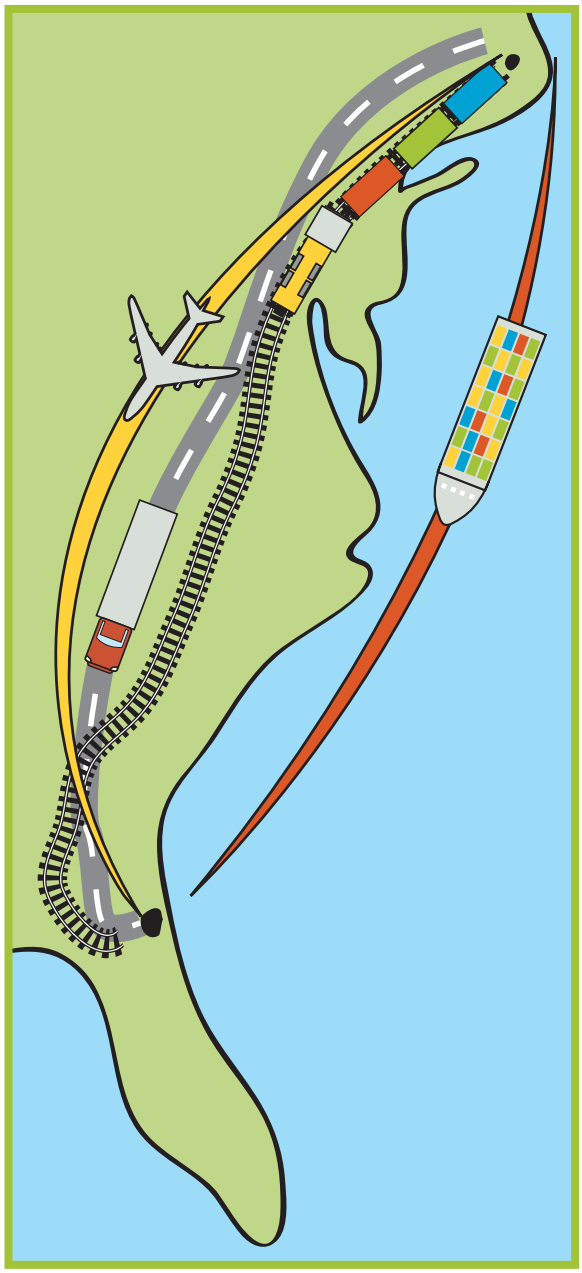
Moving Freight: Economy and Atmosphere

A curriculum unit investigating cargo transportation choices and their impacts on the environment



The movement of goods around the world impacts everything from how you get the clothes you wear to the global economy to climate change. Moving Freight: Economy and Atmosphere is designed to develop an awareness of how the goods we use everyday move through our world, as well as how our freight transportation choices have far reaching impacts on the economy and environment.

Transportation of goods is a complex real-world issue. The activities and subsequent discussions that make up this unit address core issues in science, math, and social studies. In mathematics it incorporates common core standards on measurement, calculations, comparison and data presentation. In science the activities crosscut concepts on systems, energy and matter, and stability and change. In social studies it addresses outcomes on economy, development of civilizations, and global interconnectedness.

Through these activities students will become aware that the train tracks they drive over and the trucks they pass on the highway everyday are connected to a world-wide web of industry, culture, commerce and environmental impact.

Activity Outline

This curriculum unit is divided up into activities that build with increasing complexity. They are designed to be used either individually or as a unit.

From There to Here

Students compare and contrast the efficiency of freight transportation in ships, trains, trucks and airplanes. Students will consider how the freight transportation choices differ in regard to speed, cost and environmental impact.

Fuel Efficiency and Our Atmosphere

Students will read information and look at illustrations about the carbon cycle and green house gasses. Students will discuss the impact that burning fossil fuels has on the environment.

From Farm to Food to You

Students will investigate options for the transportation of agriculture products by following the transport of wheat grown in Ohio to the pretzel factory in Pennsylvania to a school in Virginia.

Intermodal Transportation

Students will identify the transportation route that goods could take from any singular spot in the world to their school. Students will then calculate, compare and contrast the carbon dioxide produced from at least two different combinations of shipping modes for those goods.

Numbers and Sources

The numbers used for miles per hour are industry estimates used for the purpose of comparison. The fuels per ton rates are provided by CSX Transportation Corporation. The pounds of carbon dioxide coefficients are from the US Energy Information Administration, www.eia.gov.

Key

T Teacher Pages

S Student Pages

Sponsors

Moving Freight: Economy and Atmosphere is sponsored by the partnership of CSX Corporation and The Conservation Fund. CSX Corporation's National Gateway program strives to support and educate states and communities to efficiently and economically create safer, less congested roadways, bolster environmental health and promote economic growth. The Conservation Fund is a national non-profit organization with the mission is to protect our nation's land and water resources. As the Conservation Fund is the only major conservation non-profit with a dual charter to pursue economic development and environmental preservation, The Conservation Fund works on the ground across the country to help its partners, like CSX, fulfill their conservation priorities, protecting and enhancing landscapes where Americans work, play and rediscover history.

Thank you

Thank you to the following educators for their thoughtful review:

Robert Carroll, Virginia Beach Public Schools

Dr. Michelle Comer, University of Maryland Baltimore County

Dr. Phil Kelly, Gannon University

Bart Merrick, NOAA Chesapeake Bay

Ursula Pece, Fairfax County Public School

Moving Freight: Economy and Atmosphere was created by Willow Oak Group, LLC

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Willow Oak Group

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From There to Here

Understanding How the Shoes Get to Your Feet

T

Freight transportation is the commercial transport of goods. Most of the products and goods which make up our daily lives originate from somewhere else. These global patterns of production and movement of goods reflect an increasingly interconnected and complex world of commerce. Although trucks, trains and planes are frequently a barely noticed background noise of modern life, freight transportation has significant economic, environmental and societal implications. This activity is designed to educate us on the basic process of bringing something from where it is produced (there) to where we live (here). It is a direct comparison of the efficiency of truck, train, ship, and plane transportation.

Key Concepts

The key concepts of this activity are:

- All the products that make up our lives have to move from where they are made to where they are purchased.
- Cargo transportation options include: trucks, trains, ships and planes.
- Fuel consumption and speed are ways to measure the efficiency of each transportation choice

Introduction

Students will investigate options for transporting sneakers made in Boston, Massachusetts, to Jacksonville, Florida. These two cities were chosen for this example because both Boston and Jacksonville have freight airports, deepwater seaports, interstate highways and freight rail lines, therefore the two cities set up an opportunity for a direct comparison between the four major cargo transportation options. It is a realistic scenario because New Balance running shoes are manufactured in Massachusetts near Boston and there are plenty of malls in Jacksonville that sell these shoes.

Freight shipment is typically calculated by the ton; therefore this activity focuses on shipping tons of sneakers. Students will measure the distance on the map, calculate the amount of time and fuel that it takes to get a pair of sneakers manufactured in Boston to a mall in Jacksonville. The assumption could be made that the more fuel used could lead to higher costs and increased pollution, and the discussion questions will hopefully lead to weighing different aspects of these assumptions and other extenuating factors.

Summary:
Students will compare and contrast the efficiency of freight transportation for the following modes: ships, trains, trucks and airplanes. Students will consider how the freight transportation choices differ in regards to speed, cost and environmental impact.

Grade level:
3-6
7-12

Time of activity
45 Minutes plus extension questions

Materials
Student pages and ruler

Curricular goals:
Mathematics: The student will represent and analyze number relationships in a table or a graph.

Mathematics: The student will apply division of algebraic expressions to mathematical and real-world problems.

Economics: The student will explain how people make choices in response to market forces.

From There to Here

Understanding How the Shoes Get to Your Feet

Calculations and Extensions

The calculations are presented differently in the pages for grades 3-6 and the pages for grades 7-12. Depending on your students experience with division and making graphs, consider modeling the first calculations with them.
In the pages for grades 7-12, nautical miles are used in the air and water calculations. But those nautical miles do not take into consideration the actual flight pattern or shipping route that arcs further out over the water or land. You might want to add this calculation into your activity.

The discussion questions and extension activities are the same in the pages for grades 3-6 and 7-12. Depending on the age level and student experiences, your discussion will vary greatly.

An excellent idea for extension activities is to investigate what happens if some of the assumptions are changed, such as if a truck takes a longer route or if the train moves slower. Encourage your students to do web searches of freight transportation calculations. A challenge is that airline fuel is measured in pounds as opposed to gallons. However this sets up additional extension activities for investigating jet fuel and comparing it to diesel fuel.

Guide to Answers on the Student Pages — Grades 3-6

Truck
1,000 miles/55 miles per hour = _____ 18.18 hours_____
1,000 miles/140 miles per gallon of fuel = _____ 7.14 gallons_____

Train
1,000 miles/40 miles per hour = _____ 25 hours_____
1,000 miles/468 miles per gallon of fuel = _____ 2.1 gallons_____

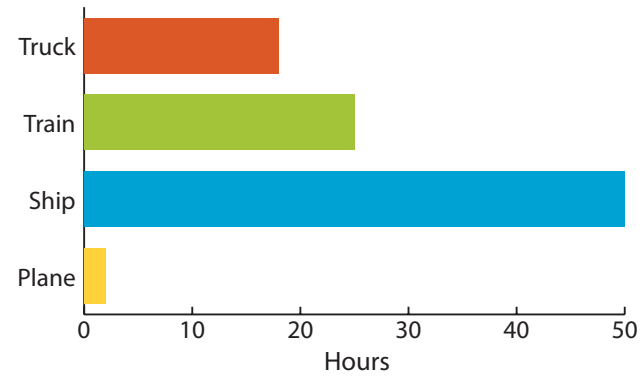
Ship
1,000 miles/20 nautical miles per hour = _____ 50 hours_____
1,000 miles/576 miles per gallon of fuel = _____ 1.74 gallons_____

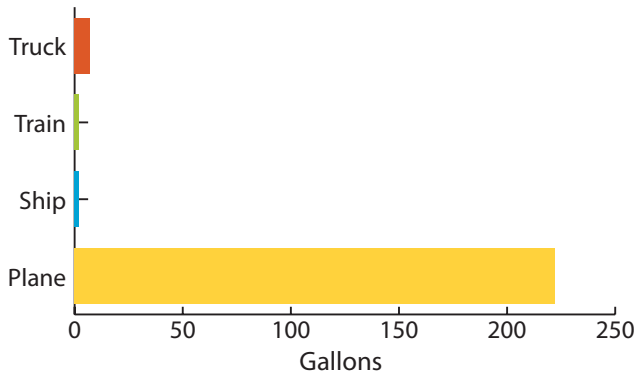
Plane
1,000 miles/560 miles per hour = _____ 1.78 hours_____
1,000 miles/4.5 miles per gallon of fuel = _____ 222.2 gallons_____

So, Who Cares About Fuel Efficiency?

The most obvious answer is that using less of any expensive natural resource saves people and businesses money. However there are other reasons to reduce your fuel consumption. Fuel efficiency can also reduce climate change impacts, increase energy sustainability and reduce oil dependent costs. The next activity "Fuel Efficiency and Our Atmosphere" goes into depth about the importance of fuel efficiency to climate change. For additional information visit the official government site for fuel economy information: www.fueleconomy.gov/feg/why.shtml

Sample Graphs





From There to Here

Understanding How the Shoes Get to Your Feet

Guide to Answers on the Student Pages — Grades 7-12

Truck
1,100 miles/55 miles per hour = _____ 20 hours_____

1,100 miles/140 miles per gallon of fuel = _____ 7.86 gallons_____

Train
1,100 miles/40 miles per hour = _____ 27.5 hours _____

1,100 miles/468 miles per gallon of fuel = _____ 2.35 gallons _____

Ship
900 miles/20 nautical miles per hour = _____ 45 hours _____

900 miles/576 miles per gallon of fuel = _____ 1.56 gallons_____

Plane
900 miles/560 miles per hour = _____ 1.6 hours _____

900 miles/4.5 miles per gallon of fuel = _____ 200 gallons _____

Conclusion and Discussion Extension

The plane is the fastest, and the ship is the most fuel efficient. The train might be the best combination of both, using these calculations.

The following discussion topics are designed to provoke thought about the complexity of the issue not to be definitively right or wrong:

Extenuating circumstances could be the costs of the different types of fuel or that the actual distance travelled by each means may be very different due to weather, flight patterns, existing rail lines, roads and traffic. In addition there are other costs to be considered such as labor and infrastructure costs.

The train may be the best transportation choice for the shoes. Cargo that is time sensitive or may expire may need to be shipped in the fastest as opposed to most fuel efficient manner. Discuss the limitations of different types of cargo.

The pros and cons of each transportation option can vary when additional factors are addressed, such as: road and rail maintenance and construction, weather, traffic, labor needs, flexibility, needing to be in bulk quantities, infrastructure needs (airports, seaports, train stations), wildlife impacts, etc.

The question of environmental impact is to set up the next activities about carbon and intermodal shipping. There is an assumption that the less fuel that is used is better for the environment. However there can be additional environmental impacts beyond the impact of carbon emissions such as the environmental impact of the infrastructure (roads, rails, shipyards) needed for the transportation of cargo, and even how freight transportation choices can affect how areas are developed. Avoid coming to definitive conclusions because each choice has impact; simply discuss different possible ways to measure the environmental impact. Brainstorm the many types of environmental impacts for instance, water quality issues or noise pollution, and consider what types of environmental impacts may be more significant than others.

From There to Here

Understanding How the Shoes Get to Your Feet

S
3-6

Everything that makes up our lives comes from somewhere. Most likely the shoes on our feet, clothes on our back, computers we use, books that we read, and food that we eat all were made somewhere else and transported to stores, restaurants and schools near to us.

Consider this example:

Someone in Jacksonville, Florida, and you would love a pair of sneakers that are made in factories near Boston, Massachusetts.

Look at the map to the right and brainstorm at least 3 different ways that the shoes can get from the factory in Massachusetts to a store in a mall store in Florida.

_____

_____

_____

_____

Draw a line from Boston to Jacksonville. Measure the line and calculate how far the distance is in miles:

_____

What do you think would be the most efficient way to transport the shoes from Boston to Jacksonville? Why do you think that is the most efficient way?

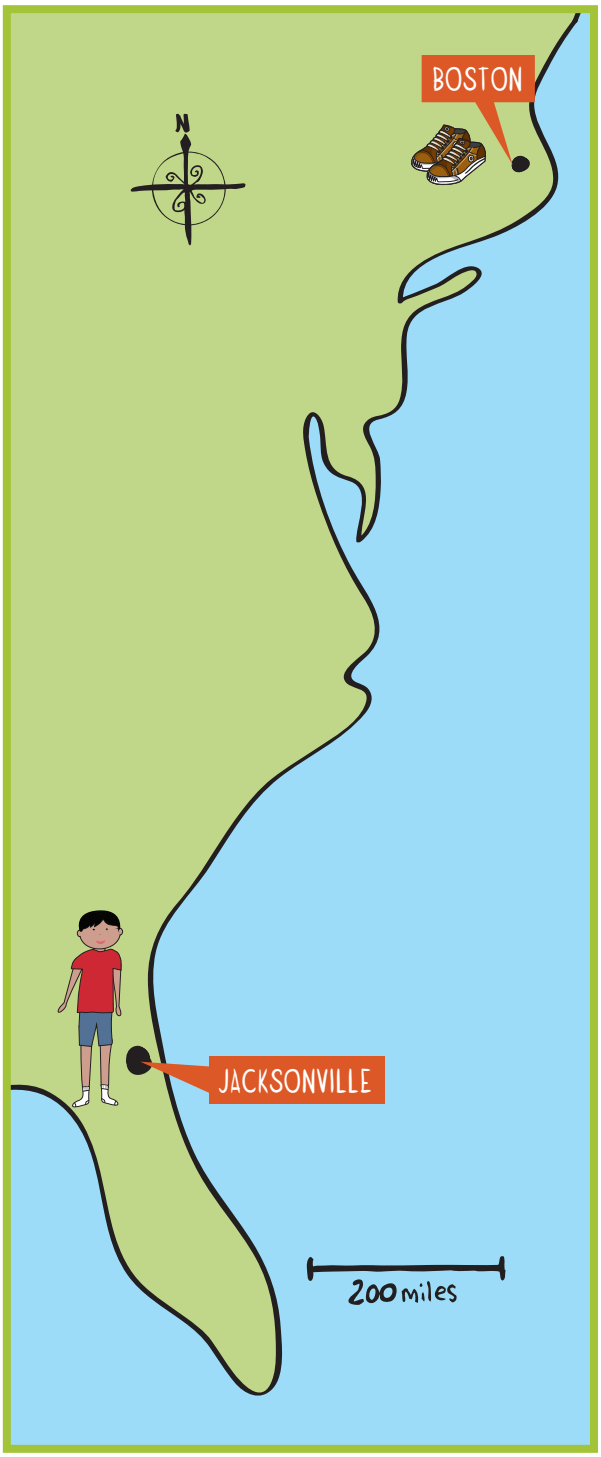
_____

_____

_____

_____

_____



From There to Here

Understanding How the Shoes Get to Your Feet

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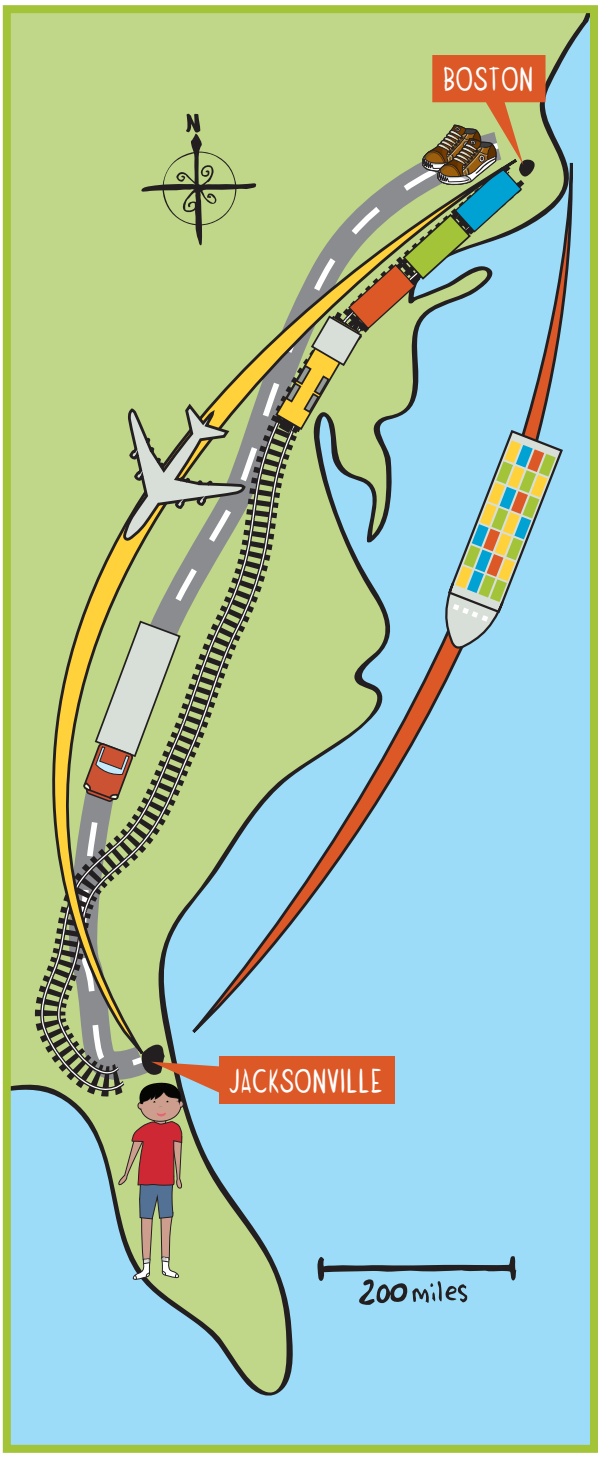
3-6

The most likely path for the shoes from Boston to Jacksonville is one of the four main ways that freight is transported in the industrialized world: Truck • Train • Ship • Plane

To be efficient, we need the shoes to travel as fast as possible with the least amount of fuel.



Truck
A freight-liner truck can average 55 miles per hour. How many hours would it take to travel 1000 miles?

_____

A fully loaded truck can travels 140 miles per gallon of fuel per ton of cargo. Assuming it is a fully loaded truck, how much fuel is needed for the one ton of cargo to travel 1,000 miles?

_____

Train
A freight train can average 40 miles per hour. How many hours would it take to travel 1000 miles?

_____

A fully loaded freight train can travel 468 miles per gallon of fuel per ton of cargo. Assuming it is a fully loaded freight train, how much fuel is needed for the one ton of cargo to travel 1,000 miles?

_____

Ship
A cargo ship can average 20 nautical miles per hour. How many hours would it take to travel 1000 miles?

_____

A fully loaded cargo ship can travel 576 miles per gallon of fuel per ton of cargo. Assuming it is a fully loaded ship, how much fuel is needed for the one ton of cargo to travel 1,000 miles?

_____

Plane
A freight plane can average 560 miles per hour. How many hours would it take to travel 1,000 miles?

_____

A fully loaded freight plane travels 4.5 miles per gallon of fuel per ton of cargo. Assuming it is a fully loaded plane, how much fuel is needed for the one ton of cargo to travel 1,000 miles?

_____

From There to Here

Understanding How the Shoes Get to Your Feet

S
3-6

Why is speed important? _____

_____

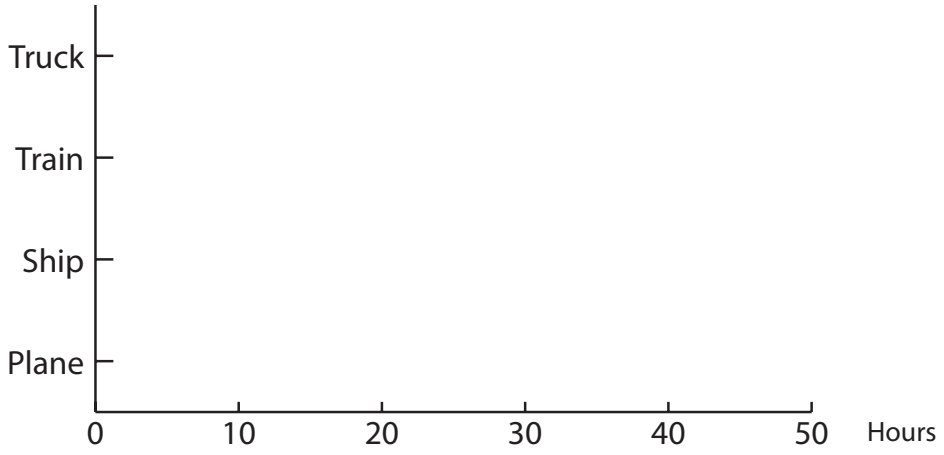
Why is fuel efficiency important? _____

_____

Create and label bar graphs to represent your calculations

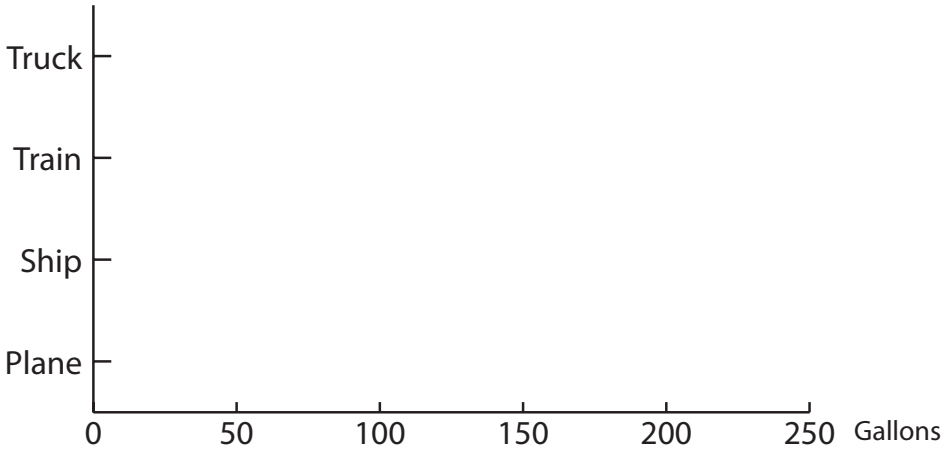
How many hours would it take to get the shoes from Boston to Jacksonville?

Title of graph: _____



How many gallons of fuel would it take to get the shoes from Boston to Jacksonville?

Title of graph: _____



From There to Here

Understanding How the Shoes Get to Your Feet

S
3-6

Conclusions:

1. Based solely on your calculations, which is the fastest method? _____

2. Based solely on your calculations, which uses the least amount of fuel per ton transported? _____

3. Which do you think is the best combination of speed and fuel efficiency? _____

Extension Discussion Questions

1. How would other circumstances (such as weather, or the availability of train tracks, ship yards, roads and traffic) change your calculations? _____

_____

_____

2. If you were the manufacturer deciding the most efficient means to transport the shoes, which way would you choose: train, truck, plane or ship? Why? _____

_____

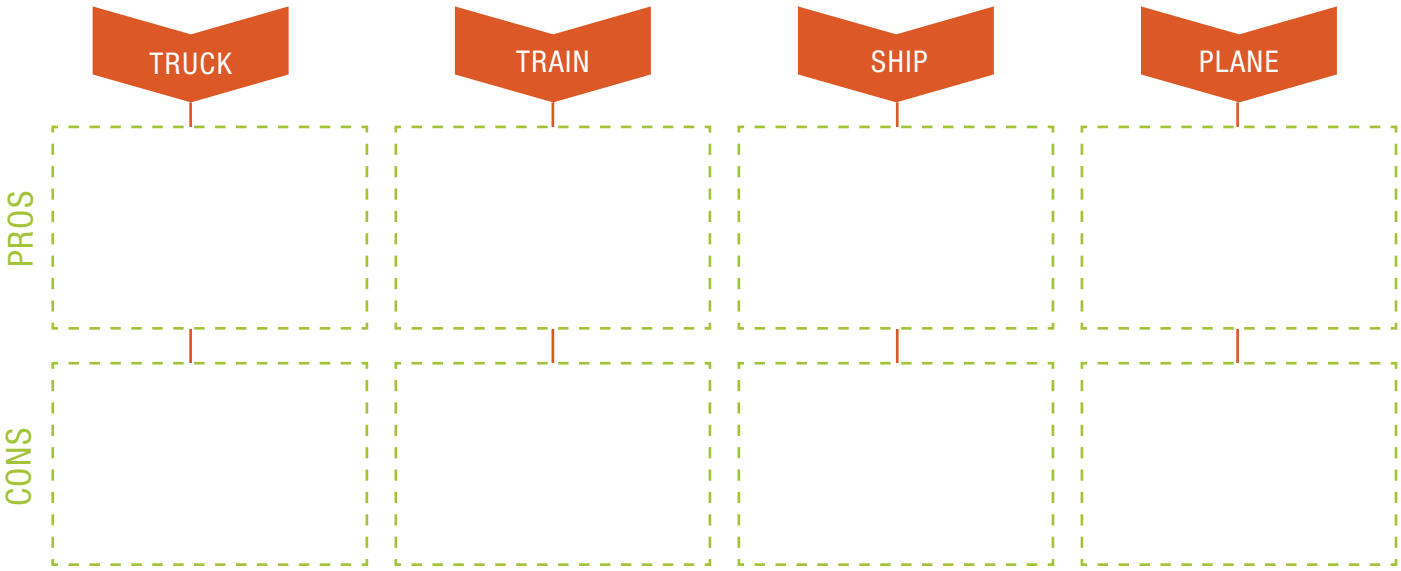
_____

3. Consider the cargo. For what type of cargo would speed be more important than fuel efficiency? For what type of cargo would fuel efficiency be more important than speed? Why? _____

_____

_____

4. There are pros and cons for each type of cargo transportation choice. Compare and contrast the methods of cargo transportation, consider types of cargo, environmental impact, weather, roads and fuel costs. Come up with at least two pros and cons for each method of transportation.



5. Consider the environmental impact of the transportation choices. Which transportation choices do you think have a lesser environmental impact? Why? _____

_____

_____

From There to Here

Understanding How the Shoes Get to Your Feet

S
7-12

Everything that makes up our lives comes from somewhere. Most likely the shoes on our feet, clothes on our back, computers we use, books that we read, and food that we eat all were made somewhere else and transported to stores, restaurants and schools near to us. Rail, truck, ship and air are the four main means of transporting cargo in the industrialized world. Each method of transporting cargo has its benefits and its drawbacks. Existing infrastructure, cost of fuel and time needed are all elements that contribute to how an industry chooses which methods to use.

Consider this example:

Someone in Jacksonville, Florida would love a pair of shoes that are made in factories near Boston, Massachusetts. What do you think would be the most efficient way to transport the shoes from Boston to Jacksonville? Why do you think your choice would be the most efficient mode of transportation?

Truck
A fully loaded truck can average 55 miles per hour and travel 140 miles per gallon of fuel per ton of cargo.

Train
A fully loaded freight train can average 40 miles per hour and travel 468 miles per gallon of fuel per ton of cargo.

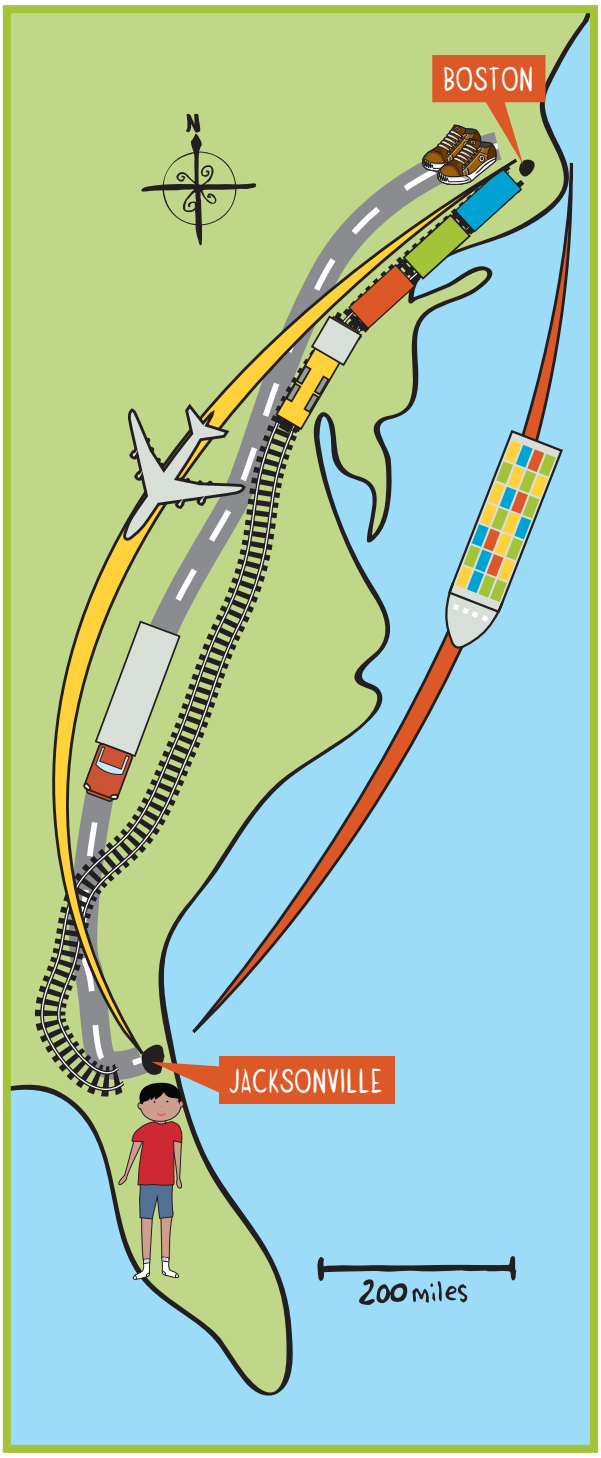
Ship
A fully loaded cargo ship can average 20 nautical miles per hour and can travel 576 miles per gallon of fuel per ton of cargo.

Plane
A fully loaded freight plane can average 560 nautical miles per hour and travel 4.5 miles per gallon of fuel per ton of cargo.

Calculation:
For this exercise, assume that the train, ship, truck, and plane are each fully loaded with one ton of cargo. Calculate and compare how much time and fuel is needed for the one ton of cargo to travel from Boston to Jacksonville using each method. By road or rail there is approximately 1,100 miles from Boston to Jacksonville. By air or water there is approximately 900 nautical miles between the two cities.

Create two bar graphs, one for fuel used and one for hours needed to complete the shipment.

Use those bar graphs to answer the discussion questions on page 11.



From There to Here

Understanding How the Shoes Get to Your Feet

S
7-12

Conclusions:

1. Based solely on your calculations, which is the fastest method? _____

2. Based solely on your calculations, which uses the least amount of fuel per ton transported? _____

3. Which do you think is the best combination of speed and fuel efficiency? _____

4. What are other extenuating circumstances that would change the accuracy of your calculations?_____

_____

Extension Discussion Questions

1. If you were the manufacturer deciding the most efficient means to transport the shoes, which way would you choose: train, truck, plane or ship? Why? _____

_____

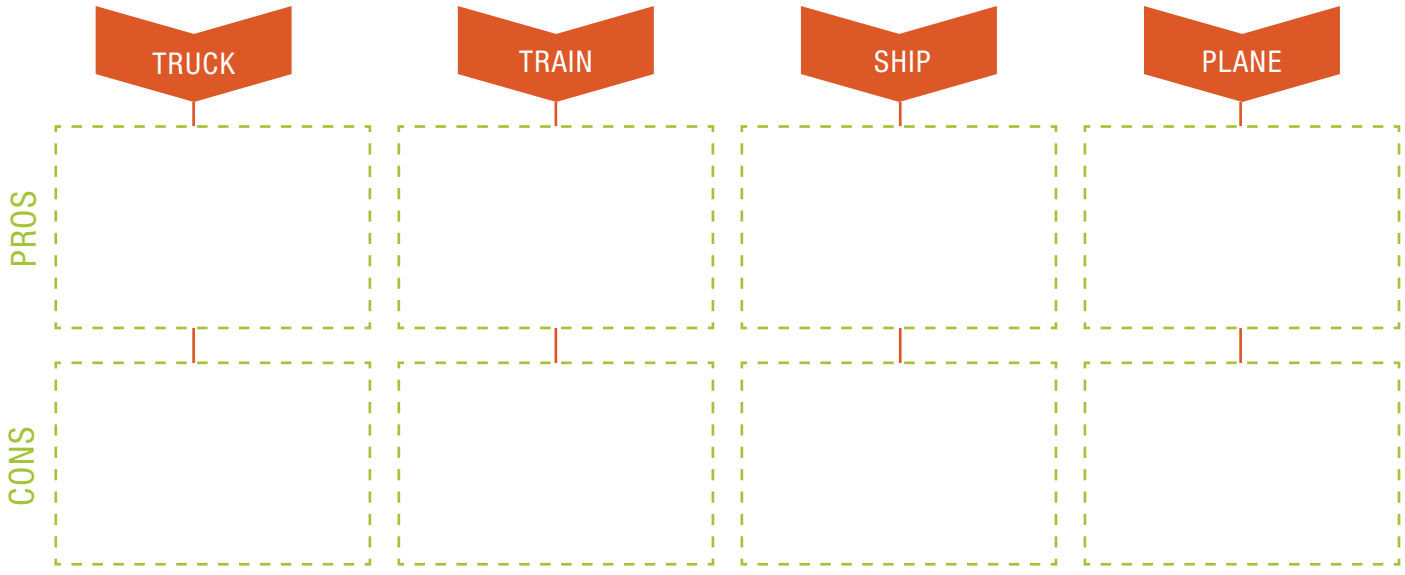
_____

2. Consider the cargo. For what type of cargo would speed be more important than fuel efficiency? For what type of cargo would fuel efficiency be more important than speed? Why? _____

_____

_____

3. There are pros and cons for each type of cargo transportation choice. Think about the larger implications and decisions that would need to be made if you were the manufacturer, such as types of cargo, environmental impact, weather, infrastructure, and fuel costs. Come up with at least two pros and cons for each method of transportation.



4. Consider the environmental impacts of the transportation choices. There are environmental impacts surrounding the fuel use and infrastructure needed for each transportation choice. Which transportation choices do you think have a lesser environmental impact? Why? _____

_____

_____

_____

TEACHER PAGE

Fuel Efficiency and Our Atmosphere

T

People around the world are talking about carbon footprints, fuel efficiency, and alternative fuels. To understand why this is an issue of global concern, first we have to review what carbon is and how it moves through our planet and atmosphere.

Key Concepts

The key concepts of these activities are:

- The burning of fossil fuels adds significant amounts of carbon dioxide into the atmosphere.
- Excess greenhouse gasses in the atmosphere leads to changes in our global climate system.
- Reducing the amount of carbon dioxide in the atmosphere requires both a reduction in use of fossil fuels and an increase in the conservation of forested lands.

Introduction

This activity was designed to be a tool to use with your students when investigating how freight transportation choices, as well as other choices that result in the burning of fossil fuels, leads to changes in our global climate system. This activity was not designed to be the only discussion of carbon cycle or climate change that you would conduct with your students.

Teaching about greenhouse gasses, fossil fuels and climate can be contentious but keep the focus on making observations not judgments. Encourage your students to consider potential bias of sites when researching on line. Have them confirm when they are reading data and when they are reading an interpretation. Also, have them discuss how different data can come from different methodologies of collecting data, and analysts look for overall trends across all methodologies.

Summary:
Students will read information and look at illustrations about the carbon cycle and greenhouse gasses and discuss the impact that burning fossil fuels has on climate change.

Grade level
4-12

Time of activity
Two 45 Minute activities

Materials
Student pages and internet search capability (for the grade 7-12 final activity)

Curricular goals
Science: Students will explain how the carbon cycle is a set of processes in which carbon changes form and moves through the earth ecosystem.

Students will examine how humans influence the global carbon cycle in several ways, including through the burning of fossil fuels.

More information

All of the web sites referenced in the activity were sources for the information in the activity, as well as the following articles.

- The Conservation Fund's "Go Zero" Program http://www.conservationfund.org/gozero
- Climate Change Glossary http://www.conservationfund.org/climate_change_glossary

Excellent examples of other curricula investigating of the carbon cycle, both supported by the National Science Foundation:

- The Carbon Cycle by Dr. John Arthur Harrison, from Vision Learning, http://www.visionlearning.com
- The Climate Literacy and Energy Awareness Network http://cleanet.org/clean/educational_resources/index.html

Emissions data is collected on the following intergovernmental sites:

- US Energy Information Administration http://www.eia.gov/totalenergy/
- Carbon Dioxide Information Analysis Center http://cdiac.ornl.gov/

Fuel Efficiency and Our Atmosphere

Guide to Student Pages

T

Fuel Efficiency and Our Atmosphere

Carbon Dioxide, Greenhouse Effect and Carbon Sinks | Student Pages 4-12

Depending on your students' experience, they may know the answers to the questions. If not, here are two paragraphs to read aloud and have them answer the questions on their sheet.

Carbon is one of the most abundant substances on the planet. Carbon is an essential part of life. It is in our food, in our cells, in the trees and rocks around us and even in the air we breathe. Carbon dioxide [CO2] is a gas that is a one carbon molecule [C] connected to two oxygen molecules [O2]. Carbon dioxide is also one of the important greenhouse gasses which help regulate the earth's temperature. Excess greenhouse gasses in the atmosphere can disrupt the balanced global climate system.

Every time fossil fuels are burned carbon, which had been stored in the earth's crust for millions of years, is released into the air as carbon dioxide. Fossil fuels, which include coal, oil and natural gas, are usually burned for many of our everyday actions such as heating and cooling our buildings, turning on lights and driving a car. Burning fossil fuels is one way that humans create excess carbon dioxide in our atmosphere. Carbon footprint is a term used to describe the amount of carbon dioxide released into the air as a result our actions.

Fuel Efficiency and Our Atmosphere

Carbon and You | Student Pages 4-12

1. When we breathe we exhale and release carbon dioxide. When we drive a car we also release carbon dioxide. If those are both ways in which we release carbon dioxide, why is only the burning of fossil fuels considered something that we should try to reduce?

Because unlike breathing, the burning of fossil fuels removes stored carbon from the earth's crust and releases it as carbon dioxide. In other words, it is adding carbon dioxide to the atmosphere much faster and in a higher quantity than biological and geochemical processes.

2. Consider your own carbon dioxide contributions using the following chart:

Answers will depend on student's experiences, opinions and ideas.

3. Think of natural areas in your community. Would you call them effective carbon sinks? Why or why not? And

4. How would you create an effective carbon sink?

For natural areas, such as wetlands and forests, to be considered effective carbon sinks they must be a preserved and healthy ecosystem. For example, planting a tree alone is not nearly as effective as planting a tree in a forest preserve. In a forest, the potential of each tree is maximized by the ecological function of the entire forest, the forest understory, soils and microorganisms all play a role in storing carbon for the long term. In addition it is only through knowing a tree will be preserved in a forest that you can make the assumption that carbon dioxide will truly be sequestered.

5. What else could you do to reduce the effect of your carbon footprint?

Answers will depend on student's experiences, opinions and ideas.

Fuel Efficiency and Our Atmosphere

Numbers in the Footprint | Student Pages 7-12

Looking at Data:

This student page is more complex and has several references to online sources that could be used as a way to further the discussion. The answers depend on what specific sites they visit.

1. 1 to 155 tons

2. 420 million tons

The other questions will depend upon the students' experiences and knowledge and what sites they visit.

Fuel Efficiency and Our Atmosphere

Carbon Dioxide, Greenhouse Effect and Carbon Sinks

S
3-12

People around the world are talking about carbon footprints, fuel efficiency, and alternative fuels. But what is a carbon footprint? And why are we looking for ways to use less fuel? To understand why, first we have to review what carbon is and how it moves through our planet.

First a few questions in review:

What are some examples of things that contain carbon?

_____

_____

_____

_____

What is carbon dioxide and what are a few ways it is produced?

_____

_____

_____

_____

What is a carbon footprint?

_____

_____

_____

_____

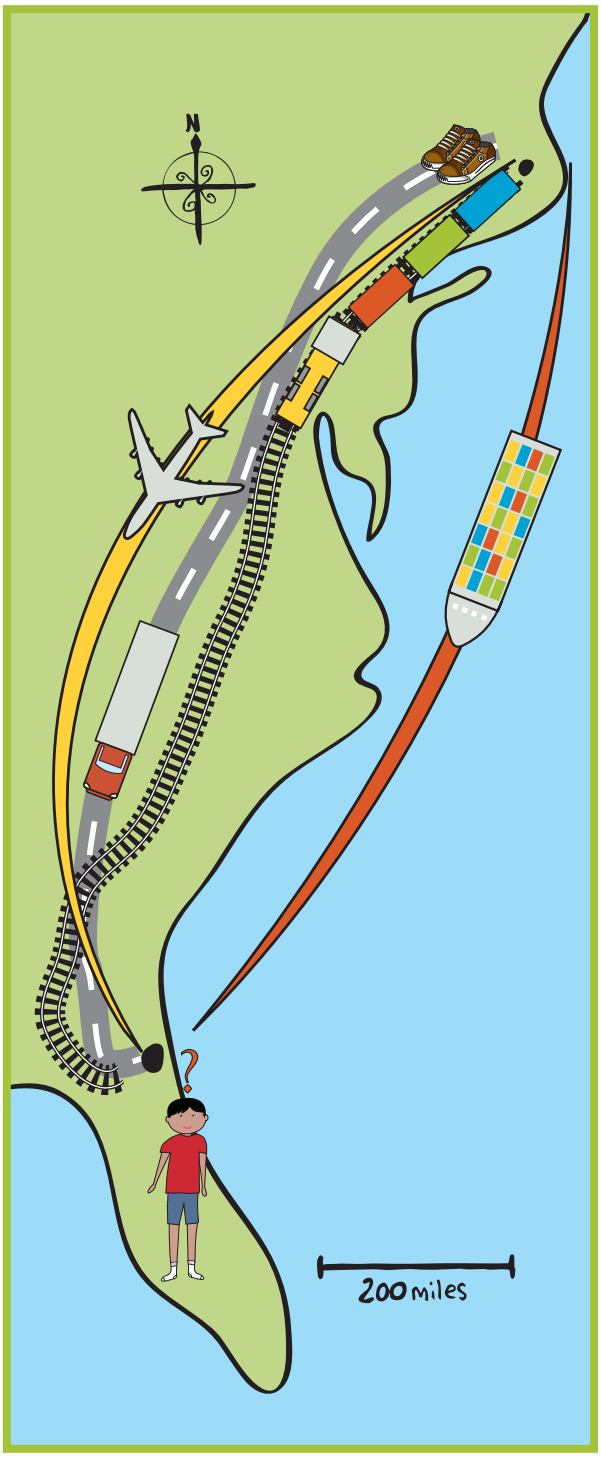
What are greenhouse gasses, and why are they significant?

_____

_____

_____

_____



Fuel Efficiency and Our Atmosphere

Carbon Dioxide, Greenhouse Effect and Carbon Sinks

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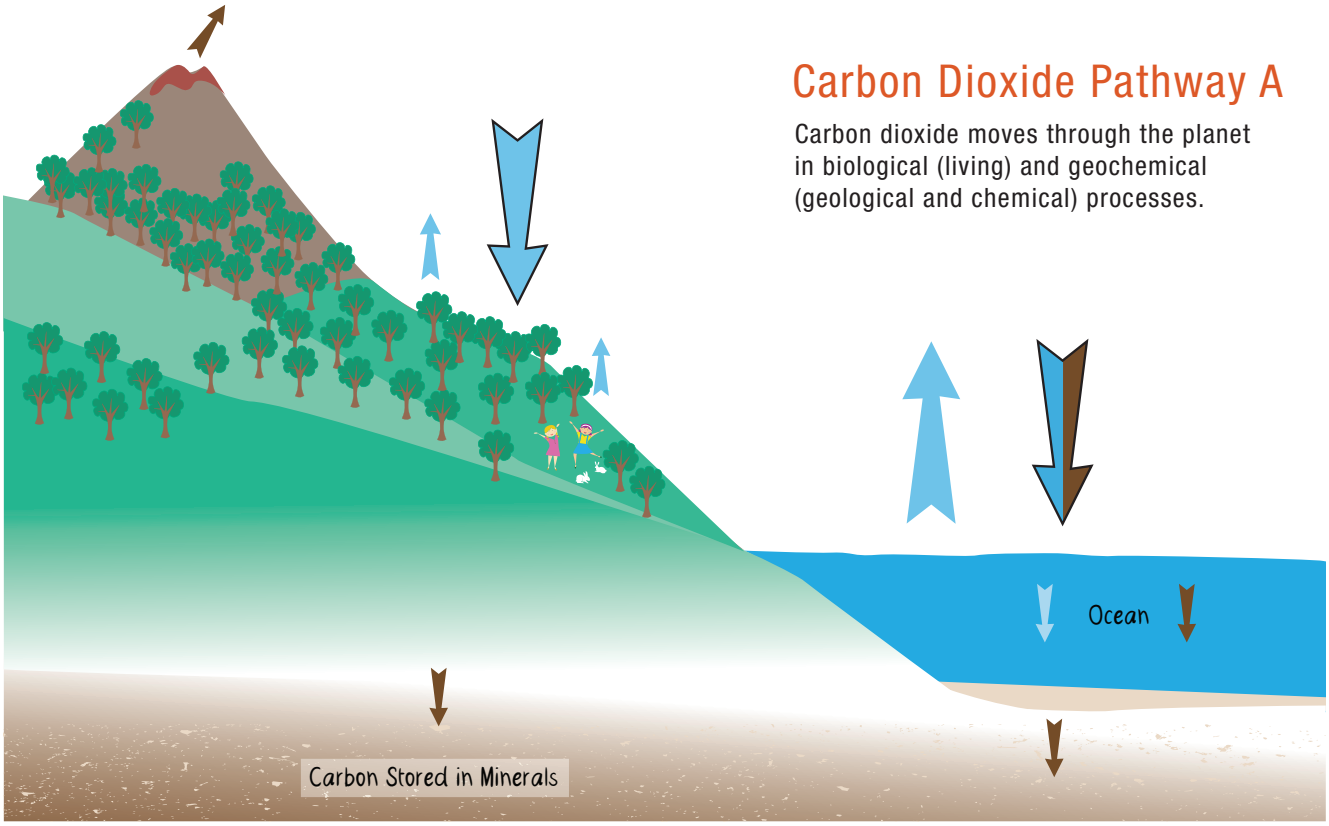
3-12



This illustration shows the releases and intakes of carbon dioxide on the earth. The system is balanced; animals and the earth's crust release carbon dioxide which is needed for the plants in photosynthesis. Through photosynthesis plants incorporate the carbon into the food that most other living things depend upon. Carbon is an essential component of life on the planet and the gas carbon dioxide is a valuable resource needed for a balanced and healthy planet.

Biological Pathway (indicated by the blue arrows)

In the biological pathway, plants take up carbon dioxide and convert it into organic material using the process of photosynthesis. Through photosynthesis, plants also release carbon dioxide into the air through cellular respiration. People and animals consume carbon in food, store in our bodies and exhale it in the form of carbon dioxide. This release and uptake of the gas of carbon dioxide happens with the plants and animals on both land and water. This process happens very quickly and is variable depending on weather and time of year.

Geochemical Cycle (indicated by the brown arrows)

On land, significant natural habitat such as forest, grasslands and wetlands, integrate carbon into the organic material of the ecosystem and eventually the carbon becomes mineralized in the soil. This process of mineralization in the soil and ocean is a long term process taking place over many years. In the ocean as well, carbon dioxide is incorporated in plants and animals and then eventually into the ocean sediments. Over thousands of years carbon is stored deep in the earth's crust and moves through the geophysical processes and some of it is released as carbon dioxide into the air through geothermal vents and volcanoes.

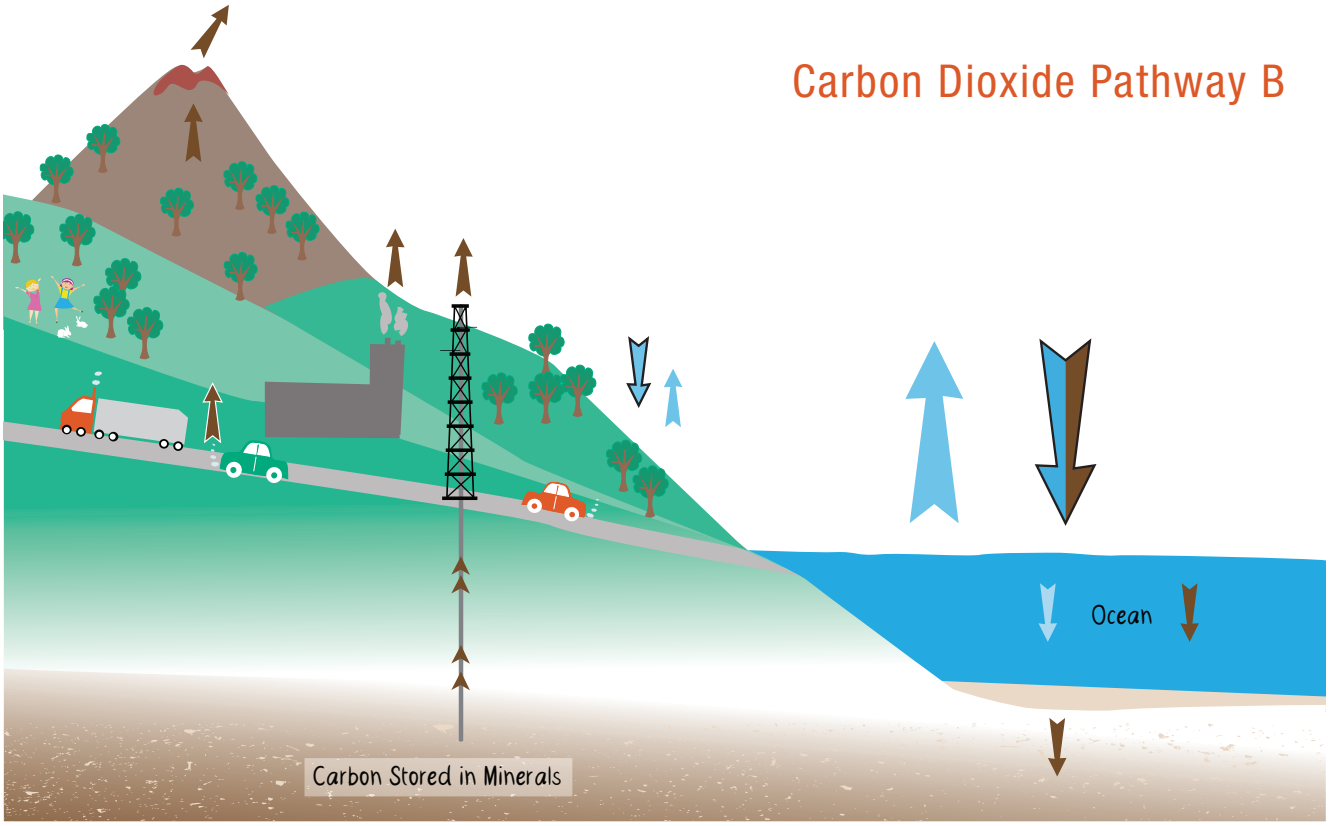
Carbon Sinks (indicated by the black outline around the down arrows)

In large natural habitats such as forests, grasslands and wetlands the biological and geochemical cycles work together to create significant stores of carbon. These are referred to as carbon sinks, or areas of carbon sequestration, because biological and geochemical processes take the carbon dioxide gas from the atmosphere and secures it as a solid in the earth.

Fuel Efficiency and Our Atmosphere

Carbon Dioxide, Greenhouse Effect and Carbon Sinks

S
3-12



Here is the illustration with the addition of some examples of industrial development. Comparing Pathway A to B, state at least 2 additional releases of carbon dioxide into the atmosphere in Pathway B: _____

_____

_____

Changes in the Biological Cycle

Deforestation releases carbon dioxide through the destruction of the forest and its soil. With fewer trees, less photosynthesis can take place. In addition, these human activities reduce the quality of the remaining forests, grasslands and wetlands which can reduce their effectiveness as a carbon sink. When carbon dioxide dissolves in the ocean, carbonic acid is created. Excess carbonic acid causes changes in ocean's chemistry and impacts the food web of the entire ocean.

Changes in the Geochemical Cycle

Extracting coal, oil and natural gas from the earth and burning those resources releases what was stored as carbon in the earth's crust into the atmosphere as carbon dioxide. This accelerates what is normally a very slow, limited and irregular geochemical process (through geothermal vents and volcanic eruptions) and makes it a very fast, daily event (power plants and vehicles).

Global Climate System

Carbon dioxide plays an important role in the earth's atmosphere, aside from being a critical component in photosynthesis it is also one of the group of gasses called greenhouse gasses. Greenhouse gasses are gasses in the earth's atmosphere that help trap enough of the earth's heat and energy to keep the earth's temperature stable.

Fuel Efficiency and Our Atmosphere

Carbon Dioxide, Greenhouse Effect and Carbon Sinks

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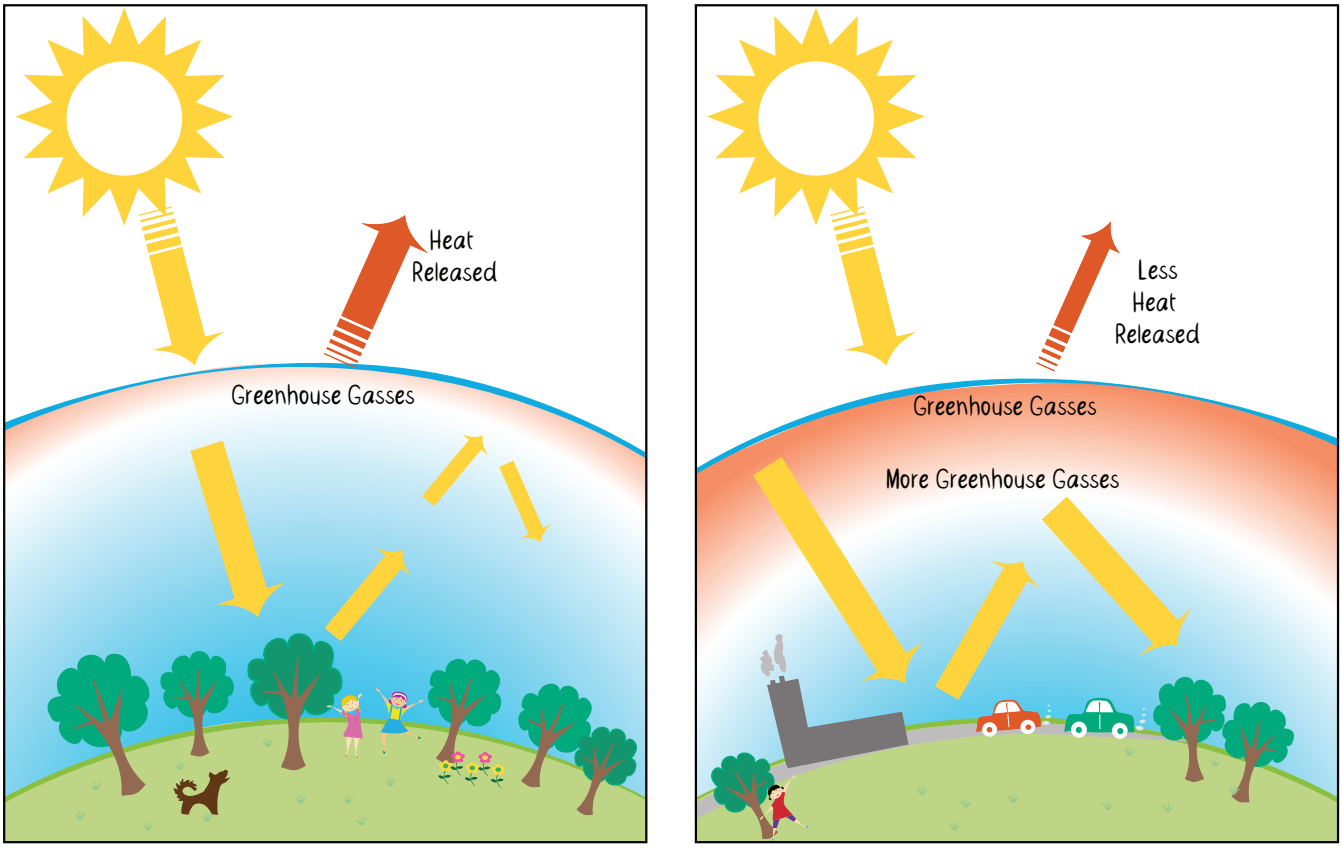
3-12

Greenhouse Effect

A – Stable Greenhouse Gasses

B – Excess Greenhouse Gasses



Comparing the two drawings, Illustration A depicts the stable atmosphere where carbon dioxide works with the other greenhouses gasses to trap some of the sun's heat, keeping the atmosphere within a stable range to support life on the planet. Illustration B depicts excess greenhouse gasses trapping more heat in the earth's atmosphere. As greenhouse gasses build up, the climate becomes less stable.

When there are more greenhouse gasses in the atmosphere the average global temperature average is warmer, when there is less the average global temperature is cooler. Studies of ice cores have confirmed this pattern over the past 600,000 years. Temperatures have fluctuated on the earth's surface for eons but the concern now is that the billions of tons of additional carbon dioxide from the burning of fossil fuels has significantly influenced this global climate system.

Fuel Efficiency, Carbon Footprint and Forest Conservation

Because of these concerns, there is a global push to have people reduce their carbon footprint. People all over the world are considering ways they can reduce the amount of fossil fuels that they use on a daily basis, this includes examining the fuel efficiency of how we transport freight around the world. Everything that you do that directly or indirectly uses fossil fuels is an opportunity to reduce your carbon footprint.

In addition to reducing the amount of carbon dioxide we release in the air there is also the opportunity to preserve and create more carbon sinks. Creating and preserving forests and other natural areas for the long term provides significant benefit to the global climate.

Fuel Efficiency and Our Atmosphere

Carbon and You

S
3-12

1. When we breathe we exhale and release carbon dioxide. When we drive a car we also release carbon dioxide. If those are both ways in which we release carbon dioxide, why is only the burning of fossil fuels considered something that we should try to reduce?

_____
_____

2. Consider your own carbon footprint by completing the following chart:

List ways in which you might use fossil fuels everyday.

List ways you could

_____
_____
_____
_____
_____
_____
_____
_____

_____
_____
_____
_____
_____
_____
_____
_____

3. Think of natural areas in your community. Would you call them effective carbon sinks? Why or why not?

_____
_____
_____

4. How could your community or school create an effective carbon sink?

_____
_____
_____

5. What else could you do to reduce the effect of your carbon footprint?

_____
_____
_____

Fuel Efficiency and Our Atmosphere

Numbers in the Footprint

S
7-12

Current concerns over carbon footprint and climate change is the result of many years of data collection from all around the world. Below are some of websites where this data has been collected and analyzed.

Looking at Data: Carbon Emissions

1. In 2006 the estimated annual amount of carbon dioxide released from volcanic activity was 200 million tons of carbon dioxide. The same period of time the average amount of carbon dioxide released from total global burning of fuel fuels was 31 billion tons of carbon dioxide.*

What is the ratio of the tonnage of carbon dioxide from volcanic activity released to the tonnage carbon dioxide from fossil fuel emissions? _____

_____

_____

2. The total carbon dioxide emissions from the burning of fossil fuels in the United States were 1.5 billion in 2010. Twenty-eight percent of those carbon dioxide emissions come from the transportation of people and freight. How much carbon dioxide was released into the atmosphere from transportation of people and freight? _____

_____

_____

_____

Looking at Data: Carbon Sink

3. Investigate the following sites and find out what the possibilities and limitations are for carbon sinks on land. How do we know how much carbon can be stored in an ecosystem. What types of ecosystems are the most effective at storing carbon? _____

_____

_____

_____

Environmental Protection Agency
http://www.epa.gov/sequestration/faq.html

Department of Energy, Carbon Sequestration in Terrestrial Ecosystems
http://csite.esd.ornl.gov/

* Estimates of volcanic emissions from US Geological Survey
http://hvo.wr.usgs.gov/volcanowatch/2007/07_02_15.html

Estimates of Fossil Fuel burning from the Carbon Dioxide Information Analysis Center
http://cdiac.ornl.gov/trends/emis/glo.html

**Total energy consumption in the US; US Energy Information Administration
http://www.eia.gov/totalenergy/

TEACHER PAGE

From Farm to Food to You

Traveling Grain

T

The United States is a market leader in growing many of the world's major crops including wheat, corn and soybean. These raw materials are grown in rural areas and transported to urban areas where they are manufactured into the products we use every day, such as clothes and foods. Freight transportation that is both economically efficient and environmentally sound is a critical backbone for agriculture and manufacturing in the US.

Key Concepts

The key concepts of this activity are:

- Many of our everyday products come from US agriculture
- The freight transportation of both the raw materials and manufactured goods combine to demonstrate the total transportation of goods.
- Carbon dioxide emissions is a multiplier that reinforces the importance of efficient fuel consumption

Introduction

Students will investigate options for transporting pretzels to a school in Norfolk, Virginia. They will follow the transport of the raw material of wheat grown in Ohio to the pretzel factory in Pennsylvania. Then they will consider the source and transportation of other agriculture products.

These websites provided information for this activity and can be used to help students find some answers on their own:

A clickable national map of Agriculture production:
http://www.agclassroom.org/kids/ag_facts.htm

EPA: Agriculture 101: national maps of crop production
http://www.epa.gov/oecaagct/ag101/cropmajor.html

Canada's report on US production, indicates when US crops are grown and harvested:
http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/sis5219

Use online mapping tools such as Google and Yahoo to calculate the distance also use the Free Map Tools website, which can be particularly helpful if determining any overseas distances
http://www.freemaptools.com/measuredistance.htm

Summary:
Students will investigate the carbon footprint of transporting the raw materials and the finished products of pretzels from farm to factory to them. The students will extend this investigation to other products whose raw materials start on farms.

Grade level:
3-6
7-12

Time of activity
45 Minutes plus extension questions

Materials
Student pages, ruler, calculator and access to internet for calculating distances.

Curricular goals:
Mathematics: The student will read a complex issue and apply mathematics to solve the issue.

The student will apply division of algebraic expressions to mathematical problems.

Economics: The student will explain how people make choices in response to market forces.

From Farm to Food to You

Traveling Grain

Guide to Answers on the Student Pages

Grades 3-6

1. **Truck:** 5 gallons of fuel used to transport the wheat 400 miles and then the pretzels 300 miles. 111.65 pounds of Carbon Dioxide is released into the air.

2. **Train:** 1.5 gallons of fuel used to transport the wheat 400 miles and then the pretzels 300 miles. 33.5 pounds of Carbon Dioxide is released into the air.

3. **Compare:** Truck transportation would release 3.3x as much carbon into the atmosphere.

4. **Train and Ship:** 0.85 gallons of fuel used by a train from Bavaria to Hamburg + 8 gallons of fuel used by a ship from Hamburg to Norfolk = 8.85 gallons of fuel total. Carbon Dioxide released = 197.6 pounds

   Truck and Ship: 2.86 gallons of fuel used by a truck from Bavaria to Hamburg + 8 gallons of fuel used by a ship from Hamburg to Norfolk = 10.85 gallons of fuel total. Carbon Dioxide released = 242.3 pounds

Grades 7-12

All the answers will be similar to the above, however the specifics may vary for each individual depending on the specific mileage they find on their online graphing tools.

Discussion Extension

1. Answers will vary, here are some possibilities:
   Oranges > Florida > orange juice
   Cotton > South Carolina > socks, shirts
   Apples > New York > apple cider
   Corn > Ohio > corn chips, corn syrup
   Soybeans > Tennessee > tofu, animal feed, biofuels

2. Answers will vary. Discuss how time sensitive cargo may need to be shipped in the fastest as opposed to most fuel efficient manner. Discuss the limitations of different types of cargo. The pros and cons of each transportation option can vary when additional factors are addressed, such as road and rail maintenance and construction, weather, traffic, labor needs, flexibility, needing to be in bulk quantities, infrastructure needs (airports, seaports, train stations), wildlife impacts, etc. Some discussion questions could center on local foods, farmers markets versus grocery stores; packaged/processed foods versus real food/unprocessed food. All of these details can be considered when investigating the transportation of those foods.

Students could also examine the transition transportation miles, the miles between the farm and the rail road station and the railroad station and the school when trucks have to be used because there is no rail.

From Farm to Food to You

Traveling Grain

S
3-6

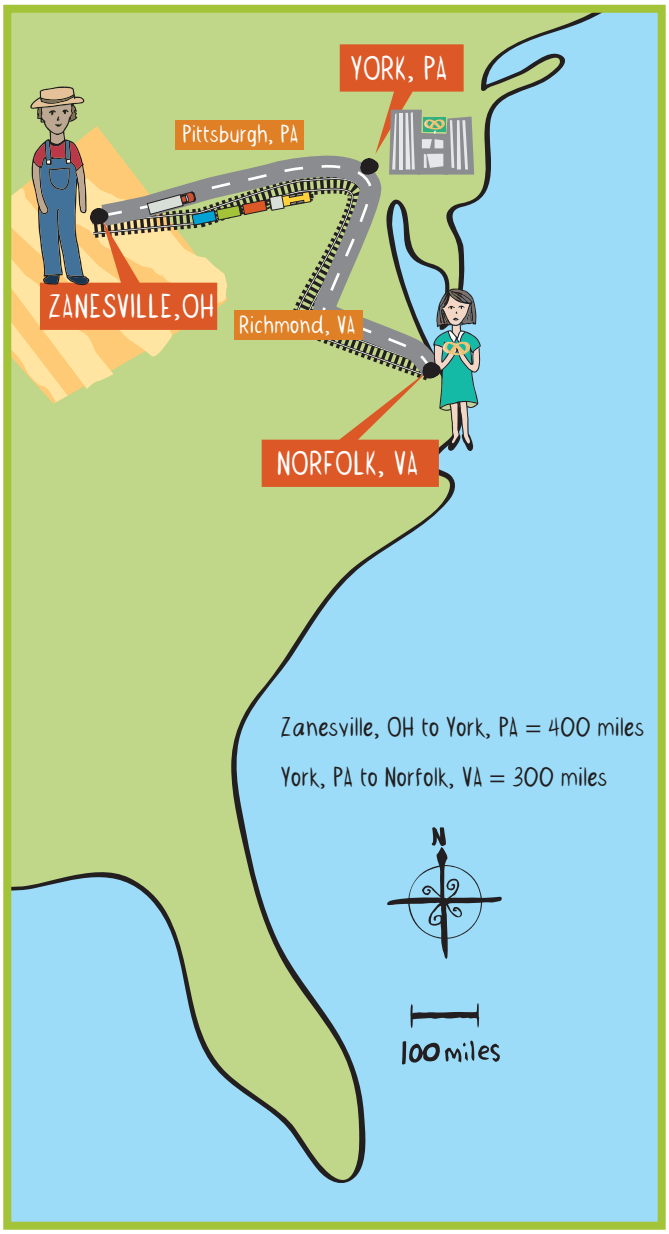
Our farms produce the raw materials that are a part of the products we use every day, from the cotton in our shirts to the corn and wheat in our food. Most likely you do not live next to the farms that produce these foods and raw materials. So it is only through freight transportation that products grown on farms get to us.

Consider this example:

Students in Norfolk Middle School want to have genuine Bavarian style pretzels for their Oktoberfest event.

But to calculate the true carbon footprint of getting these we need to consider not just the transportation of the pretzels but also the transportation of the wheat to the pretzel factory. The soft winter wheat used to make their pretzels is grown by farmers near Zanesville, OH and the pretzels are made in a factory in York, PA.

Compare the carbon footprint of truck and train shipments of the wheat from the farm to the factory to the school.



Calculation:

Calculate the fuel efficiency and carbon output per ton of wheat and then ton of pretzels. Calculate and compare how much fuel is needed for the one ton of Wheat to travel from Zanesville, OH to York, PA.

By road or rail there is approximately 400 miles from Zanesville to York. By road or rail there is approximately 300 miles from York to Norfolk, VA. **Trains** can travel 468 miles per gallon of fuel per ton or cargo. **Trucks** can travel 140 miles per gallon of fuel per ton of cargo. **Diesel fuel** releases 22.33 pounds of carbon dioxide per gallon consumed.

1. Train:

How much **fuel** is used to transport the wheat to York then pretzels to Norfolk if a **train** is used?
What are the pounds of **carbon** released into the atmosphere if the wheat and pretzels are transported by **train**?

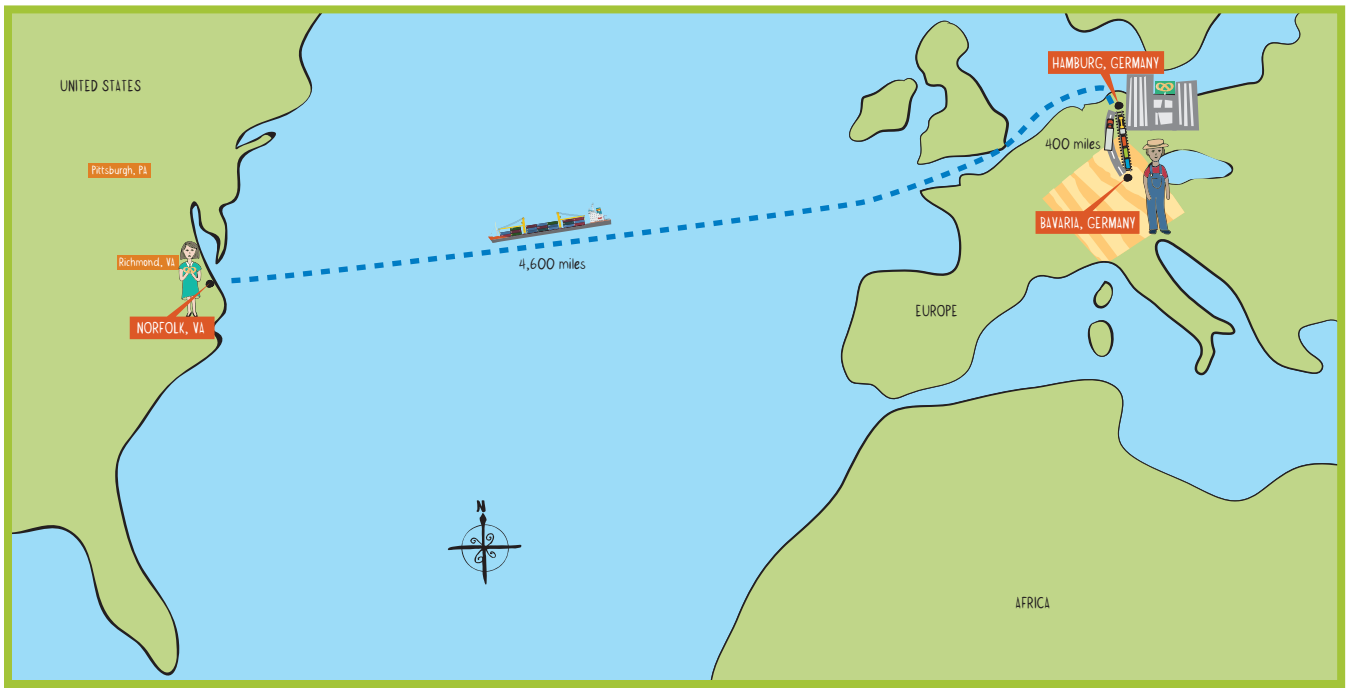
2. Truck:

How much **fuel** is used to transport the wheat to York then pretzels to Norfolk if a **truck** is used?
What are the pounds of **carbon** released into the atmosphere if the wheat and pretzels are transported by **truck**?

3. Compare the carbon numbers between the two.
For example: (train or truck) freight transportation releases ___ times the amount of the carbon that (train or truck) does.

From Farm to Food to You

Traveling Grain



4. What if we had the pretzels shipped from where pretzels were invented? The pretzels made in York, PA are based off of the same recipie as those made orginally in Germany from Bavarain wheat. Norfolk, Va is also the location of a major shipping port. What would be the fuel usage and carbon footprint of getting the pretzels from Bavaria to Norfolk?

Use the following conversions:

Train: 468 miles per gallon of fuel per ton

Truck: 140 miles per gallon of fuel per ton

Ship: 576 miles per gallon of fuel per ton of cargo

Diesel fuel releases 22.33 pounds of carbon dioxide per gallon consumed.

5. Create graph that illustrates the difference in fuel consumption and carbon dioxide emissions between these four shipping options for the pretzels:

a. Ohio to Pennsylvania to Norfolk via Train

b. Ohio to Pennsylvania to Norfolk via Truck

c. Bavaria to Hamburg to Norfolk via Train and Ship

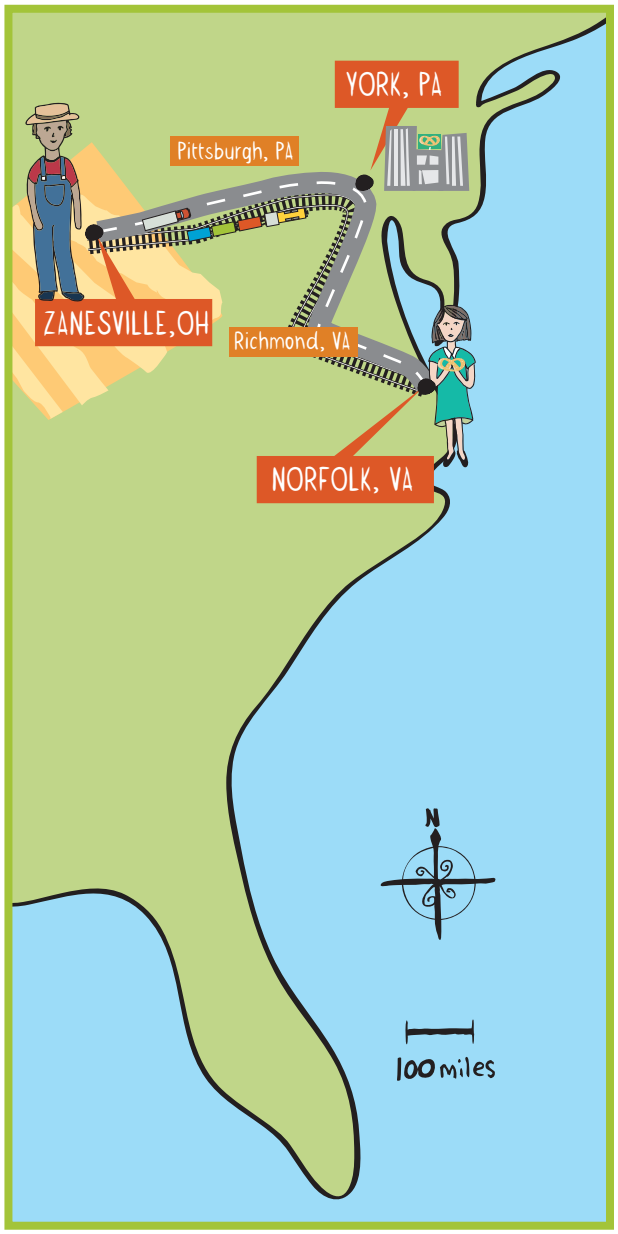
d. Bavaria to Hamburg to Norfolk via Truck and Ship

From Farm to Food to You

Traveling Grain

S
7-12

Our farms produce the raw materials that are a part of the products we use every day, from the cotton in our shirts to the corn and wheat in our food. Most likely you do not live next to the farms that produce these foods and raw materials. So it is only through freight transportation that products grown on farms get to us.



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Calculate the distance traveled and compare the carbon footprint of truck and train shipments of the wheat from the farm to the factory to the school.

Use online mapping tools such as *Google* and *Yahoo* to calculate the distance also use the *Free Map Tools* website, which can be particularly helpful if determining any overseas distances http://www.freemaptools.com/measure-distance.htm

Calculation:

Calculate the fuel efficiency and carbon output per ton of wheat and then ton of pretzels. Calculate and compare how much fuel is needed for the one ton of wheat to travel from Zanesville, OH to York, PA. **Trains** can travel 468 miles per gallon of fuel per ton or cargo. **Trucks** can travel 140 miles per gallon of fuel per ton of cargo. **Diesel fuel** releases 22.33 pounds of carbon dioxide per gallon consumed.

1. Train:

How much **fuel** is used to transport the wheat to York then pretzels to Norfolk if a **train** is used?
What are the pounds of **carbon** released into the atmosphere if the wheat and pretzels are transported by **train**?

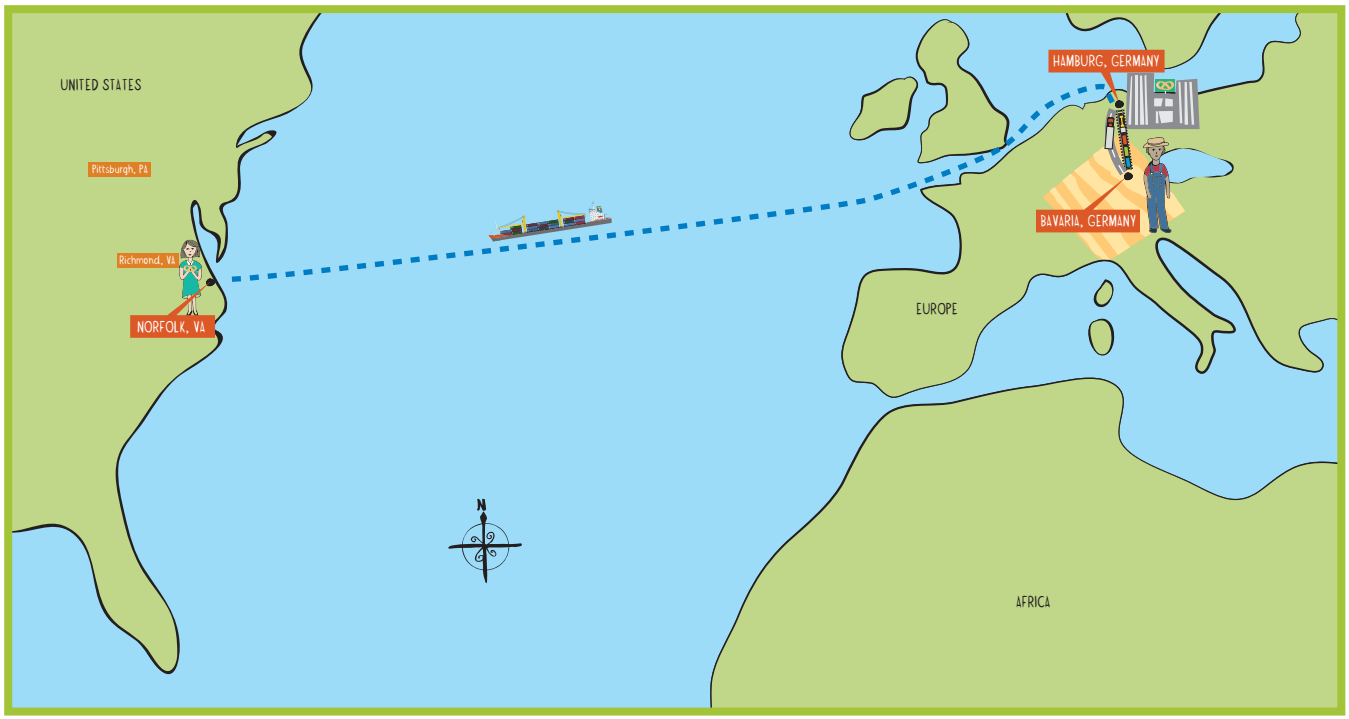
2. Truck:

How much **fuel** is used to transport the wheat to York then pretzels to Norfolk if a **truck** is used?
What are the pounds of **carbon** released into the atmosphere if the wheat and pretzels are transported by **truck**?

3. State a comparison between the carbon calculations.

From Farm to Food to You

Traveling Grain



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Use the following conversions:

Train: 468 miles per gallon of fuel per ton

Truck: 140 miles per gallon of fuel per ton

Ship: 576 miles per gallon of fuel per ton of cargo

Diesel fuel releases 22.33 pounds of carbon dioxide per gallon consumed.

5. Create a graph that illustrates the carbon footprint difference between these shipping options for the pretzels.

From Farm to Food to You

Traveling Grain

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3-12

Extension Activity

1. What other raw materials are produced by farms that need to be shipped elsewhere to be manufactured into a product?

Brainstorm other raw materials, where they are farmed and examples of what could be produced.

	Raw material	One state that produces it in large quantity	Examples of what the raw material makes.
1	Wheat	Ohio	Pretzels, Bread, Cake
2	Cotton	South Carolina	
3	Oranges		
4	Soybeans		
5			
6			
7			

2. Select a product from Column C and identify a city where this final product is made. Use online mapping tools such as Google and Yahoo to map the path that this product takes from raw material to factory to you. Calculate the fuel usage and carbon footprint of that path.

TEACHER PAGE

Intermodal Transportation

Putting it all Together

T

Intermodal transportation is the international standard for freight transportation in which a standard size cargo box is transferred between trucks, trains, ships and planes. Intermodal transportation started in the 1950s and has since significantly changed how manufacturing and shipping is done.

A great source for more information about intermodal shipping is *The Box* written by economist Marc Levinson. This book has fascinating stories and explanations of the beginnings of intermodal shipping, and its extensive economic impact. Although the original motivation for intermodal shipping may have been economic, intermodal shipping has significantly improved fuel efficiency and therefore reduced the carbon footprint of freight transport.

Key Concepts

- Most freight transportation today uses more than one mode.
- In freight transportation, small changes in fuel economy can produce large changes in carbon footprint.
- Every consumer product has a carbon footprint that includes how it was transported.

Introduction

A possible introduction for you and your students to the concept of intermodal shipping is to view this 2 minute video from CSX Corporation's Beyond Our Rails program http://www.beyondourrails.org/green/understanding-green-shipping

Another introduction could be to ask your students the following question:

We use many different things throughout our daily lives. These goods are the things we eat, wear, live in and use every day. Most of these goods have to travel to get to us. We frequently think of traveling to the store to buy things, but how did those goods travel to the store? Look at your shoes, where were they made? Malaysia, Germany, China, USA? No matter where they were made it most likely wasn't at the shoe store. So how did the shoes get to the store? Discuss what your students think.

Summary:
Students will identify the transportation route that goods would take from any singular spot in the world to their school. Students will then calculate, compare and contrast the carbon dioxide produced from of at least two different combinations of shipping modes for those goods.

Grade level:
7-12

Time of activity:
1 to 1.5 hours depending on time needed for research

Materials:
Student pages and internet search capability

Curricular goals:
Mathematics: Students will develop and use a multistep equation as a process of reasoning and explain that reasoning.

Students will interpret, compare and contrast data.

Then read them this except from *The Box*, asking them to imagine the journey to the store.

A 25-ton container of coffeemakers can leave a factory in Malaysia, be loaded aboard a ship, and cover the 9,000 miles to Los Angeles in 16 days. A day later, the container is on a unit train to Chicago, where it is transferred immediately to a truck headed for Cincinnati. The 11,000-mile trip from factory gate [in Malyasia] to the Ohio warehouse can take as little as 22 days at a cost lower than that of a single first class air ticket. More than likely, no one has touched the contents or even opened the container, along the way. (page 27)

Guide to Answers on Student Pages

This activity is completely dependent on where your school is located and what you decide to research. Use the websites provided to explore all of the things that make up our lives move to and from other places.

Intermodal Transportation

Putting it all Together

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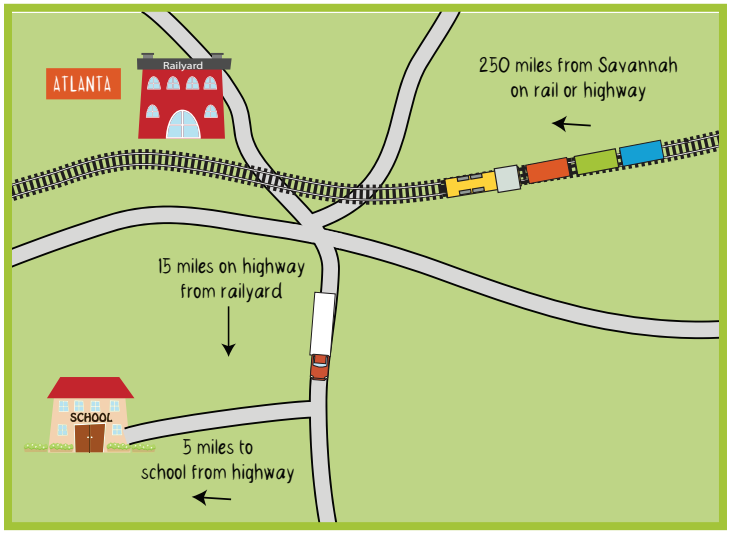
7-12

Whether car parts from Michigan, t-shirts from Malaysia, or electronic gadgets from Germany, all goods have to be transported via freight to get to us. Depending on the choices made, transportation can have very different carbon footprints.

Consider this example of a school in Atlanta, Georgia. The closest deepwater seaport to Atlanta is in Savannah, Georgia. Anything received in Savannah and then shipped from that seaport to this school in Atlanta would have to use either truck or a combination of train and truck.



Option One: Intermodal Rail and Truck

Step one: Add up the miles for each type of transit.

250 miles by train
20 miles by truck

Step two: Calculate the gallons of fuel used per ton of weight pulled and add them up.

250 miles by train/468 miles per gallon of fuel per ton = 0.53 gallons of fuel per ton
20 miles by truck/140 miles per gallon of fuel per ton = 0.14 gallons of fuel per ton

0.67 gallons of fuel per ton

Step three: Calculate the pounds of carbon dioxide produced.

0.67 gallons of fuel * 22.33 pounds of carbon dioxide per gallon of diesel fuel = 14.96 pounds of carbon dioxide released

Result: *Option one produces 15 pounds of carbon dioxide pollution.*

Option Two: Only Truck

Step one: Add up the miles for each type of transit.

270 miles by truck

Step two: Calculate the gallons of fuel used per ton of weight pulled.

270 miles by truck/140 miles per gallon of fuel per ton = 37.8 gallons of fuel per ton

Step three: Calculate the pounds of carbon dioxide produced.

37.8 gallons of fuel * 22.33 pounds of carbon dioxide per gallon of diesel fuel = 844.1 pounds of carbon dioxide released

Result: *Option two produces 844.1 pounds of carbon dioxide.*

Which option was a better carbon footprint? Why?_____

_____

_____

_____

Intermodal Transportation

Putting it all Together

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7-12

Now try it yourself! Find something in your school that was made anywhere else but where you live. It could be made in the United States or in another country. Look at a map and devise at least two different combinations of freight transportation for how that item could get to where you live.

FIRST: Find the closest highways, rail yards and deepwater seaports.

Here are some online tools that can help your search:

- Online mapping tools such as *Google* and *Yahoo* can help with locations and distances
- Also the *Free Map Tools* website, which can be particularly helpful if determining any overseas distances http://www.freemaptools.com/measure-distance.htm

Lists of rail yards and shipping ports can be found on these sites:

- CSX Rail yards http://csx.com/index.cfm/about-csx/company-overview/state-fact-sheets/
- North American Shipping Ports http://en.wikipedia.org/wiki/List_of_North_American_ports

SECOND: Calculate which pathway has the lowest carbon footprint by following these steps:

Step one: Add up the miles for each type of transit

Step two: Calculate the gallons of fuel used per ton of weight pulled

Step three: Calculate the pounds of carbon dioxide produced

FINALLY: Decide which freight transportation option was the best and why.

Extensions:

Do you think the most fuel efficient mode of transportation is always chosen? What are some other reasons why cargo transportation choices may be made?

What changes would happen to the carbon footprint once alternative fuels such as biodiesel are used? Biodiesel options are reported on EIA: http://www.eia.gov/oiaf/1605/coefficients.html#tbl2 Remember to convert to pounds using the conversion 1 kg = 2.2 lbs in order to ensure a direct comparison. Also on the EIA site are conversions for jet fuel as well, if you would like to compare the carbon footprint of airplanes.

Also consider what choices a manufacturer has in your town. What would be the options and carbon footprints for shipping goods out of your town?

If you live in or near a seaport calculate different distances travelled from your seaport. Look at the railway maps such as this one from CSX http://www.csx.com/index.cfm/customers/maps/csx-system-map/ and calculate the carbon footprint of those possible destinations.