles or kilometers).

21. Point out the signs posted around the room representing different regions of the United States. Share with students that they will learn more about the next steps of the supply chain at these stations.

22. Point out the 3 different sets of cards, *Step 2: Refinery, Step 3: Storage Terminal,* and *Step 4: Gas Station* at each station. Tell students they will get the information they need about each step from the cards. Remind them to return their card to the appropriate pile once they have completed the corresponding step before moving on to take a card from the next step.

    Note: If you have added additional resources at the stations, point these out now.

23. Tell students how you would like them to proceed through each step (individually, in partners, or as a small group).

24. Instruct students to move with their handout *The Supply Chain of Fuel* to the station representing the U.S. region on their *Oil Well* card.

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25. Monitor student work and provide guidance as needed.
26. Once students have completed their handout, list the following countries on the board: Angola, Canada [1], Canada [2], Ecuador, Iraq, Mexico, Nigeria, Saudi Arabia, and Venezuela.
27. Invite students to come to the board to write the total distance they traveled next to the country in which they began. **Note:** More than 1 student will write a distance listed next to each country. Students can check their math against the peers who began in the same country.

    Option: As a math extension, draw a scaled bar graph or a line plot to represent the total distance traveled from each oil well to a gas station. Another option is to have students convert the number of miles traveled into feet or kilometers into meters.
28. Analyze the activity using the following questions:
    - Between which 2 steps did you travel the farthest? Why do you think this is?
    - Between which 2 steps did you travel the shortest distance? Why do you think this is?
    - What types of transportation were used to move oil and petroleum products? How is energy required for these different types of transportation?
    - Did the maps help you better understand the supply chain of fuel? How did they or how didn't they?
    - What might be some consequences of transporting oil and petroleum products over thousands of miles?
29. Conclude this activity with the following discussion questions.

Discussion Questions

1. How did learning about the steps in the supply chain of fuel change your thinking about gasoline?
2. How does geography impact the way oil and petroleum products are transported?
3. What are some of the pros and cons of the different types of transportation used to move oil and petroleum products?
4. How is the United States dependent on other countries for gasoline?
5. How is energy used to produce gasoline?
6. What might be some of the impacts of having a long-distance supply chain versus a short-distance supply chain?
7. When you consider how crude oil is formed, what is the original source of energy in this supply chain? *(The sunlight that plants used to make food millions of years ago.)*
8. How would your life be different if this supply chain did not exist?
9. What are some other products you use that might be produced by a supply chain?

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Activity 2

Introduction

1. Project the display copy *The Supply Chain of Gasoline.*
2. In Think-Pair-Share, have students answer the following questions:
   - How do the words or phrases "consumption," "economy," "supply and demand," and "supply chain" relate to the diagram?
   - How are the words or phrases "consumption," "economy," "supply and demand," and "supply chain" related to each other?
   - What human need or want is met with this supply chain?

Steps

1. Tell students that they will review and analyze the steps of this supply chain by acting out some scenarios.
2. Divide students into groups of 5. Assign each student in the group a different element of the supply chain, or let students choose. There are four locations in the chain—oil well, refinery, storage terminal, and gas station—and a fifth element, transportation. The person representing transportation is the only person that can move from one place to another.
3. Give each group 3 minutes to come up with a silent action or mime for each step. For example, students representing storage terminals may pretend to add ingredients to a bowl and stir them together just as additives are blended together with fuel at storage terminals.
4. When time is up, have students line up in their respective supply chains, leaving space for the person representing transportation to take the product from 1 step to the next.

   Option: Give students at the oil wells some object (e.g., a ball) to represent their product and have students pass this "product" down the supply chain.
5. Once groups are ready, have the groups act out their supply chain.
6. Now tell students that there have been some changes in the oil market and students will need to modify their performance to reflect to this change in the oil market.
7. Read each of the following scenarios and assign each scenario to a group. Depending on your class size, some scenarios will be used by multiple groups.
   - The refinery's machines have broken.
   - The storage terminals are full.
   - Customer demand for gasoline has increased.
   - Customer demand for gasoline has decreased.

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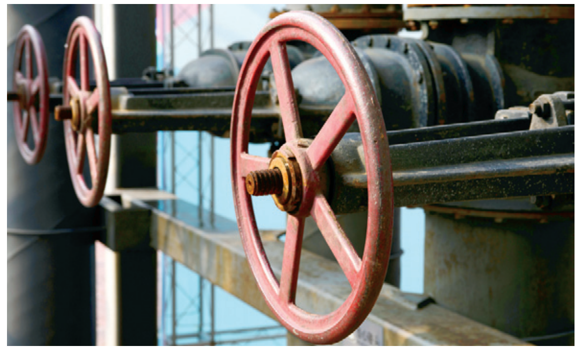
- Less oil is being extracted.
- The government has required that fuel be made from biofuels, such as wood or algae, instead of crude oil.

Option: Instead of changing their performance, groups could simply identify the step(s) in the supply chain that would most likely be affected as a result of these changes.

5. Give groups 1-2 minutes to modify their performance.
6. Invite each group to act out their scenario.
7. After the last performance, ask students to return to their seats.
8. Write the following definition for **system** on the board:
   - **system**—A collection of many interconnected parts that work together; changing one part affects other parts.
9. Ask students to identify other kinds of systems. *(Answers could include food chains, Rube Goldberg machines, and the human nervous system.)*
10. As a class, reflect on this activity using the display copy *The Supply Chain of Gasoline* and 1 or more of the following questions:
    - What are the different parts of the supply chain of gasoline?
    - Though the arrows of a supply chain are pointed in 1 direction, how do steps later in the process (this is also called downstream) affect the earlier steps? For example, what would happen if customers suddenly no longer bought gasoline?
    - What are the boundaries of this supply chain? What things flow into and out of these boundaries?
    - What might be some smaller systems within the big system of a fuel supply chain?
    - How does a supply chain of fuel compare to a food chain or a Rube Goldberg machine?
11. Give each student the handout *Supply and Demand.*
12. Review the directions and instruct students to complete this during class or assign it as homework.
13. Conclude this activity with the following discussion questions.

Discussion Questions

1. How is the supply chain of gasoline an example of a system? What role(s) do you play in this system?
2. How do the different steps of this supply chain interact with each other?
3. What are the different resources used to produce gasoline?



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4. How might the supply chain of fuel impact the world? Why is it important to think about the entire supply chain of a product when you want to know its impact?
5. How do people who buy gasoline play a role in the supply chain of fuel?
6. How do you use gasoline and petroleum products? Do you see reason to reduce your use of gasoline and petroleum products? Why or why not?
7. Do you think most people know where their gas comes from? Why or why not?
8. How could the nonrenewable nature of oil affect the supply chain of gasoline or the price of gasoline?
9. Do you think people should take into consideration the length of time it takes crude oil to form when they extract it or when they use gasoline? Why or why not?

Lesson Extensions

Science Extension

Have small groups research different types of biofuels and create a poster showing the supply chain for that biofuel. Students can then compare the supply chain of petroleum-based fuel with biofuels.

Scale and Measurement Extension

Have students compare the time it takes to form fossil fuels with the time it takes to form different types of biomass. Divide the class into small groups and assign each group either a fossil fuel such as coal, oil, or gas, or a type of biomass such as such as algae, trees, or corn. Have them conduct research and create a timeline to represent the length of time it takes their feedstock to form on a long strip of paper such as receipt paper. Discuss the how to compare the units of measure each group chooses.

Pie Graph Extension

Ask students to estimate the percentage of their energy use that is related to transportation. Share with students that about 28 percent of the energy used in the U.S. is for transportation, and have them think of a benchmark fraction that is close to this percentage. Display for students the following pie graph from the U.S. Energy information Administration:[10]

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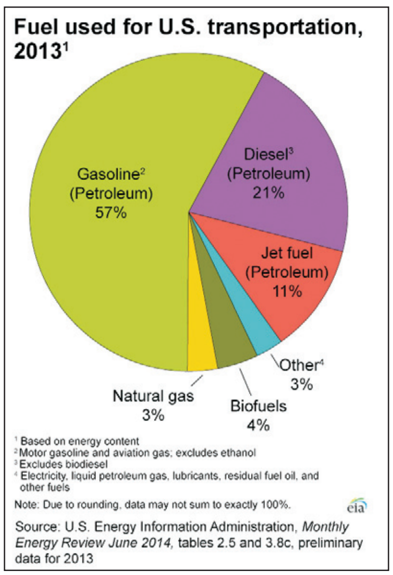
- **Graph:** *Fuel used for U.S. transportation, 2013*
http://www.eia.gov/energyexplained/index.cfm?page=us_energy_transportation



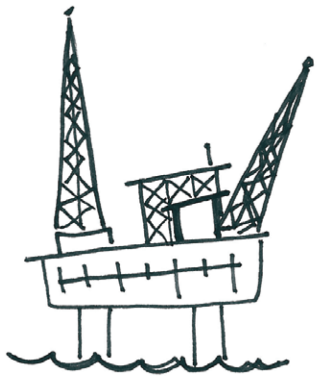
Help students examine the graph by asking the following questions:

- How do pie graphs represent information? *(Pie graphs show parts of a whole.)*
- What does the entire graph represent? *(The total amount of energy used for transportation.)*
- What do the pieces of the pie represent? *(Different types of fuel.)*
- Would a bar graph be an effective way to show this information? Why or why not?
- Which type of fuel is used most? *(Gasoline.)*
- Why is the word petroleum written after several different types of fuels?

Additional Resources

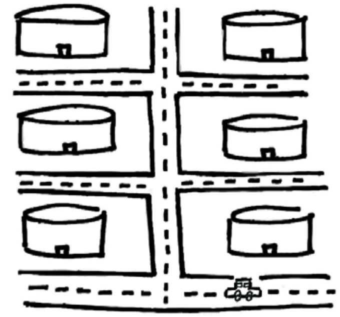
- **Picture Book:** *An Orange in January*
This book by Dianna Hutts Aston and Julie Maren leads the reader through the journey that an orange takes from tree to a school lunch. It could be used to expand the conversation about supply chains to products such as food.
- **Website:** *Learning About Fossil Fuels—For Younger Students*
The Office of Fossil Energy provides study guides and classroom activities to help students learn about fossil fuels and their importance in our everyday lives: www.fossil.energy.gov/education/energylessons/index.html
- **Website:** *International Energy Portal*
This U.S. Energy Information Administration resource provides interactive visuals of international energy statistics and rankings such as energy production and consumption: http://www.eia.gov/beta/international/
- **Video:** *Energy Literacy Essential Principle 4*
This U.S. Department of Energy video has several pictures of the different types of transportation used to move energy from one place to the next including pipelines, barges, and rail.
https://www.youtube.com/watch?v=7CU9iqm2Hcw&list=PLgU0cHea5t3omiamgQK70Ff7vCsbP5QF&index=5

The Supply Chain of Gasoline

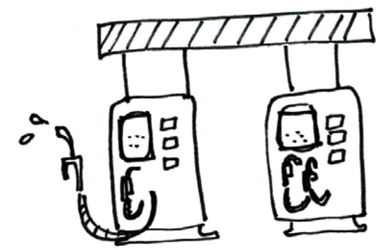


Oil Well →

Refinery →



Terminals →



Gas Station

Consumption
The process of using natural resources or manufactured products to satisfy human wants and needs.

Economy
The system of production, distribution, and consumption of goods and services.

Supply and Demand
The amount of a product that is available (supply) and the amount of a product that is wanted by customers (demand).

Supply Chain
All the steps, resources, people, and businesses it takes to get a product or service from supplier to customer.

Name _______________ Date _______________

The Supply Chain of Fuel, page 1

Directions: In each box, summarize the activities that take place during each step of the supply chain. Then, inside each arrow, write the type of transportation used to get from one step to the next and how far you traveled in miles or kilometers. Finally, answer the questions that follow.

1. Oil Well

Type of Transportation:

Distance Travelled:

2. Refinery

Type of Transportation:

Distance Travelled:

Factory for Co-products

Some of the products of crude oil do not become fuel. These products are sent to factories where they are turned into things like chemicals, plastics, crayons, and medicines.[11]

Name Date

The Supply Chain of Fuel, page 2

3. Storage Terminal

Type of Transportation:

Distance Travelled:

4. Gas Station

1. Calculate the total number of miles you traveled from the oil well (Step 1) to the gas station (Step 4).

2. Between which two steps did you travel the longest distance? Why do you think this is?

3. Between which two steps did you travel the shortest distance? Why do you think this is?

4. What might be some consequences of transporting natural resources and products over thousands of miles?

The Supply Chain of Fuel, Answer Key

Angola → East Coast
Arrow 1: 6869 mi; 11,054 km (Ship)
Arrow 2: 68 mi; 109 km (Pipelines)
Arrow 3: 5 mi; 8 km (Truck)
TOTAL: 6942 mi; 11,171 km

Canada [1] → Midwest
Arrow 1: 1409 mi; 2268 km (Trains and pipelines)
Arrow 2: 5 mi; 8 km (Pipelines)
Arrow 3: 25 mi; 40 km (Truck)
TOTAL: 1934 mi; 2316 km

Canada [2] → Rocky Mountain Region
Arrow 1: 937 mi; 1508 km (Pipelines)
Arrow 2: 114 mi; 183 km (Pipelines)
Arrow 3: 50 mi; 80 km (Truck)
TOTAL: 1101 mi; 1771 km

Ecuador → West Coast
Arrow 1: 3592 mi; 5781 km (ship)
Arrow 2: 0 mi; 0 km (Refinery and storage are on same site)
Arrow 3: 5 mi; 8 km (Truck)
TOTAL: 3597 mi; 5789 km

Iraq → West Coast
Arrow 1: 7650 mi; 12,311 km (Ship)
Arrow 2: 0 mi; 0 km (Refinery and storage are on same site)
Arrow 3: 5 mi; 8 km (Truck)
TOTAL: 7655 mi; 12,319 km

Mexico → Gulf Coast
Arrow 1: 683 mi; 1099 km (Ship)
Arrow 2: 6 mi; 10 km (Pipelines)
Arrow 3: 6 mi; 10 km (Truck)
TOTAL: 695 mi; 1119 km

Nigeria → East Coast
Arrow 1: 5488 mi; 8832 km (Ship)
Arrow 2: 68 mi; 109 km (Pipelines)
Arrow 3: 5 mi; 8 km (Truck)
TOTAL: 5561 mi; 8949 km

Saudi Arabia → Midwest
Arrow 1: 6982 mi; 11,236 km (Ship and pipelines)
Arrow 2: 5 mi; 8 km (Pipelines)
Arrow 3: 25 mi; 40 km (Truck)
TOTAL: 7012 mi; 11,284 km

Venezuela → Gulf Coast
Arrow 1: 2404 mi; 3869 km (Ship)
Arrow 2: 6 mi; 10 km (Pipelines)
Arrow 3: : 6 mi; 10 km (Truck)
TOTAL: 2416 mi; 3889 km

1. Oil Well—Sample Summary
Scientists find oil. Then a hole is drilled and a well is made. Oil is pushed out of the ground by pressure.

2. Refinery—Sample Summary
The different chemicals in oil are separated. Then the chemicals are made into products like fuel, ink, and plastics.

3. Storage Terminal—Sample Summary
Gasoline is mixed with chemicals and biofuels. Then it is stored until gas stations need it.

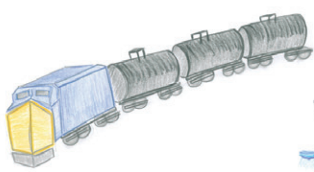
4. Gas Station—Sample Summary
Gasoline is stored underground. Pumps move the gasoline to a car or truck's gas tank. The gasoline is burned in the engine. This helps the car move and causes pollution.

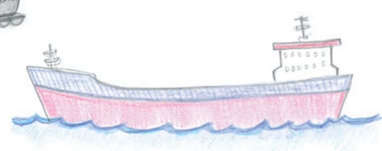
Step 1: Oil Well in Angola

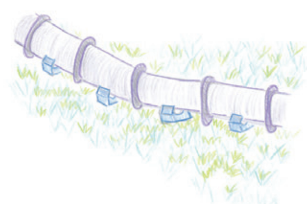
Extracting, or removing, oil from the ground is the first step in this supply chain. First, scientists and engineers find out where oil is located. Then they drill a hole and make a well. Pressure may push oil out of the ground. Chemicals, gas, or steam can also be put down the well to push oil out of the ground.[12] After oil is produced, it is taken to a refinery. Pipelines, ships, trains, and trucks can transport oil. The oil from your well will travel to Pennsylvania.

You begin at an oil well in Angola. Angola is a country in Africa. It is on the coast of the Atlantic Ocean. One of its natural resources is oil. Angola exports a lot of oil to the United States of America, China, the European Union, and India.[13]

Pennsylvania is a state on the East Coast of the United States. It will travel about 6,869 miles, or 11,054 kilometers. Can you guess how oil is transported from Angola to the East Coast?







If you guessed by ship, then you are correct! Most crude oil imported from other countries is shipped over water to United States ports.[14] Oil tankers and barges are large ships that carry crude oil. Some oil tankers can carry 320,000 barrels of gasoline! It would take 552 rail cars, or 1,728 trucks to carry this many barrels of gasoline.[15]

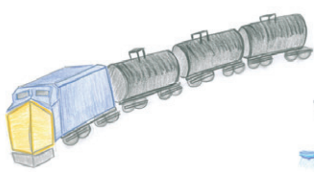
The World

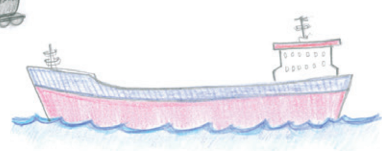
Step 1: Oil Well in Canada (1)

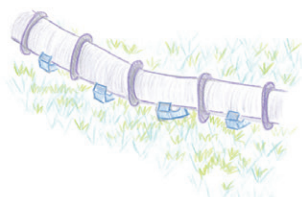
Extracting, or removing, oil from the ground is the first step in this supply chain. First, scientists and engineers find out where oil is located. Then they drill a hole and make a well. Pressure may push oil out of the ground. Chemicals, gas, or steam can also be put down the well to push oil out of the ground.[16] After oil is produced, it is taken to a refinery. Pipelines, ships, trains, and trucks can transport oil. The oil from your well will travel to Indiana.

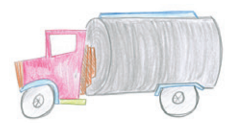
You begin at an oil well in Canada. Canada is a country in North America. One of its natural resources is oil. Canada is the fifth largest oil producer in the world. Most of its oil is exported to the United States.[17]

Indiana is state in the Midwest of the United States. The oil will travel about 1,409 miles, or 2,268 kilometers. Can you guess how oil is transported from Canada to the Midwest?



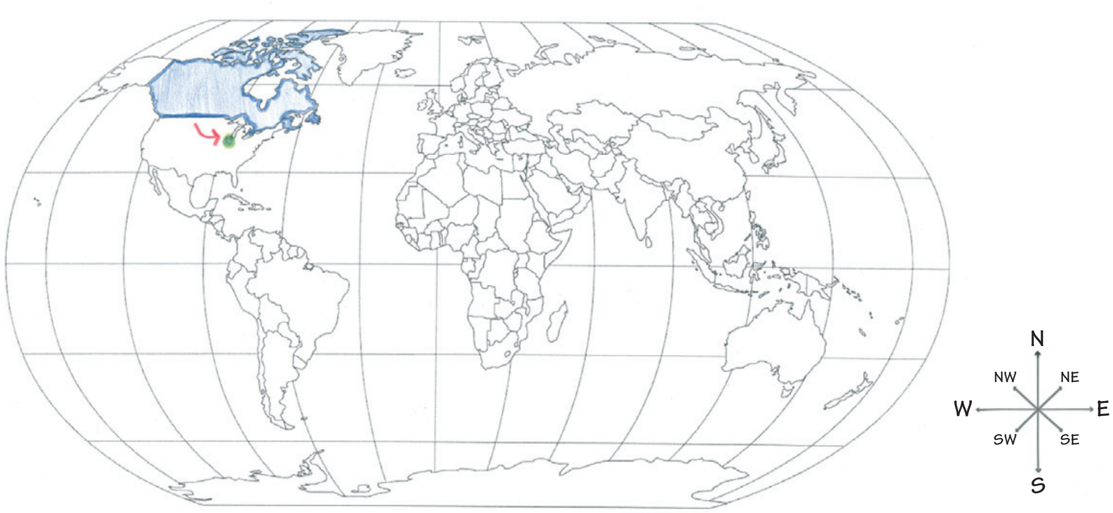






If you guessed that oil is transported from Canada to the Midwest by trains or pipelines, then you are correct! Crude oil is transported to the Midwest by train or through pipelines. There are about 140,000 miles of railroad in the United States.[18] There are about 55,000 miles of oil pipelines in the United States. These pipes vary in length and diameter. Even medium-sized pipelines can carry 150,000 barrels of crude oil a day.[19]

The World

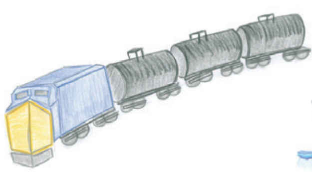


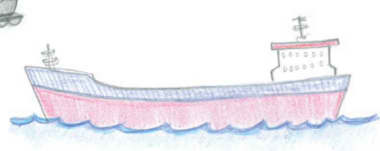
Step 1: Oil Well in Canada (2)

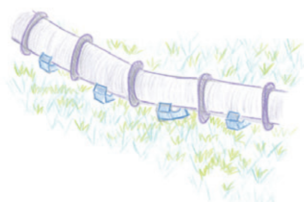
Extracting, or removing, oil from the ground is the first step in this supply chain. First, scientists and engineers find out where oil is located. Then they drill a hole and make a well. Pressure may push oil out of the ground. Chemicals, gas, or steam can also be put down the well to push oil out of the ground.[20] After oil is produced, it is taken to a refinery. Pipelines, ships, trains, and trucks can transport oil. The oil from your well will travel to Wyoming.

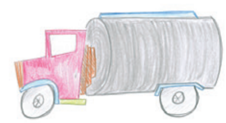
You begin at an oil well in Canada. Canada is a country in North America. One of its natural resources is oil. Canada is the fifth largest oil producer in the world. Most of its oil is exported to the United States.[21]

Wyoming is a state in the Rocky Mountains region of the United States. The oil will travel about 937 miles, or 1,508 kilometers. Can you guess how oil is transported from Canada to the Rocky Mountain region?



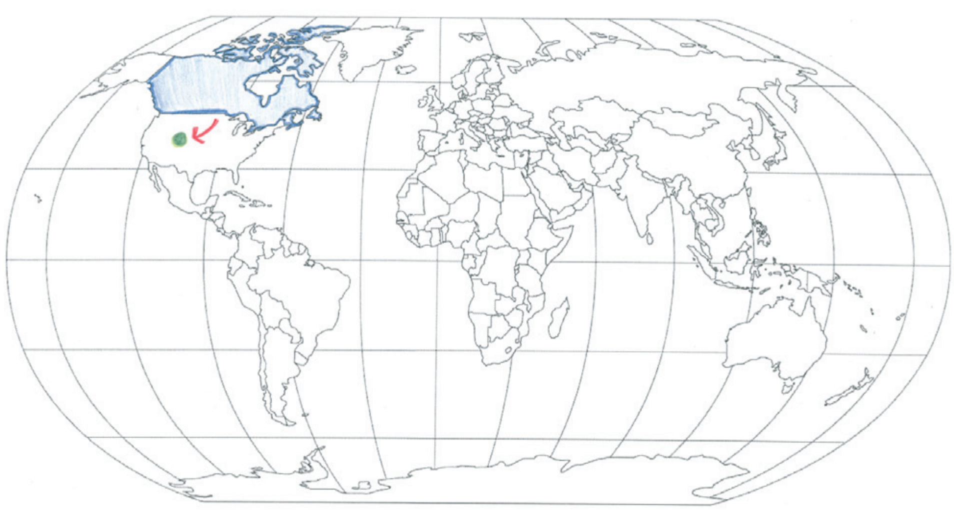


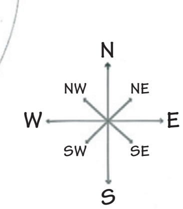




If you guessed that oil is transported from Canada to the Rocky Mountain region by pipelines, then you are correct! Crude oil is transported to the Rocky Mountains by pipelines. There are about 55,000 miles of oil pipelines in the United States. These pipes vary in length and diameter. Even medium-sized pipelines can carry 150,000 barrels of crude oil a day.[22]

The World



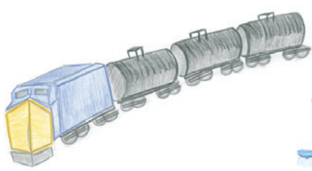
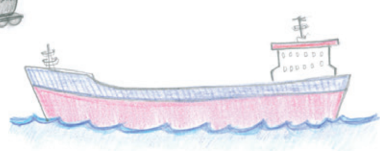


Step 1: Oil Well in Ecuador

Extracting, or removing, oil from the ground is the first step in this supply chain. First, scientists and engineers find out where oil is located. Then they drill a hole and make a well. Pressure may push oil out of the ground. Chemicals, gas, or steam can also be put down the well to push oil out of the ground.[23] After oil is produced, it is taken to a refinery. Pipelines, ships, trains, and trucks can transport oil. The oil from your well will travel to California.

You begin at an oil well in Ecuador. Ecuador is a country in South America. One of its natural resources is oil. Ecuador exports a lot of its oil to the United States of America.[24]

California is a state on the West Coast of the United States. The oil will travel about 3,592 miles, or 5,781 kilometers. Can you guess how oil is transported from Ecuador to the West Coast?

If you guessed that oil is transported from Ecuador to the West Coast by ship, then you are correct! Most crude oil imported from other countries is shipped over water to United States ports. Crude oil and petroleum products can also be carried from place to place over rivers.[25] Tankers and barges are ships that carry crude oil over water. Some tankers can carry 320,000 barrels of gasoline! It would take 552 rail cars, or 1,728 trucks to carry this many barrels of gasoline.[26]

The World

Step 1: Oil Well in Iraq

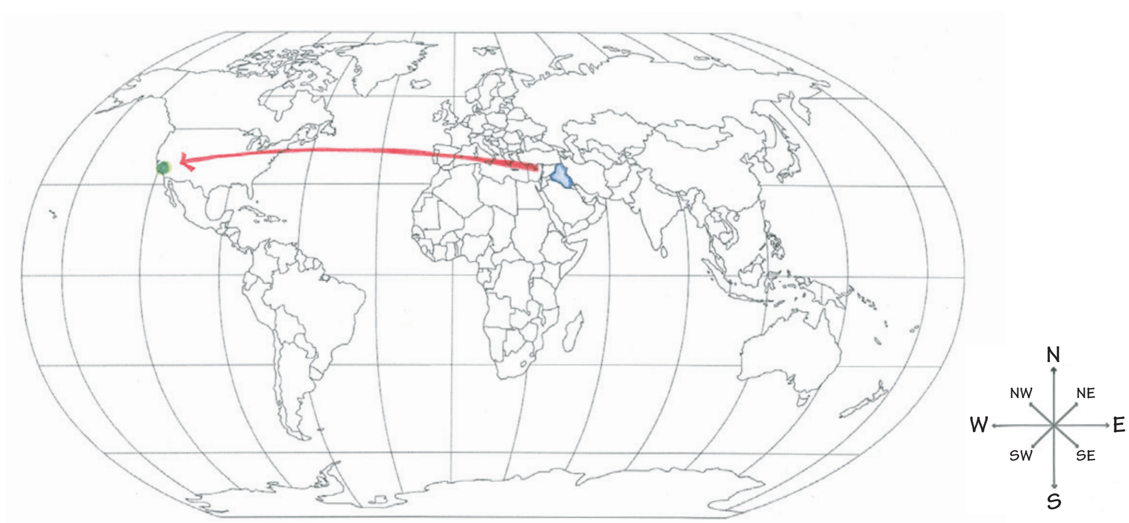
Extracting, or removing, oil from the ground is the first step in this supply chain. First, scientists and engineers find out where oil is located. Then they drill a hole and make a well. Pressure may push oil out of the ground. Chemicals, gas, or steam can also be put down the well to push oil out of the ground.[27] After oil is produced, it is taken to a refinery. Pipelines, ships, trains, and trucks can transport oil. The oil from your well will travel to California.

You begin at an oil well in Iraq. Iraq is a country in Southwest Asia. One of its natural resources is oil. Iraq exports a lot of oil to the United States of America, China, India, and South Korea.[28]

California is a state on the West Coast of the United States. This oil will travel about 7,650 miles, or 12,311 kilometers. Can you guess how oil is transported from Iraq to the West Coast?

If you guessed that oil is transported from Iraq to the West Coast by ship, then you are correct! Most crude oil imported from other countries is shipped over water to United States ports. Crude oil and petroleum products can also be transported over rivers.[29] Tankers and barges are ships that carry crude oil over water. Some tankers can carry 320,000 barrels of gasoline! It would take 552 rail cars, or 1,728 trucks to carry this many barrels of gasoline.[30]

The World



Step 1: Oil Well in Mexico

Extracting, or removing, oil from the ground is the first step in this supply chain. First, scientists and engineers find out where oil is located. Then they drill a hole and make a well. Pressure may push oil out of the ground. Chemicals, gas, or steam can also be put down the well to push oil out of the ground.[31] After oil is produced, it is taken to a refinery. Pipelines, ships, trains, and trucks can transport oil. The oil from your well will travel to Texas.

You begin at an oil well in Mexico. Mexico is a country in North America. One of its natural resources is oil. Most of Mexico's crude oil is extracted offshore, meaning the oil wells are located underwater.[32]

Texas is a state on the Gulf Coast of the United States. This oil will travel about 683 miles, or 1,099 kilometers. Can you guess how oil is transported from Mexico to the Gulf Coast?

If you guessed that oil is transported from Mexico to the Gulf Coast by ship, then you are correct! Most crude oil imported from other countries is shipped over water to United States ports. Crude oil and petroleum products can also be transported over rivers.[33] Tankers and barges are ships that carry crude oil over water. Some tankers can carry 320,000 barrels of gasoline! It would take 552 rail cars, or 1,728 trucks to carry this many barrels of gasoline.[34]

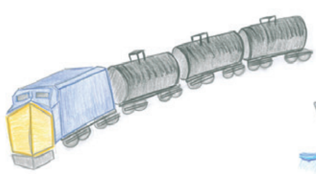
The World

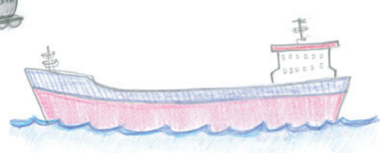
Step 1: Oil Well in Nigeria

Extracting, or removing, oil from the ground is the first step in this supply chain. First, scientists and engineers find out where oil is located. Then they drill a hole and make a well. Pressure may push oil out of the ground. Chemicals, gas, or steam can also be put down the well to push oil out of the ground.[35] After oil is produced, it is taken to a refinery. Pipelines, ships, trains, and trucks can transport oil. The oil from your well will travel to Pennsylvania.

You begin at an oil well in Nigeria. Nigeria is a country on the western coast of the Africa. One of its natural resources is oil. Nigeria produces more oil than any other country in Africa. Its largest oil customer is Europe.[36]

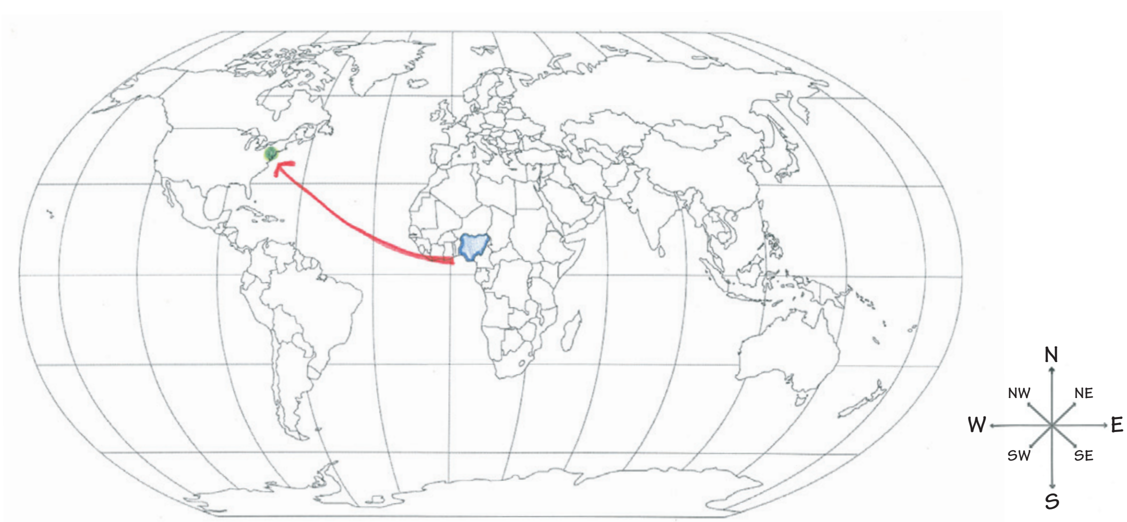
Pennsylvania is on the East Coast of the United States. This oil will travel about 5,488 miles, or 8,832 kilometers. Can you guess how oil is transported from Nigeria to the East Coast?





If you guessed that oil is transported from Nigeria to the East Coast by ship, then you are correct! Most crude oil that is imported from other countries is shipped over water to United States ports. Crude oil and petroleum products can also be transported over rivers.[37] Tankers and barges are ships that carry crude oil over water. Some tankers can carry 320,000 barrels of gasoline! It would take 552 rail cars, or 1,728 trucks to carry this many barrels of gasoline.[38]

The World

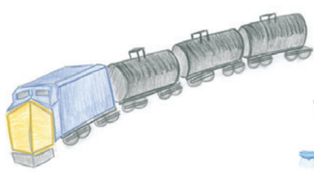


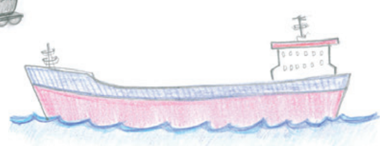
Step 1: Oil Well in Saudi Arabia

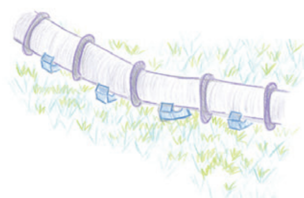
Extracting, or removing, oil from the ground is the first step in this supply chain. First, scientists and engineers find out where oil is located. Then they drill a hole and make a well. Pressure may push oil out of the ground. Chemicals, gas, or steam can also be put down the well to push oil out of the ground.[39] After oil is produced, it is taken to a refinery. Pipelines, ships, trains, and trucks can transport oil. The oil from your well will travel to Indiana.

You begin at an oil well in Saudi Arabia. Saudi Arabia is a country found in Southwest Asia. One of its natural resources is oil. Saudi Arabia produces the second largest amount of crude oil in the world.[40]

Indiana is state in the Midwest of the United States. This oil will travel about 6,982 miles, or 11,236 kilometers. Can you guess how oil is transported from Saudi Arabia to the Midwest?

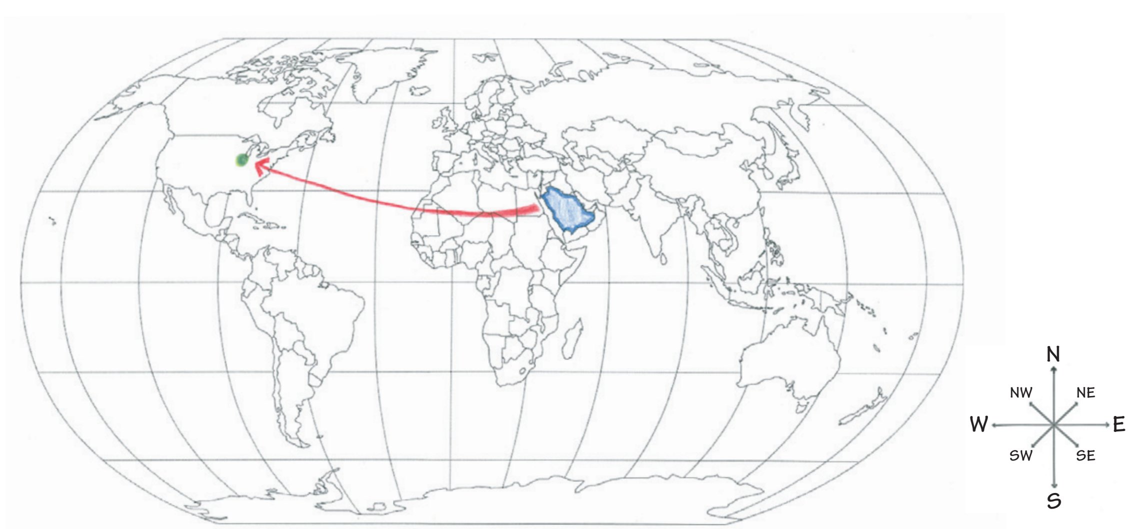






If you guessed that oil is transported from Saudi Arabia to the Midwest by ship and pipelines, then you are correct! Most crude oil imported from other countries is shipped over water to United States ports.[41] Tankers and barges are large ships that carry crude oil over water. Some tankers can carry 320,000 barrels of gasoline! It would take 552 rail cars, or 1,728 trucks to carry this many barrels of gasoline.[42] To get from a port to the Midwest, the oil will travel through pipelines.

The World

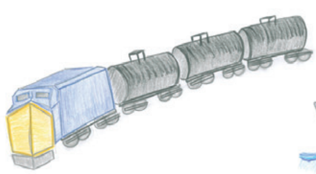


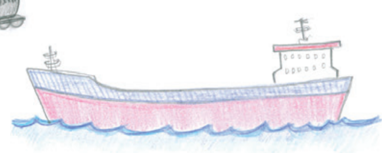
Step 1: Oil Well in Venezuela

Extracting, or removing, oil from the ground is the first step in this supply chain. First, scientists and engineers find out where oil is located. Then they drill a hole and make a well. Pressure may push oil out of the ground. Chemicals, gas, or steam can also be put down the well to push oil out of the ground.[43] After oil is produced, it is taken to a refinery. Pipelines, ships, trains, and trucks can transport oil. The oil from your well will travel to Texas.

You begin at an oil well in Venezuela. Venezuela is a country found in South America. One of its natural resources is oil. Venezuela has the largest oil reserves in the world. Most of this oil is located in an area called the Orinoco Belt.[44]

Texas is on the Gulf Coast of the United States of America. This oil will travel about 2404 miles, or 3,869 kilometers. Can you guess how oil is transported from Venezuela to the Gulf Coast?





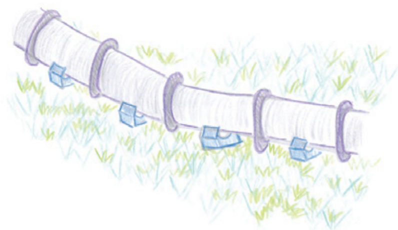
If you guessed that oil is transported from Venezuela to the Gulf Coast by ship, then you are correct! Most crude oil imported from other countries is shipped over water to United States ports. Crude oil and petroleum products can also be transported over rivers.[45] Tankers and barges are ships that carry crude oil or petroleum products over water. Some tankers can carry 320,000 barrels of gasoline! It would take 552 rail cars, or 1,728 trucks to carry this many barrels of gasoline.[46]

The World

Step 2: Refinery on the East Coast

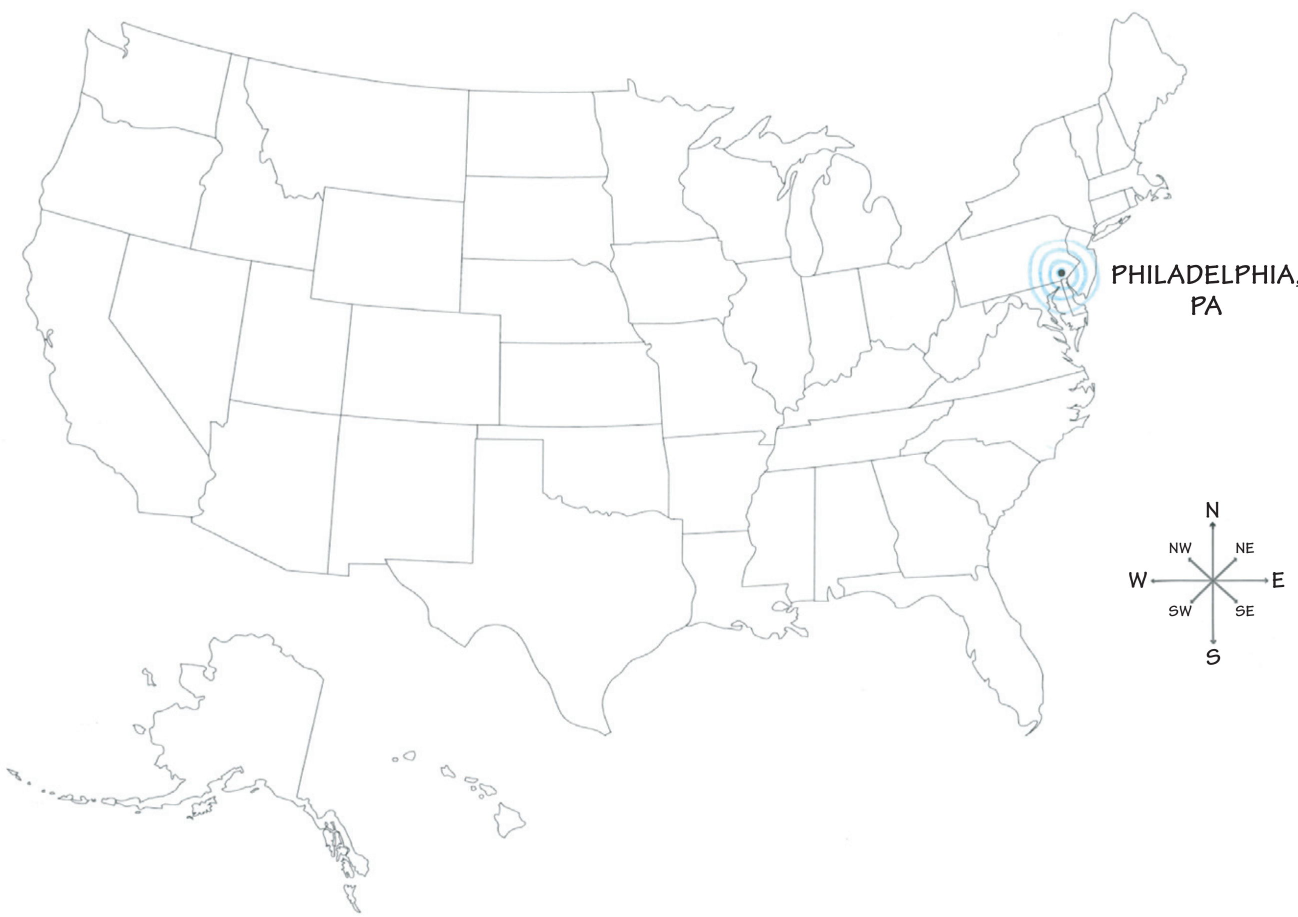
Refineries are like factories. They are very large. Sometimes workers ride bicycles to get around the refinery![47]

Oil is a mixture of different chemicals. At refineries, these chemicals are separated. Then they are changed into different products. Most oil is made into fuel. Products such as ink, medicines, plastics, and tires also come from crude oil.[48] After gasoline is made at the refinery, it is shipped to a storage terminal. Storage terminals are located closer to gas stations.[49]



You will follow the path that gasoline takes. In your supply chain, gasoline will travel 68 miles, or 109 kilometers, through pipelines. It will travel from a refinery in Philadelphia, Pennsylvania to a storage terminal in Sinking Spring, Pennsylvania.

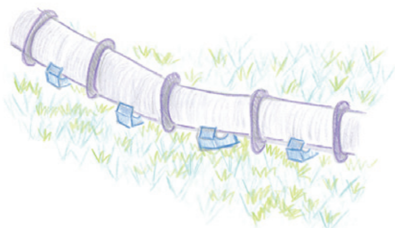
United States of America



Step 2: Refinery on the Gulf Coast

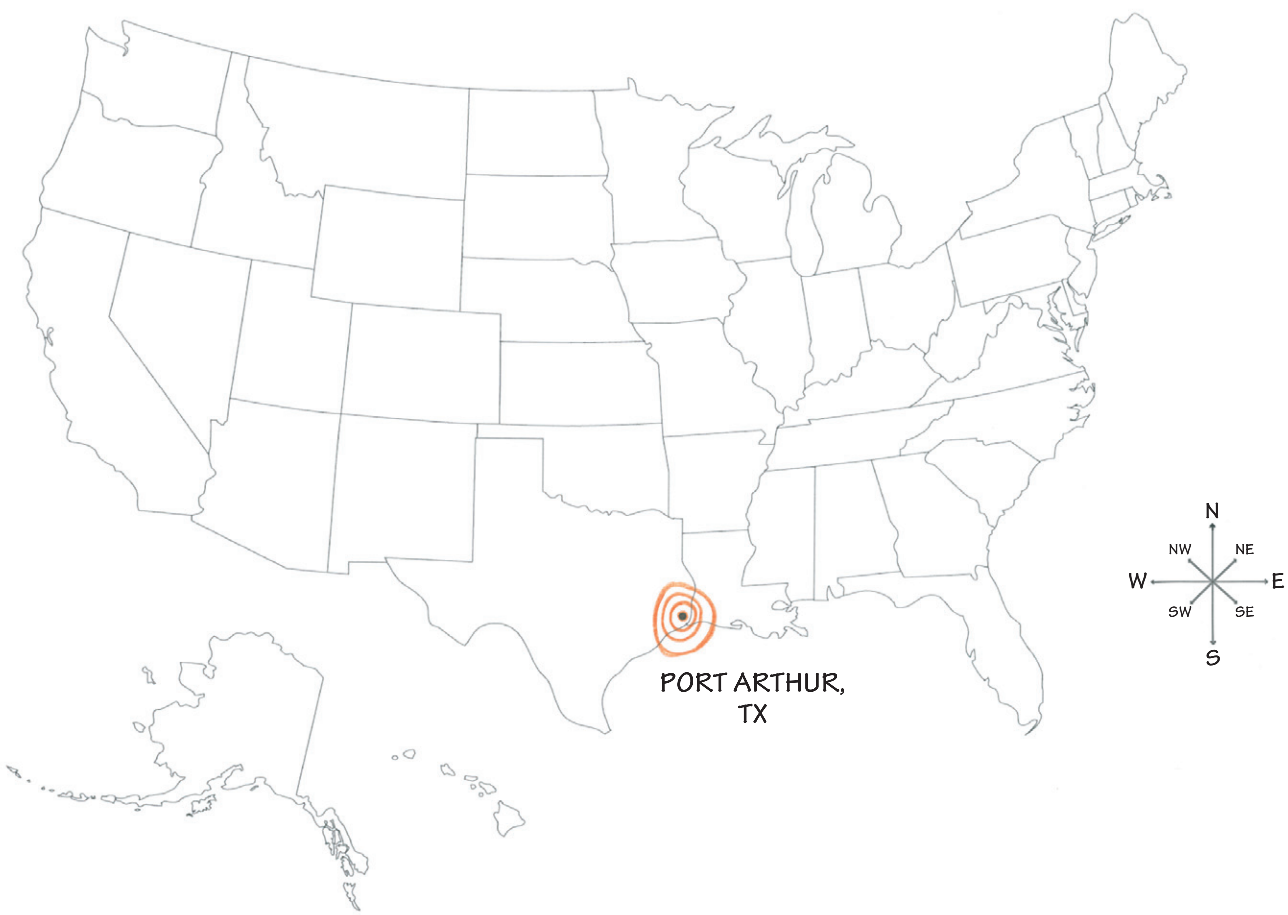
Refineries are like factories. They are very large. Sometimes workers ride bicycles to get around the refinery![50]

Oil is a mixture of different chemicals. At refineries, these chemicals are separated. Then they are changed into different products. Most oil is made into fuel. Products such as ink, medicines, plastics, and tires also come from crude oil.[51] After gasoline is made at the refinery, it is shipped to a storage terminal. Storage terminals are closer to gas stations.[52]



You will follow the path that gasoline takes. In your supply chain, gasoline will travel 6 miles, or about 10 kilometers, through pipelines. It will travel from the refinery in Port Arthur, Texas to a storage terminal in the same town.

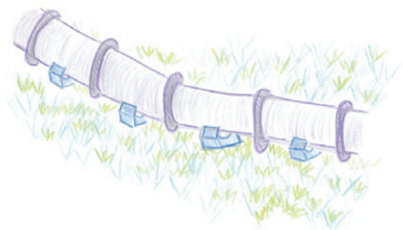
United States of America



Step 2: Refinery in the Midwest

Refineries are like factories. They are very large. Sometimes workers ride bicycles to get around the refinery![53]

Oil is a mixture of different chemicals. At refineries, these chemicals are separated. Then they are changed into different products. Most oil is made into fuel. Products such as ink, medicines, plastics, and tires also come from crude oil.[54] After gasoline is made at the refinery, it is shipped to a storage terminal. Storage terminals are closer to gas stations.[55]



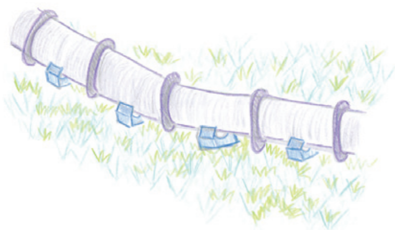
You will follow the path that gasoline takes. In your supply chain, gasoline will travel 5 miles, or about 8 kilometers, through pipelines. It will travel from the refinery in Whiting, Indiana to a storage terminal in East Chicago, Indiana.

United States of America

Step 2: Refinery in the Rocky Mountain Region

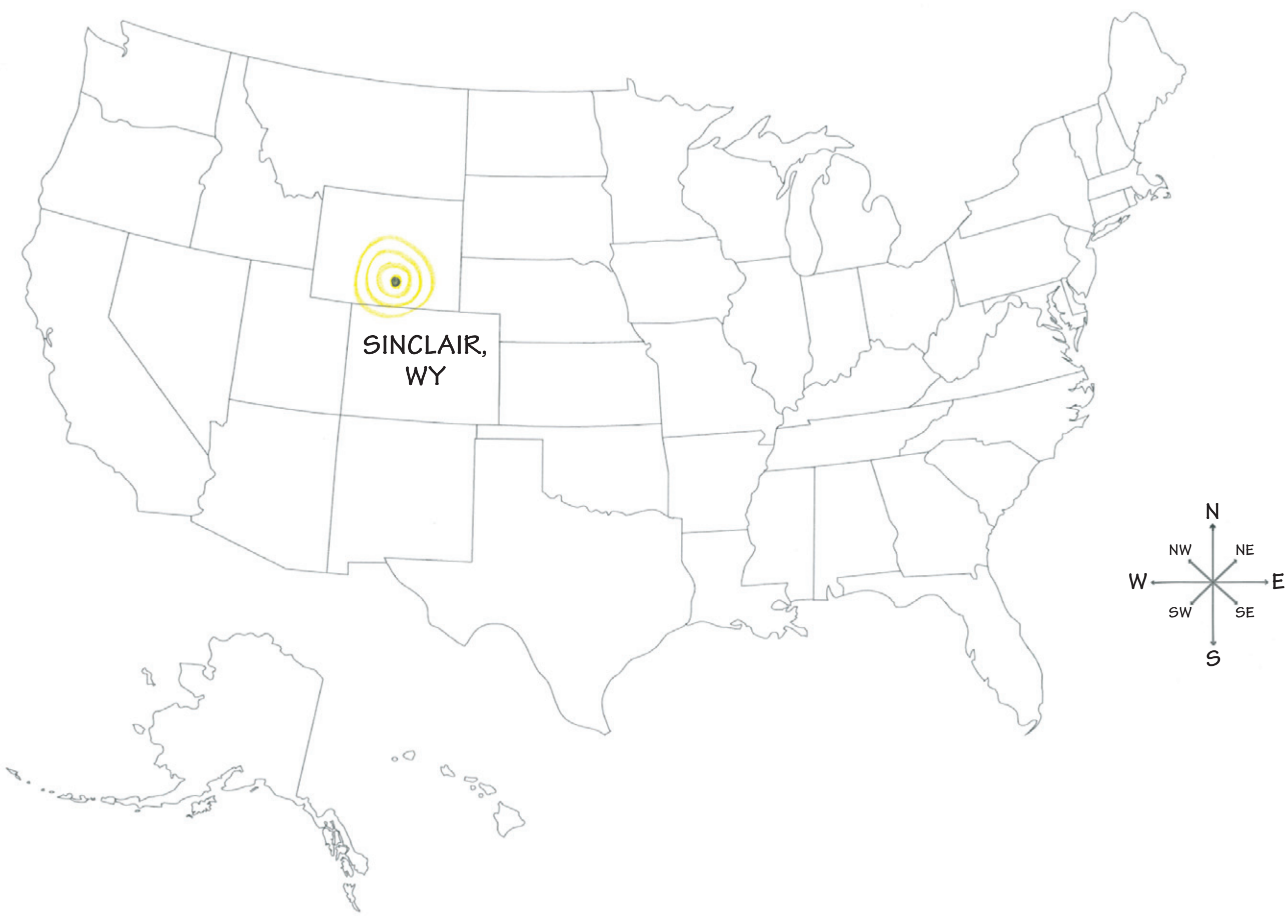
Refineries are like factories. They are very large. Sometimes workers ride bicycles to get around the refinery![56]

Oil is a mixture of different chemicals. At refineries, these chemicals are separated. Then they are changed into different products. Most oil is made into fuel. Products such as ink, medicines, plastics, and tires also come from crude oil.[57] After gasoline is made at the refinery, it is shipped to a storage terminal. Storage terminals are closer to gas stations.[58]



You will follow the path that gasoline takes. In your supply chain, gasoline will travel 114 miles, or about 183 kilometers, through pipelines. It will travel from the refinery in Sinclair, Wyoming to a storage terminal in Rocky Springs, Wyoming.

United States of America



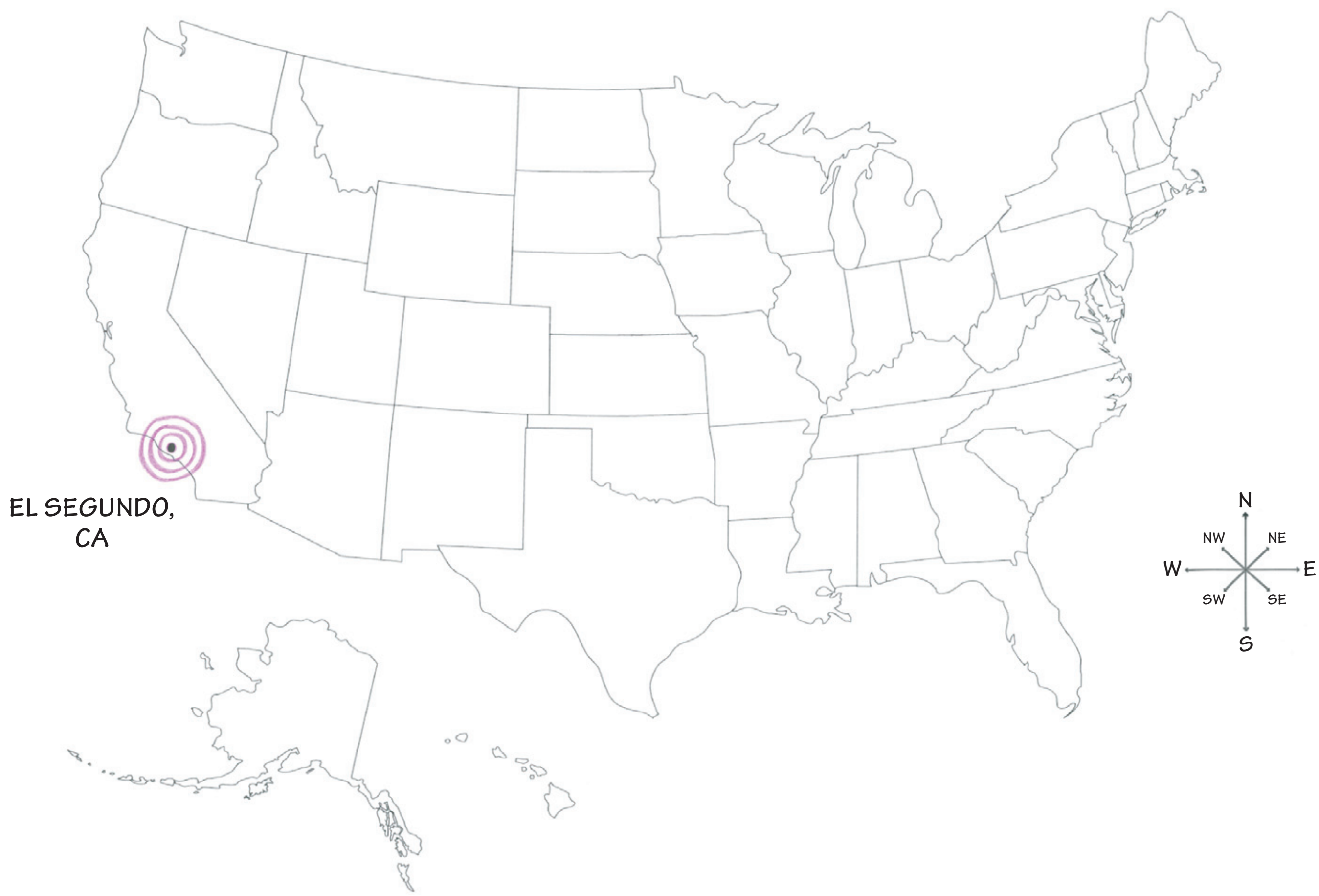
Step 2: Refinery on the West Coast

Refineries are like factories. They are very large. Sometimes workers ride bicycles to get around the refinery![59]

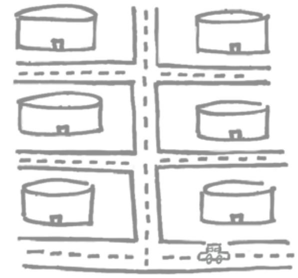
Oil is a mixture of different chemicals. At refineries, these chemicals are separated. Then they are changed into different products. Most oil is made into fuel. Products such as ink, medicines, plastics, and tires also come from crude oil.[60] After gasoline is made at the refinery, it is shipped to a storage terminal. Storage terminals are closer to gas stations.[61]

You will follow the path that gasoline takes. In your supply chain, gasoline does not travel to get from a refinery to a storage terminal at all. It can be stored right next to the refinery in El Segundo, California.

United States of America

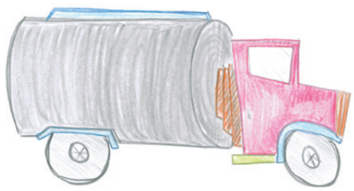


Step 3: Storage Terminal on the East Coast



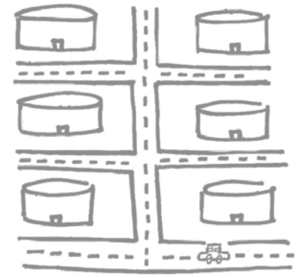
Storage terminals store gasoline. They are often near places where a lot of trucks, trains, and barges come and go.[62] At the storage terminals, gasoline is mixed with chemicals and biofuels. A biofuel is a fuel made from renewable resources such as wood, algae, or corn.

When gas stations need more fuel, large trucks fill their tanks with gasoline from the storage terminals. Then they transport the gasoline to gas stations. Tank trucks can hold about 10,000 gallons of gasoline![63]



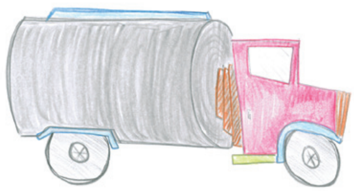
In your supply chain, tank trucks travel 5 miles, or about 8 kilometers, to the nearest gas station.

Step 3: Storage Terminal on the Gulf Coast

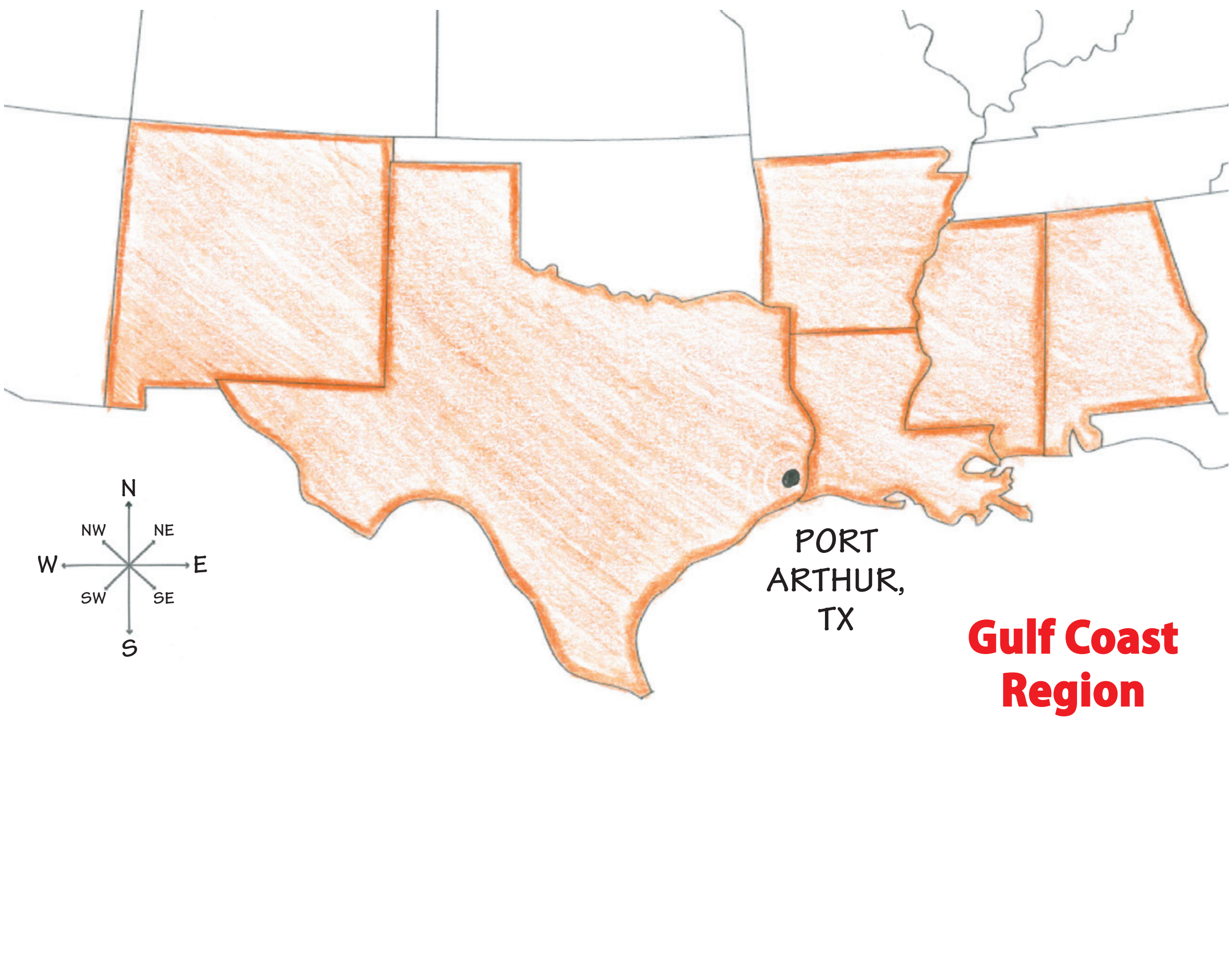


Storage terminals store gasoline. They are often near places where a lot of trucks, trains, and barges come and go.[64] At the storage terminals, gasoline is mixed with chemicals and biofuels. A biofuel is a fuel made from renewable resources such as wood, algae, or corn.

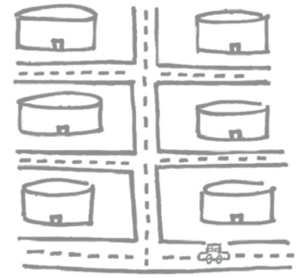
When gas stations need more fuel, large trucks fill their tanks with gasoline from the terminals. Then they transport the gasoline to gas stations. Tank trucks can hold about 10,000 gallons of gasoline![65]



In your supply chain, tank trucks travel 6 miles, or about 10 kilometers, to get to the nearest gas station.

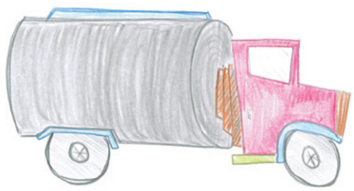


Step 3: Storage Terminal in the Midwest

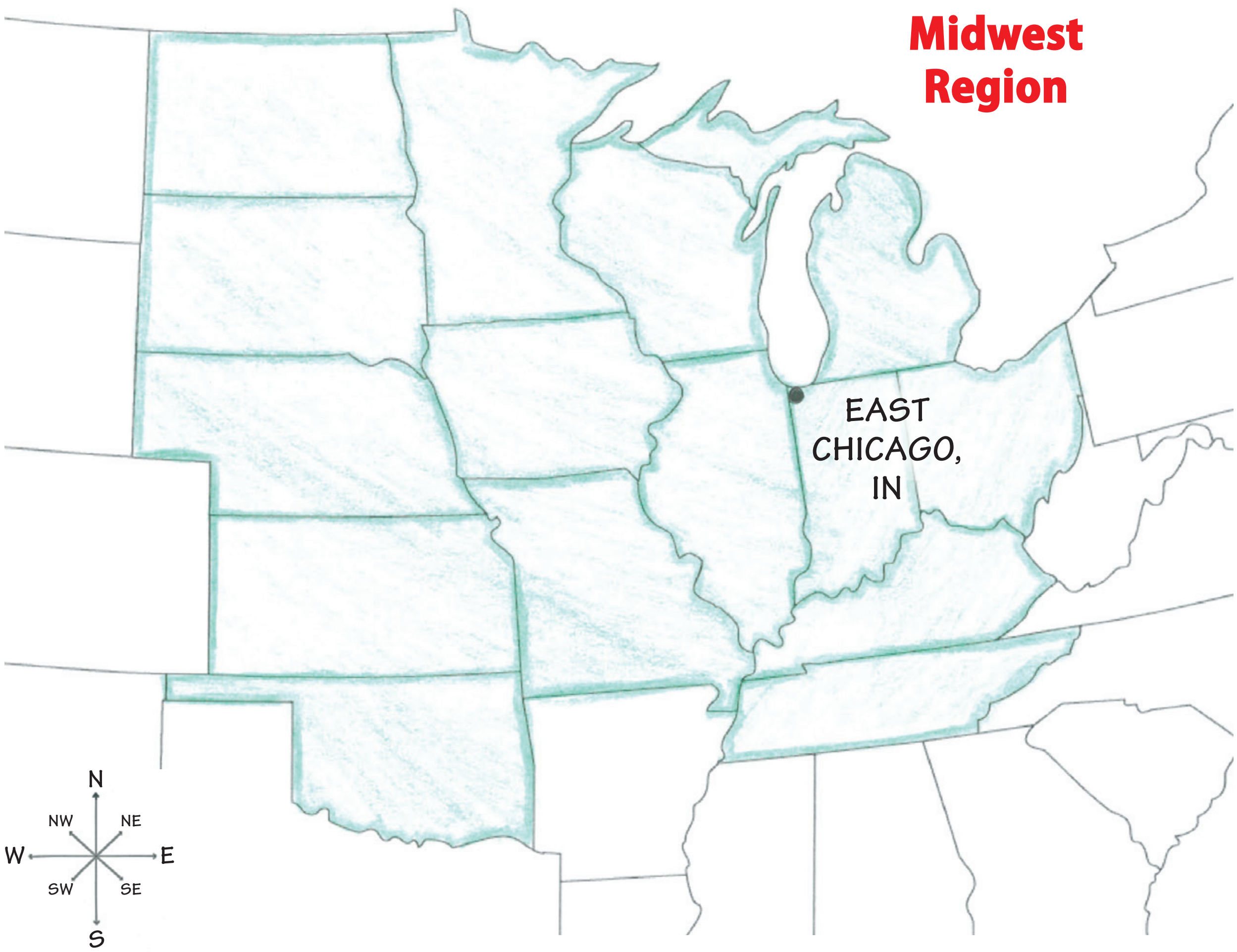


Storage terminals store gasoline. They are often near places where a lot of trucks, trains, and barges come and go.[66] At the storage terminals, gasoline is mixed with chemicals and biofuels. A biofuel is a fuel made from renewable resources such as wood, algae, or corn.

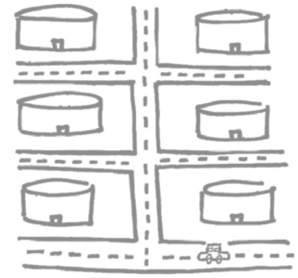
When gas stations need more fuel, large trucks fill their tanks with gasoline from the terminals. Then they transport the gasoline to gas stations. Tank trucks can hold about 10,000 gallons of gasoline![67]



In your supply chain, tank trucks travel 25 miles, or about 40 kilometers, to get to the nearest gas station.

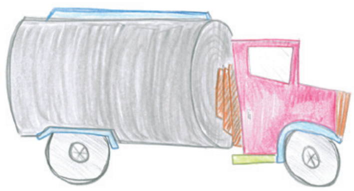


Step 3: Storage Terminal in the Rocky Mountain Region

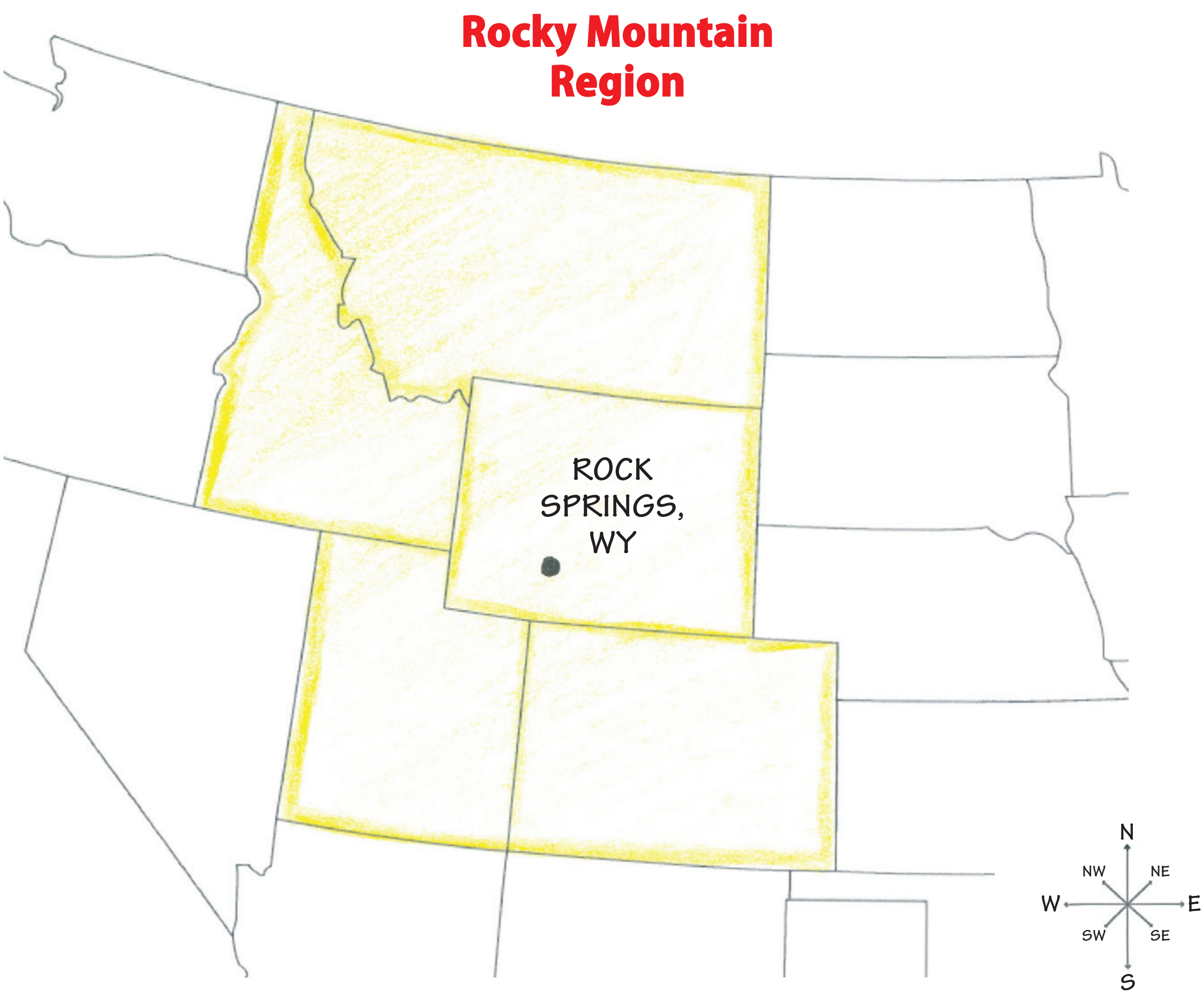


Storage terminals store gasoline. They are often near places where a lot of trucks, trains, and barges come and go.[68] At the storage terminals, gasoline is mixed with chemicals and biofuels. A biofuel is a fuel made from renewable resources such as wood, algae, or corn.

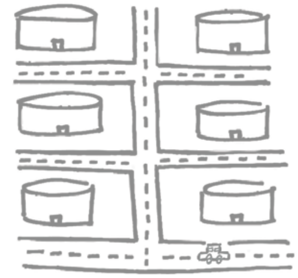
When gas stations need more fuel, large trucks fill their tanks with gasoline from the terminals. Then they transport the gasoline to gas stations. Tank trucks can hold about 10,000 gallons of gasoline![69]



In your supply chain, tank trucks travel 50 miles, or about 80 kilometers, to get to the nearest gas station.

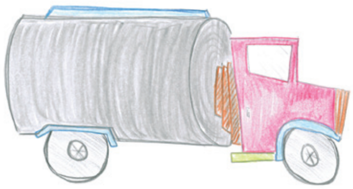


Step 3: Storage Terminal on the West Coast



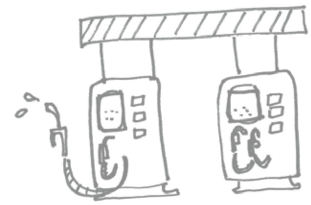
Storage terminals store gasoline. They are often near places where a lot of trucks, trains, and barges come and go.[70] At the storage terminals, gasoline is mixed with chemicals and biofuels. A biofuel is a fuel made from renewable resources such as wood, algae, or corn.

When gas stations need more fuel, large trucks fill their tanks with gasoline from the terminals. Then they transport the gasoline to gas stations. Tank trucks can hold about 10,000 gallons of gasoline![71]



In your supply chain, tank trucks travel 5 miles, or about 8 kilometers, to get to the nearest gas station.

Step 4: Gas Station

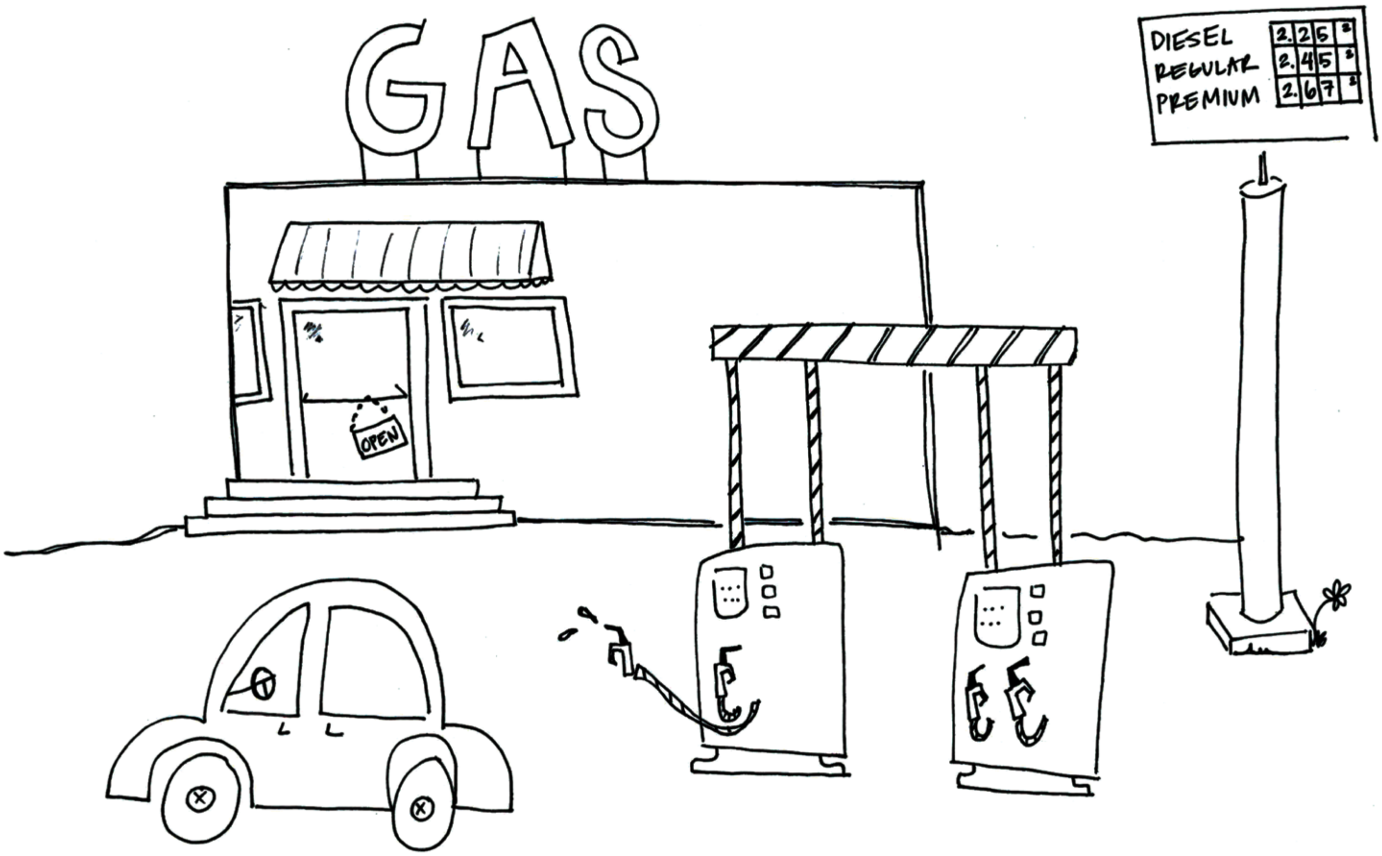


There are about 180,000 gas stations in the United States. These stations can hold over 2 billion gallons of fuel at one time![72]

At gas stations, gasoline is stored in underground tanks. Pumps move the gasoline from underground tanks to our cars and trucks.[73]

Gasoline is burned in a car or truck's engine. This produces heat and moves the vehicle. It also produces pollution and carbon dioxide. These can be harmful to humans and the environment.

Once a car or truck's gas tank is almost empty, it must return to a gas station to be refilled.

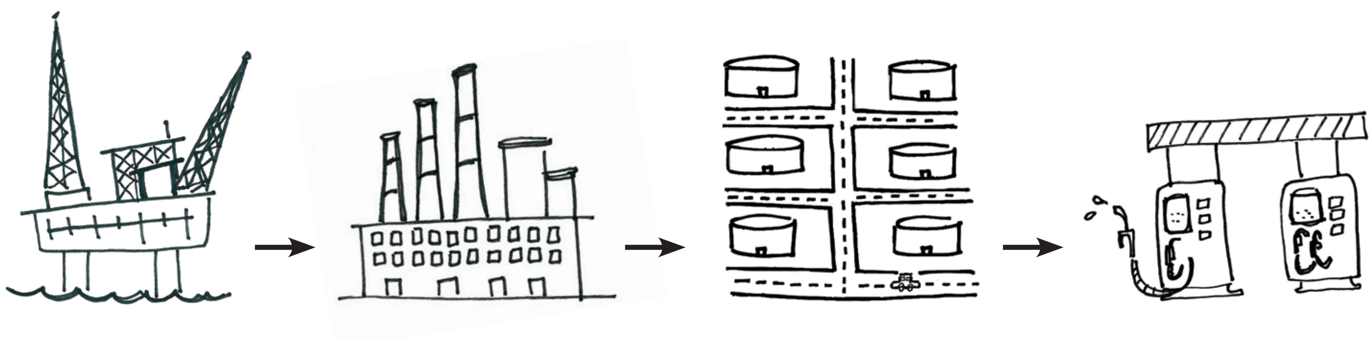


Name Date

Supply and Demand, page 1

Part 1. Mapping

Directions: Think about what resources might be needed for each step of this supply chain. Draw or write these resources next to the step where they are needed. Then connect these resources to the step with a line. The word bank can help you think of some types of resources that might be needed. These words can be used more than once.



Word Bank

buildings crude oil

gas (for machines or transportation)

electricity machines people

pipelines ships trucks

trains water

Name Date

Supply and Demand, page 2

Part 2. Evaluating

Directions: Read each question and discuss answers as a group. Then record your answers. You should use the map that you created in Part I to help you answer these questions.

1. What natural resource is extracted for this supply chain? Is this resource renewable or nonrenewable?

2. What other resources are needed to produce gasoline?

3. What are some of the benefits of this supply chain? What are some of the costs?

4. How is this product used to meet human wants or needs?

5. Do you think there are other ways to meet the human wants or needs you described above?

6. How do people who buy gas play a role in the production of gasoline?

7. What might be some of the social, economic, and environmental consequences of producing gasoline?

Lesson 6

Energy for All

The class revisits the way they use energy, reviews the natural resources used to supply them with energy, and brainstorms reasons for using energy sustainably. Small groups then read and analyze case studies about youth conservationists around the world to learn 4 different strategies to conserve energy and nonrenewable resources. This lesson can be used as a springboard for a service learning project.

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Objectives

Students will:

- Identify ways energy helps them, their families, and their communities.
- Know reasons for conserving energy.
- Analyze a real-world example to learn different ways to conserve energy.
- Describe examples of 4 different energy conservation strategies.
- Present information about an energy conservation strategy to the class.

Inquiry/Critical Thinking Questions

- Why should we conserve energy?
- How can I reduce the amount of energy I use?
- How could reducing my energy use increase my quality of life?
- How can collaboration, perseverance, and a commitment to solving problems help people conserve energy?
- What skills and strategies can you borrow from other youth around the world in order to conserve energy in your own life?

Time Required

60 minutes

Key Concepts

- **biodiesel**—A fuel made from fat or vegetable oil instead of petroleum oil.
- **case study**—A real-life example that can be studied in order to learn something.
- **collaboration**—Teamwork; working with another person or group to accomplish a shared goal.
- **community organization**—A group of people who work together to solve problems in their city or neighborhood.
- **consume**—To use.
- **embodied energy**—All of the energy used to grow or make something.
- **energy conservation**—Behaviors and actions that save or use less energy, such as turning off the lights when you leave a room.
- **energy efficiency**—Saving energy by choosing technology that uses less energy for the same service. For example, you might use LED light bulbs, which use less energy than other light bulbs to produce the same amount of light.
- **engineering**—A systematic process for solving problems.[1]
- **evaluate**—To judge an idea or action in a careful and thoughtful way.
- **landfill**—A place where garbage is buried. Often, a landfill is lined with plastic to stop garbage from harming the water and soil around it.

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- **natural resource**—Something from nature that people can use.
- **nonrenewable resource**—A limited resource, such as coal, natural gas, or oil, that cannot be replaced in a short amount of time.
- **perseverance**—The characteristic of continuing to try when things become difficult.
- **perspective**—A point of view or particular attitude toward something.
- **renewable resource**—A resource, such as biomass, sunlight, wind, or water, that can be replaced quickly and naturally.
- **responsibility**—Something you do because it is right or legally required.
- **sustainability**—The principle of meeting current needs without limiting the ability of future generations to meet their needs.
- **watt**—A measurement of electrical power.

Energy Literacy: Essential Principles and Fundamental Concepts for Energy Education

6.1 Conservation of energy has two very different meanings.

6.2 One way to manage energy resources is through conservation.

6.4 Earth has limited energy resources.

6.5 Social and technological innovation affects the amount of energy used by human society.

6.6 Behavior and design affect the amount of energy used by human society.

6.7 Products and services carry with them embedded energy.

6.8 Amount of energy used can be calculated and monitored.

7.1 Economic security is impacted by energy choices.

7.3 Environmental quality is impacted by energy choices.

7.4 Increasing demand for and limited supplies of fossil fuels affects quality of life.

7.5 Access to energy resources affects quality of life.

7.6 Some populations are more vulnerable to impacts of energy choices than others.

U.S. Standards Correlation

- **State and national standards:** Visit our Standards Correlation Tool at www.facingthefuture.org/CurriculaFreeUnits/StandardsCorrelations

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Materials/Preparation

- ☐ **Handout:** *Case Studies,* 1 case study per student

  Option

  - For more support, create 1 copy of each case study for each student. Read and analyze each case study as a class.
  - For more challenge, create a station for each case study and have students move through the stations to read each case study at their own pace. Have students complete the questions themselves or in collaborations as they move through the station. Then divide the class into small groups of 3–4 and assign a case study to each group. Have each group present answers to the questions about their case study while the audience members check their own answers and fill out the handout *Energy For All.*
- ☐ **Handout:** *Energy for All,* 1 per student

Background Information for Educators

People use energy in many different ways to meet and exceed their daily needs. Food provides our bodies with sustenance; fuel moves our cars and trucks; and electricity powers our lights, charges our computers, keeps our refrigerators working, and more. Access to reliable energy has significant positive impact for individuals, families, and communities—it enables us to study and learn, work and make a living, and keep our bodies healthy. Yet, our energy use has negative consequences as well. Energy can be expensive to purchase, create international conflict, and cause environmental damage during mining, production, and consumer use. Furthermore, some of the natural resources we use for energy are limited and cannot be replaced.

There are many reasons to use energy more sustainably, and, just as many ways to do so. For example, individuals and communities can conserve energy and nonrenewable resources by changing behavior, using more energy-efficient technology, reducing the amount of energy wasted, and using renewable sources of energy in place of nonrenewable energy sources. As the youth showcased in this lesson demonstrate, working toward sustainable energy solutions can foster benefits beyond energy conservation, such as community development, skill building, and a sense of efficacy and fulfillment.


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Activity 1

Introduction

1. Write the following prompts on the board and give students time to complete each sentence on a piece of paper:
   - One of the most interesting things I have learned about energy is…
   - Energy helps me…
   - Energy helps my family…
   - Energy helps my community…
   - Without energy…

   Option: If your class completed *Lesson 3: Mapping My Energy Use,* have students revisit their personal energy maps to review the ways they use energy.
2. In Think-Pair-Share format, have students discuss their answers.
3. Ask the class to name some different natural resources used to provide us with energy. On the board, list students' answers, under the heading "Renewable" or "Nonrenewable." *(Renewable resources include biomass, geothermal, hydropower, solar, and wind. Nonrenewable resources include coal, natural gas, petroleum [oil], and uranium [nuclear].)*
4. Ask students what people mean when they talk about "conserving energy." *(Reducing the amount of energy we use, or saving energy. "Energy conservation" can also refer to the Law of Conservation of Energy, but people usually use the phrase to reference human energy use.[2])*
5. In Think-Pair-Share format, have students come up with 3 reasons to conserve energy.
6. Write students' reasons on the board and invite the class to look for similarities and categories.

   Note: Make sure that the following reasons are included on the board:
   - **limited natural resources**
     There are limited amounts of nonrenewable energy resources. Even energy from renewable resources requires other natural resources, such as water or minerals, for production and delivery to the consumer.
   - **pollution**
     Producing energy can emit pollution into the air, water, and soil.
   - **cost**
     Gas, electricity, and fuel cost money.
   - **equity**
     How can we share limited resources, or use or care for them, in a way that all people, not just a select few, have enough energy to meet their needs?
7. Share with students that one reason people try to conserve energy is so everyone is able to meet their energy needs and so there will be energy resources for future generations. Tell students that this idea is often referred to as sustainability and share the following definition with students:
   - **sustainability**—The principle of meeting current needs without limiting the ability of future generations to meet their needs.

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8. Ask students how the way we use energy today could affect people in the future. *(Answers could include: if we use too many nonrenewable resources now, there might not be enough for future generations; or some of the energy we use today could cause air, water, or soil damage that may impact people in the future.)*

Steps

1. Share with students that today they will learn about young people around the world who have worked to use energy more sustainably in their homes, schools, and communities.
2. Show students one of the case studies and explain that small groups will read a case study, answer questions about it on a separate sheet of paper, and present what they learned to the class.

   Option: Share with students the definition of a case study.

   - **case study**—A real-life example that can be studied in order to learn something.
3. Divide the class into small groups of 3–4 and assign a case study to each group. Depending on your class size, more than 1 group may review each case study.
4. Give each student a copy of his or her group's case study so students may annotate as they read.

   Option: Provide more support for this activity by reading 1 or more case studies as a class; provide more challenge by having students read each case study on their own at 4 different stations and complete the questions at the end of each case study. Then divide the class into small groups of 3–4 and assign a case study to each group. Have each group present answers to the questions about their case study while the audience members check their own answers and fill out the handout *Energy For All*.
5. Give small groups enough time to read their case study and complete the questions at the end of the reading. Circulate around the room to provide students guidance as needed.
6. Once all groups are finished, give each student a copy of the handout *Energy for All*.
7. Tell students each group will have 3 minutes for their presentations, and that listeners will complete the corresponding section of the handout *Energy for All* during each presentation.
8. Select a group to begin class presentations and continue until all groups have presented.
9. As a class, review the 4 energy conservation strategies that were presented, paying special attention to the distinction between energy conservation and energy efficiency. *(Energy conservation refers to the*

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act of saving energy by choosing actions that use less energy, even if that means less service in return. However, energy efficiency refers to the act of saving energy by choosing technology that uses less energy for the same service.)

10. Have students raise their hands if their case study had examples from more than 1 strategy and ask students why one might want to use more than 1 energy saving strategy.

11. Give students a couple of minutes to make sure the handout *Energy for All* is complete.

Option: Have group mates share some of their energy-saving goals with one another.

12. Conclude this activity with the following discussion questions.

Discussion Questions

1. How is energy connected to our lives?

2. What are some reasons for saving or conserving energy?

3. How do energy conservation and energy efficiency compare?

4. Do you think we have a responsibility to save energy? Why or why not?

5. In your opinion, what is an important skill or characteristic of people who work toward sustainable solutions?

6. How could *reducing* your energy use *increase* your quality of life?

7. How could you encourage others to conserve energy?

8. What did you learn from reading these case studies?

Lesson Extensions

Vocabulary Extension

Have students design a matching game with the vocabulary words presented in this lesson. A matching pair can include 1 card with the definition and 1 card with an illustration or description of an example of the term. For example, students could draw a picture of an LED light bulb for energy efficiency or a soccer team for collaboration.

Language Arts/Art Extension

Have students write and design a picture book that features the ways we use energy and the ways we can save energy. Students can create their own book or use the ABC Book Template from the CBK Associates website: http://www.cbkassociates.com/abcd-books/curriculum/abc-books/.

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Service Learning Extension

After students have completed this lesson, have students brainstorm ways they can help conserve energy in their homes, classroom, school, or community. Have small groups interview students, parents, staff, or community members to learn what others feel are the biggest energy needs, or the biggest energy conservation needs. Compile these opportunities into 1 classroom list on a poster paper and have individuals place a dot or a sticky note by their top choice. Once the top need has been identified, the class can create an action plan for a project. Be sure to make time and space for student reflection and an opportunity for them to share what they learned. Resources that might be useful include the following.

- **Website:** *Facing the Future*
  Find a collection of resources for service learning and student action projects: www.facingthefuture.org
- **Website:** *Design for Change*
  A global movement that encourages children to take action in the world using a simple design thinking process based on 4 steps: Feel, Imagine, Do, and Share. This website has more information about this design thinking process and a Design for Change Challenge: www.dfcworld.com
- **Books:** *ABCD Books*
  ABCD Books offers a catalogue of books and other resources, including curricula, suggested by Service Learning expert Cathryn Berger Kaye to inspire youth to take action: www.cbkassociates.com/abcd-books

Additional Resources

Interactive Game

- ***The Energy Elf***
  The U.S. Department of Energy website challenges students to identify opportunities to save energy in a home in an interactive game: www1.eere.energy.gov/education/games/eere.html

Website

- ***Clean Energy***
  The U.S. Environmental Protection Agency lists several useful tools and resources for local and regional renewable energy projects: www.epa.gov/cleanenergy
- ***ENERGY STAR®***
  ENERGY STAR is a voluntary program of the U.S. Environmental Protection Agency that promotes energy efficiency in homes and businesses. Their website provides information and interactives about energy efficiency: http://www.energystar.gov/
- **Webpage:** *Biomass: Biofuels*
  This U.S. Energy Information Administration webpage has been designed for kids to learn about biofuels and biodiesel. http://www.eia.gov/kids/energy.cfm?page=biofuel_home-basics

CASE STUDY 1 Energy Conservation

Small Steps Save Energy: Kyle Swimmer Works to Save Energy Everyday

Sometimes the little things in life make a big difference. This is very true when it comes to taking care of the planet.

Kyle Swimmer knows this well. Each day, he thinks carefully about how his actions impact the earth. "Nearly everything we do takes energy," he explains. Because of this, he looks for ways to conserve energy. **Energy conservation** refers to behaviors and actions that save or use less energy. Turning off the lights when you leave a room or putting on a sweater instead of turning up the heat are examples of energy conservation.

Kyle takes action to use less energy at home. He often hangs his clothes outside to dry instead of using a dryer. When he leaves for school, Kyle turns off the lights and unplugs electronic devices that he is not using. This is important because things like phone chargers, stereos, and televisions use energy even if they are not turned on. A cell phone charger, for example, uses 3.68 **watts** when it is charging a phone's battery.[3] But even when it is not connected to a phone, a charger plugged into an outlet uses 0.26 watts of energy.[4] Kyle also saves energy by walking instead of using a car.

Kyle made changes to his house to conserve energy. He added insulation to the walls of his home and replaced old windows with new ones. These new windows do a better job keeping heat inside the house. Now, his house uses less energy to stay warm during the winter.

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Growing his own food is just one of the ways Kyle Swimmer saves energy.

Kyle makes careful choices about food to save energy. "When I go to the grocery store, I try to buy things that are grown nearby," Kyle explains. These items tend to have less **embodied energy** than food that is grown far away. It takes energy to plant, grow, and ship a potato. Energy is also used to wash and package the potato.

Kyle also conserves energy by growing his own food. He grows corn, potatoes, melons, and other fruits and vegetables. His garden is near his family's home in the Laguna Pueblo of New Mexico. He works in his garden when he is not at college. Kyle carefully decides which crops to grow each year. He plants seeds that grow well in dry weather to reduce water use. Using less water helps

Kyle lower the embodied energy of the things he grows.

Over time, the small actions that Kyle takes to save energy add up. Taking care of the planet has always been important to Kyle. "We are not the only things that use the resources around us. We are not the only things living on this planet," he explains. "It's important to take care of the place that we live in because, in turn, it will take care of us." Kyle feels that taking care of the planet is his **responsibility**.

Kyle hopes to encourage others to save energy through his example. "You can make a change in your lifestyle to make a huge difference—an impact," Kyle says. "It's just a spark that starts a wildfire and you can really motivate people just by the way you live your life."

Directions: Read the questions below and discuss the answers with your group. On a separate piece of paper, record your answers to these questions.

1. Who is involved in this project?
2. What does he or she do? How?
3. Why does he or she take these actions?
4. What does energy conservation mean?
5. List 2 examples of energy conservation from this case study.
6. Describe another example of energy conservation that is not in this case study.

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Collecting rainwater can help save water and energy.

CASE STUDY 2 Energy Efficiency

Aaron Laszewski Saves Energy By Using It Wisely

There are many ways to make a difference in the world, especially when it comes to saving energy. Aaron Laszewski understands this very well. At home and at his job, he saves energy by using it wisely.

Even as a kid, Aaron knew that renewable resources were important for helping the planet. Then a class he took in high school on energy conservation and renewable energy expanded his **perspective**. The class taught Aaron that we can also save energy by increasing efficiency.

Renewable resources are being used more and more for energy. However, the world still uses more nonrenewable resources. In 2014, over 78% of the world's energy came from nonrenewable resources.[5] Aaron realized that many people were not able to change quickly to renewable energy. But they could make their energy systems more efficient. And, he could help.

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Aaron has learned that using energy-efficient technology can save energy and money.

Energy efficiency means using less energy to complete the same task or get the same result. For example, an LED light bulb uses less energy than other bulbs to produce the same amount of light. "By making our current energy systems more efficient, we can make a big difference and use far less energy," Aaron explains.

Knowing this led him to study **engineering** at the University of Wisconsin in Madison. Engineers use science, math, and creativity to solve problems. They help design everything from roads to buildings to machines. Some engineers focus on improving energy efficiency.

While in college, Aaron and his roommates used more energy-efficient technology in their home. "We made small changes to make things more energy efficient," he explains. They installed new light bulbs and a thermostat that they could program. A thermostat is a device that controls the temperature of a room. During the winter, it lowered the temperature when they were in class and at night when they slept. This helped them use less energy to heat their house.

Aaron and his roommates made plans before taking action. "You need to do the math to **evaluate** a project," he explains.

They looked at the price you first pay for a product or service. This is called the upfront cost. Then they calculated the long-term savings of using technology that is more efficient. Long-term savings refers to the money or energy a product can save during its lifetime.

"There were challenges," he explains. "It took us time, and we had to spend some money to get started." The energy-efficient thermostat and light bulbs cost more to buy than other ones. But by using less energy, the items saved money over time. One energy-efficient light bulb, for example, uses about 70-90% less energy than a traditional one. It can also save between $30 and $80 in electricity costs over its lifetime.[6]

Aaron just finished college and will soon start working as an engineer at a refinery. There, he'll be working on larger projects than changing light bulbs and thermostats. Yet he will use the same ideas that he and his roommates worked on together. After all, he explains, "Little efficiencies can add up to make a big difference."

Directions: Read the questions below and discuss the answers with your group. On a separate piece of paper, record your answers to these questions.

1. Who is involved in this project?
2. What did they do? How?
3. Why did they take these actions?
4. What does energy efficiency mean?
5. List 2 examples of energy-efficient technology.
6. Describe another example of energy-efficient technology that was not in this case study.

CASE STUDY 3 Reducing Wasted Energy

Finding New Opportunities: Cassandra Lin Uses Grease to Heat Homes

Restaurants called it waste. Cassandra Lin called it an opportunity. Thanks to Cassandra and other students, this waste is now used to help families heat their homes in the winter. Cassandra and her friends do this by collecting cooking oil that used to be thrown away.

In fifth grade, Cassandra learned that used cooking oil could be turned into fuel. This used cooking oil is called grease. Cassandra knew that many towns and restaurants sent their grease to **landfills**. Often, a landfill is lined with plastic to stop garbage from harming the water and soil around it.

Cassandra also learned of a need in her community. "I saw an article in the newspaper that said a lot of local families could not afford to heat their homes in the wintertime," she explains. **Community organizations** in her city no longer had money to help the families.

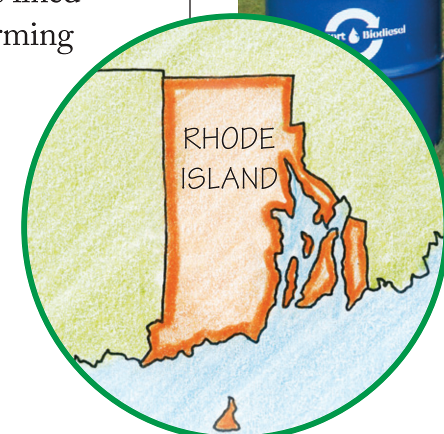
She then had an idea. People could recycle cooking oil to help these families. The cooking oil could be turned into **biodiesel**. Then the families could use the biodiesel to heat their homes. Biodiesel is a fuel made from fat or vegetable oil instead of petroleum (oil).

Cassandra began working on this idea with classmates in her hometown of Westerly, Rhode Island. They are part of Westerly Innovations Network. This group of students works on service projects to help its community.

The students did some research. They researched how biodiesel was made. The students learned that it takes less energy to produce biodiesel than other fuels. (It often takes less energy to make a product from recycled materials than from new natural resources. Recycling is just one way to reduce wasted energy. You can also waste less energy by unplugging chargers when they are not in use, and keeping doors closed when the heat or air conditioning is on.)

Cassandra and her classmates visited the water treatment plant in their town. They learned that grease could cause problems if people just poured it down the drain. The students also went to a refinery. The refinery turned cooking oil into biodiesel.

Cassandra and her friends collect used cooking oil so it can be turned into fuel.



The students also met with the organizations that helped families. The students wanted to make sure they understood these families' needs. Meeting all of these people showed the students how they could help. According to Cassandra, "We could link them all together in a system."

After they better understood the problems, the students developed a plan for working on them. "I think it was important because we had to have a structure. We could stick to a plan and follow through with it," Cassandra says. "This helped us set our goals from the beginning, and I think it was really helpful."

This planning helped the group create Project T.G.I.F.—Turn Grease Into Fuel. The students began working with local restaurants to collect grease. Some restaurants did not want to work with the students because they were so young. The students, however, did not get discouraged. They knew that **perseverance** was important.

Over time, Project T.G.I.F grew. More restaurants began working with Project T.G.I.F. And, the students also started to collect grease from other people in their town. The group even worked with lawmakers to create a law that requires businesses to recycle used cooking oil.

Today, Project T.G.I.F. is six years old. It now collects grease in Rhode Island, Massachusetts, and Connecticut. Over 150 restaurants provide the group with grease. So far, Project T.G.I.F. has helped make over 160,000 gallons of biodiesel.[7] Each year, the group is able to heat the homes of nearly 100 families. This also helps the planet. The biodiesel creates far less carbon dioxide than other fuels.[8] And, much less waste is going to landfills.

The students hope to bring Project T.G.I.F. to even more states. They know it will not be easy, but it will be worth it. Cassandra has advice for other students who want to make a difference in their communities. Her advice is simple. As she explains, "Perseverance is definitely the most important thing."

Directions: Read the questions below and discuss the answers with your group. On a separate piece of paper, record your answers to these questions.

1. Who is involved in this project?
2. What did they do? How?
3. Why did they take these actions?
4. What does it mean to reduce wasted energy?
5. List 2 examples of reducing wasted energy from this case study.
6. Describe another example of reducing wasted energy that was not in this case study.

CASE STUDY 4

Replacing Nonrenewables with Renewables

Students Use Renewable Energy and Work to Inspire Others

The students at Colegio Franklin Delano Roosevelt, The American School of Lima in Lima, Peru are not waiting for others to change the future. Instead, *they* are working to change it.

Taking care of the planet is important to many of the students at the school. Therefore, they use renewable resources, education, and teamwork to conserve energy. "It's important to conserve energy because we are all part of the future, and energy is what moves the world," explains Valeria Wu, a ninth grade student. **Energy conservation** refers to behaviors and actions that save or use less energy.

The school uses **renewable resources** for energy. Energy from the sun heats the school's swimming pool. Solar energy provides power for a classroom for the 3 to 4 year old students. Energy from the wind makes electricity for the library. Using renewable sources of energy can save nonrenewable resources and reduce pollution.

Students and teachers also created two Green Teams. One Green Team is a club for primary students. This team creates workshops and skits for the school to encourage students to take better care of the planet. "If everyone contributed just a little bit to saving energy, we could make a big difference," says Valentina Gonzalez-Maertens, a fourth grader.

Students of all ages **collaborate** to conserve energy at this school. The youngest students are three years old and the oldest are finishing high school. For example, Valeria and her classmates worked with the school to install the solar water heaters. "We were in middle school, and it was really a challenge to get people to believe that it would work," she explains. The students researched the water heaters and talked to businesses to find out how much they would cost. They then worked with the school to plan the project and install the water heaters.

The students hope that these projects are just the beginning. Using renewable energy "is important because it is a first step in the right direction," explains fifth grader Isabella Gonzalez-Maertens. "Maybe one day in the future, with so much roof space at school, we can install more solar panels to generate more energy onsite."

Valeria, Isabella, and Valentina work to inspire others to conserve energy.

Valentina and her classmates are always looking for ways to save energy. “During the day I try to use natural light from the sun instead of lights that **consume** energy. Instead of running the air conditioning that consumes a lot of energy, we open the windows,” she explains.

Like other students, Valentina turns off lights when classrooms are not being used. Some students take the bus to school or walk to save energy. “We are also trying to generate awareness in saving energy with our classmates. The idea is to save energy at school and at home,” Valentina says.

Valentina, Isabella, and Valeria all look for small things they can do each day to save energy. “We have choices, and we can have an impact—a positive impact—if we choose to,” says Isabella. To have this positive impact, the students work to share ideas with their classmates. “Educating others is very important,” Isabella says. Valeria is quick to agree with her. “One of the things that inspires me to take action is the power that ideas have to change the world, and the importance of sharing them,” explains Valeria. “I believe that we can all make a change, no matter how difficult it might seem.”

Directions: Read the questions below and discuss the answers with your group. On a separate piece of paper, record your answers to these questions.

1. Who is involved in this project?
2. What did they do? How?
3. Why did they take these actions?
4. How does using renewable resources help save natural resources?
5. List 2 examples from this case study of how renewable resources can be used to provide energy.
6. Describe another example of using renewable resources for energy that was not in this case study.

Solar water heaters are used to heat the school’s pool.

© ALLANA RUMBLE

Name Date

Energy for All

Directions: Use the following table to record what you learn about saving energy from each case study.

Case Study	**Strategy** Describe this energy saving strategy.	**Example** Describe 1 example of this strategy in action.	**Personal Goal** What is one action you could take to try out this energy saving strategy?
Case Study # 1: Energy Conservation			
Case Study # 2: Energy Efficiency			
Case Study #3: Reducing Wasted Energy			
Case Study #4: Replacing Nonrenewables with Renewables			

Pre and Post Assessment

Name Date

Pre and Post Assessment: Content Knowledge, page 1

Recall

Directions: Match the following words on the left with their definitions on the right.

1. energy	A limited resource that cannot be replaced in a short amount of time.
2. fossil fuel	A nonrenewable energy source created when dead plants and animals are exposed to heat and pressure over millions of years.
3. nonrenewable resource	A resource that can be replaced quickly and naturally.
4. renewable resource	The ability of a system to do work or cause change.

Reasoning

Directions: Circle the one best answer for each question.

5. Which of the following is an example of chemical energy?

a. gasoline
b. a siren
c. a street light
d. wind

6. What is the original source of energy stored in food?

a. consumers
b. soil
c. sunlight
d. water

Name Date

Pre and Post Assessment: Content Knowledge, page 2

7. Which of the following is a nonrenewable source of energy?

a. biomass

b. oil

c. water

d. wind

8. What is an example of energy **transfer**?

a. your car burns gasoline and makes heat

b. a domino hits a marble and makes the marble move

c. a domino hits another domino and makes a sound

d. you rub your hands together and they warm up

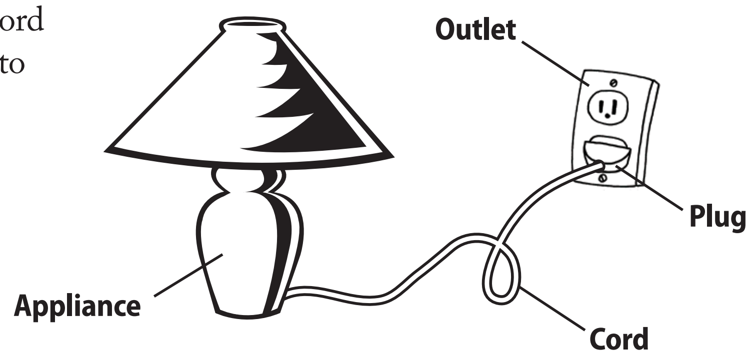
9. Which part of an electrical cord should you use to connect it to and from an outlet?

a. the appliance

b. the cord

c. the outlet

d. the plug



10. Which of these likely has the most embodied energy?

a. An apple you pick from your own tree.

b. An orange grown in your town that you buy at the store.

c. Applesauce that is made in another state.

d. Orange juice made from oranges from a different country.

Pre and Post Assessment: Content Knowledge, page 3

Directions: Use the flow chart below to answer questions 11 and 12.

The Supply Chain of a Fuel

Oil Well ⟶ Refinery ⟶ Storage Terminal ⟶ Gas Station

Refinery ↓ Co-product

11. At which step of the supply chain is a natural resource removed from the ground?

a. Gas Station

b. Oil Well

c. Refinery

d. Storage Terminal

12. Which step of the supply chain represents the demand for a product?

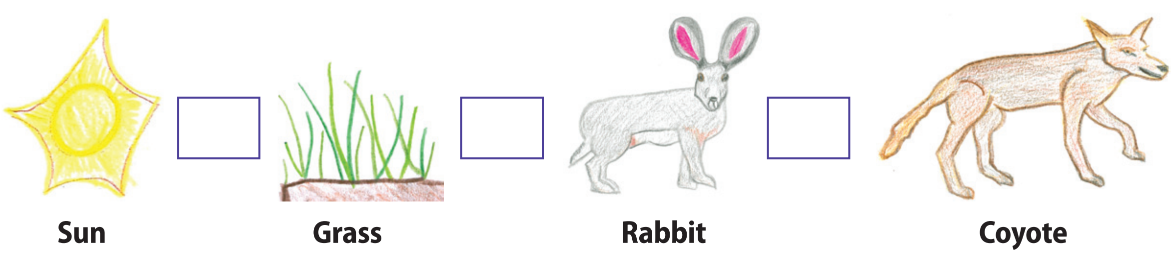
a. Gas Station

b. Oil Well

c. Refinery

d. Storage Terminal

Directions: Use the diagram below to answer questions 13 and 14.



13. Draw an arrow in each box to show the direction of energy flow in this food chain.

14. Circle the organism in this food chain that changes light energy into chemical energy.

Name Date

Pre and Post Assessment: Content Knowledge, page 4

Explanation and Analysis

Directions: Answer the following questions below using complete sentences.

15. A. Describe 1 way an ecosystem is example of a system.

B. Use 1 example or piece of evidence to support your answer.

16. A. What natural resource is used to make gasoline?

B. Describe 1 positive or negative impact on our society, economy, or environment of using this natural resource to fuel our cars and trucks.

17. A. People can use different strategies to save energy. This includes conserving energy, using energy-efficient technology, replacing nonrenewable with renewable resources, and reducing wasted energy. Choose 1 of these strategies to evaluate in questions B and C. Write your choice here:

B. Describe one specific action an individual or a community could take to save energy using this strategy.

C. Explain 1 reason why people should save energy.

Name Date

Pre and Post Assessment: Attitudes and Beliefs,[1] page 5

Directions: Select a number to show how much you agree with each statement below. One means you strongly disagree and 5 means you strongly agree.

1 = strongly disagree **5 = strongly agree**

1. I know a lot about energy and energy use.

1 2 3 4 5

2. I know how I use energy.

1 2 3 4 5

3. The choices we make about energy affect future generations of people.

1 2 3 4 5

4. The way I use energy personally affects my community and the world.

1 2 3 4 5

5. I find ways to save energy in my everyday life.

1 2 3 4 5

6. I can help solve energy problems by working with others.

1 2 3 4 5

7. I encourage others to save energy.

1 2 3 4 5

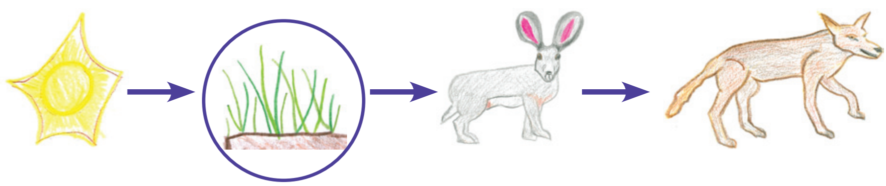
Teacher Master: Pre and Post Assessment, page 1

Recall (4 points total)

1. energy— The ability of a system to do work or cause change. (Lesson 1)
2. fossil fuel—A nonrenewable energy source created when dead plants and animals are exposed to heat and pressure over millions of years. (Lessons 4 and 5)
3. nonrenewable resource—A limited resource that cannot be replaced in a short amount of time. (Lesson 4)
4. renewable resource—A resource that can be replaced quickly and naturally. (Lesson 4)

Reasoning (10 points total)

5. a—gasoline (Lesson 1)
6. c—sunlight (Lesson 2)
7. b—oil (Lessons 4 and 5)
8. b—a domino hits a marble and makes the marble move (Lesson 1)
9. d—the plug (Lesson 3)
10. d—Orange juice made from oranges from a different country. (Lesson 6)
11. b—Oil Well (Lesson 5)
12. a—Gas Station (Lesson 5)
13. See diagram below. Arrows should point from sun to grass to rabbit to coyote. (Lesson 2; 1 point)



14. See diagram above. Grass should be circled. (Lesson 2; 1 point)

Explanation and Analysis (6 points total)

15. **A.** (Lesson 2; 1 point)
Answers will vary. Possible answers include:
    - An ecosystem has many different parts that work together.
    - Changing 1 part of an ecosystem can affect the other parts of the ecosystem.
    - There is an input of energy.

    B. (Lesson 2; 1 point)
Answers will vary. Possible answers include:
    - A tree can provide shelter for an animal, which can then transport seeds from the tree.
    - If a population of coyotes in an ecosystem decreases, then the population of rabbits in an ecosystem can increase.
    - The sun is absorbed by plants and helps plants produce food that the rest of the food chain depends upon.

Teacher Master: Pre and Post Assessment, page 2

16. **A.** (Lesson 5; 1 point)
Crude oil or petroleum

B. (Lesson 5; 1 point)
Answers will vary. Possible answers include:
- Pollution
- Amount of crude oil/petroleum will decrease
- Producing gasoline creates jobs for people

17. **A.** (Lesson 6)
Students may choose energy conservation, energy efficiency, renewable resources, or reducing waste.

B. (Lesson 6; 1 point)
Answers will vary and depend upon the type of strategy chosen. Possible answers include:

Energy Conservation:
- A person could turn off the lights when they leave a room.
- A class could shut the blinds on a sunny day instead of turning on the air conditioner.

Energy Efficiency:
- A school could use LED light bulbs instead of incandescent light bulbs.
- A person could buy an energy-efficient refrigerator.

Renewable Resources:
- A school could use solar panels to heat their swimming pool.
- A family could buy electricity from a company that uses wind farms.

Reducing Waste:
- A person or family could work to reduce food waste.
- A school could buy paper made from recycled paper.

C. (Lesson 6; 1 point)
Answers will vary. Possible answers include:
- To protect/conserve natural resources
- To reduce/prevent pollution
- To save money spent on fuel/electricity

Glossary

A B

biodiesel—A fuel made from fat or vegetable oil instead of petroleum oil.

biome—A specific region of Earth that has similar climate, plants, and animals; a biome may be made of many different ecosystems.[1]

British thermal unit (Btu)—The amount of heat required to raise the temperature of a pound of water by 1 degree Fahrenheit.

C D

case study—A real-life example that can be studied in order to learn something.

collaboration—Teamwork; working with another person or group to accomplish a shared goal.

community organization—A group of people who work together to solve problems in their city or neighborhood.

consume—To use.

consumer—An organism that does not make its own food (i.e., is not a producer). There are different types of consumers: *primary consumers,* or herbivores, eat producers (such as plants or algae); *secondary consumers* eat primary consumers; and *tertiary consumers* eat secondary consumers.

consumption—The process of using natural resources or manufactured products to satisfy human wants or needs.

co-product —A useful product that is made in a step required for the manufacture of another product.

crude oil—A liquid fossil fuel found deep within the Earth; the raw material for petroleum products such as gasoline and plastics.

decomposers—Organisms such as fungi or bacteria that use dead organisms or waste as food and in this process return nutrients to the ecosystem.

E

economy—The system of production, distribution, and consumption of goods and services.

ecosystem—A community of organisms (plant, animal, and other living organisms) that interact with one another and with the nonliving factors in their environment.

electricity—A form of energy associated with the movement of charged particles; generally produced as a secondary form of energy by converting other sources of energy, such as coal or wind, into electricity.

embodied energy—All of the energy used to grow or make something.

energy—The ability of a system to do work or cause change.

energy conservation—Behaviors and actions that save or use less energy, such as turning off the lights when you leave a room.

energy efficiency—Saving energy by choosing technology that uses less energy for the same service. For example, you might use LED light bulbs, which use less energy than other light bulbs to produce the same amount of light.

energy transfer—The movement of energy from one object to another. For example, when a falling domino hits a stationary second domino, the second domino starts moving because motion energy has been transferred from the first domino to the second one.

energy transformation—When energy is changed from one type to another. For example, the light that hits a solar cell (also called photovoltaic cell) is changed, or converted, into electrical and heat energy.

engineering—A systematic process for solving problems.[2]

evaluate—To judge an idea or action in a careful and thoughtful way.

export—To send a product or service to another country to be sold.

extraction—The process of obtaining natural resources from the land or the oceans.

F G H I

food chain—A series of organisms through which energy is transferred. Each organism feeds on the one before it (except for producers which get their energy from the sun) and is eaten by the organism following it.

fossil fuel—A nonrenewable energy source created when dead plants and animals are exposed to heat and pressure over millions of years.

heat—Also called thermal energy, heat is the random motion or vibration of particles in a substance.

import—To bring a product or service into a country to be sold.

infrastructure—The basic facilities, services, and installations needed for the functioning of a community or society, such as transportation and communication systems, roads, water, power lines, and public institutions such as schools, post offices, and libraries.

J K L

landfill—A place where garbage is buried. Often, a landfill is lined with plastic to stop garbage from harming the water and soil around it.

law of conservation of energy—Energy cannot be created or destroyed, but it can be transferred or transformed.

light—Energy that travels in transverse waves (waves that move perpendicular to the forward motion) and can travel in a vacuum or through a substance such as water. Light energy is a visible form of electromagnetic radiant energy. However, radiant energy includes forms that are not visible, such as infrared, ultraviolet, x-ray, gamma ray, and radio waves.

M N

motion—Energy of a moving object. The faster an object moves, the more motion energy it has.

natural resource—Something from nature that people can use.

nonrenewable resource—A limited resource, such as coal, natural gas, or oil, that cannot be replaced in a short amount of time.

O P

perseverance—The characteristic of continuing to try when things become difficult.

perspective—A point of view or particular attitude toward something.

producer—An organism that is able to make its own food (e.g., plants and algae).

Q R

renewable resource—A resource, such as biomass, sunlight, water, or wind, that can be replaced quickly and naturally.

responsibility—Something you do because it is right or legally required.

Rube Goldberg machine (or Rube Goldberg contraption)—A silly and complicated invention designed to perform a simple task.

S

sound—Energy that moves through substances such as air or water in a back-and-forth motion (longitudinal waves). Sound travels in a similar way to a slinky that has been pulled straight out and released.

supply and demand—The amount of a product that is available (supply) and the amount of a product that is wanted by customers (demand).

supply chain—All the steps, resources, people, and businesses it takes to get a product or service from supplier to customer.

sustainability—The principle of meeting current needs without limiting the ability of future generations to meet their needs.

system—A collection of many interconnected parts that work together; changing one part affects other parts.

T U V W

technology—The use of scientific knowledge to create tools or solve problems.

transportation—The carrying of people, animals, or goods from one place to another.

watt—A measurement of electrical power.

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LESSON 6

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PRE AND POST ASSESSMENT

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Fueling Our Future:
Exploring Sustainable Energy Use

Student Engagement and Achievement

Energy is an engaging topic that is relevant to students' lives inside and outside the classroom. *Fueling Our Future* includes hands-on activities that engage students in a rigorous and personal exploration of energy and lessons that provide opportunities to learn 21st century skills. Lessons in this unit are aligned to Common Core State Standards, and the principles and concepts outlined in the U.S. Department of Energy's *Energy Literacy: Essential Principles and Fundamental Concepts for Energy Education.*

Global Knowledge and Competency

Fueling Our Future presents students with multiple perspectives on important energy issues facing our world today. Topics include personal energy use, energy flow through ecosystems around the world, and the global supply chain of fuel. The unit culminates with a lesson that showcases young people from around the world implementing energy conservation strategies in their homes, schools, communities and beyond. Lessons allow students to grapple with these real-world issues and to formulate their own perspectives on how to respond positively.

Interdisciplinary Connections

Energy is a generative topic that spans many disciplines. *Fueling Our Future* engages students in an authentically interdisciplinary study of energy through six student-centered lessons that cover important energy concepts from basic energy science, to the economics of oil, to the characteristics of a successful energy conservation project. Students use art, calculations, maps, and nonfiction text to demonstrate understanding of these interdisciplinary ideas and to gain a holistic view of human energy use.

Application and Assessment

Throughout *Fueling Our Future,* students are invited to apply learned concepts to their own lives, and the final lesson provides a launchpad for students to apply these concepts to a class or school energy action project. The unit contains multiple and varied opportunities for assessment, such as acting, drawings, discussions, predictions and conclusions, presentations, and individual and group products. This unit includes a pre and post assessment designed to show students' growth in content knowledge, ability to analyze energy concepts, and personal energy-related attitudes and behaviors toward energy consumption and energy resources.

What Educators Say:

"This lesson beautifully blends science and social studies, engaging students in global map activities while teaching about fossil fuels. Students were highly engaged and felt they were learning something that was really important."

—**Eileen Hynes**, Director of Thematic Studies, Washington

"I think [this lesson is] a great way to help kids continue to make connections about energy. It's important for students to make cross-references with the knowledge they learn and apply their knowledge in new settings and situations. I feel this lesson helped them to further understand transfer and conservation of energy. They immediately made the connection to the first two lessons I taught. . .and very easily explained the connections with the concept of systems."

—**Emily Gold**, Gifted Education Teacher, Missouri

Facing the Future

Western Washington University

Facing the Future is an independent program of Western Washington University.