

Lesson 1 Overview

Carbon is one of the most abundant elements in the universe and one of the most abundant elements on Earth. Carbon is in the air we breathe, the food we eat, the clothes we wear, and so many more places. Carbon is everywhere, and its structure makes it critical to life and energy on our planet. Carbon makes up 17% of the human body and 40% of plants. <u>Lesson 1</u> will emphasize the chemical structure and components of carbon, fossil fuels, new and old carbon, and how carbon is harvested and used within the bio-renewable realm.

Lesson 1 consists of three main activities:

Carbon Comparison	Students practice identifying products containing carbon and distinguishing those typically derived from old vs. new carbon.	for a stan
Carbon in the Energy Cycle	Through discussion and viewing a short video, students learn carbon's role in the energy cycle and how old vs. new carbon affects carbon in the atmosphere.	<u>Sta</u>
Fermentation Lab	Students perform a lab experiment illustrating how enzymes effect the rate of fermentation converting plant starches into ethanol and CO ₂ .	NG MS-

Here are the BIG IDEAS and *Learning Objectives* for <u>Lesson 1</u>

BIG IDEAS

1. Carbon is an important resource for living things and our economy

2.

ource

- Carbon-based energy has many different sources and useful forms
- Energy and fuels that humans use are mostly derived from natural resources

Students will define carbon and be able

Learning Objectives (LO)

to understand its chemical structure and physical role for life and within the environment

- Students will categorize energy sources between old carbon and new carbon
- Students will be able to identify energy and fuels derived from natural resources



See the <u>Educational Standards</u> section at the end of this lesson for a detailed table of how standards apply.

Standards Summary

Carbon Comparison

NGSS MS-ESS2-1 — *Link*

 $\begin{array}{l} AFNRCCS\\ \text{CS.02.02} - \underline{Link}\\ \text{NRS.02.04} - \underline{Link}\\ \text{NRS.02.05} - \underline{Link} \end{array}$

Learning Objectives (LO)

LO1 See BIG IDEAS text box

Carbon in the Energy Cycle

NGSS MS-ESS2-1 — *Link*

Learning Objectives (LO)

LO1 See BIG IDEAS text box

Fermentation Lab

NGSS HS-ESS2-6 — *Link*

MS-LS2-3 — <u>Link</u>

AFNRCCS

NRS.02.01 — <u>*Link</u>*</u>

Learning Objectives (LO)

LO3 See BIG IDEAS text box

OVERVIEW

page



Lesson 1 Outline

- 1. Give each student a copy of Carbon KWL and time to complete the first two columns.
- 2. Discuss what carbon is based on their KWL work.
- - 1. Introduce examples of carbon.
 - Follow <u>Carbon Comparison Activity Guide</u> to facilitate students in developing an understanding of carbon, its significance to humans and life in general, and its sources.
 - Play <u>What is Carbon</u>, individually using student tablets or as a group using a projection of the class's computer or tablet screen.
 - 4. Have students organize the knowledge they have gained thus far using Old Carbon and New Carbon Frayer Models.

Part C | Complete Carbon in the Energy Cycle discussion 11

- 1. Introduce the visual Carbon Flow in the Global Energy System.
- 2. Facilitate students' generating questions and developing understanding of the energy cycle.
- 3. Have students watch the video *What's the Deal with Carbon?* about the carbon cycle.
- Use the <u>Carbon in the Energy Cycle Discussion Guide</u> to facility a group discussion.

- 1. Ask students to share what they know about fermentation and carbon's role in it.
- 2. Use the <u>Fermentation Lab Activity Guide</u> to facilitate students' completion of the Fermentation Lab. (*This takes at least 2, typically 3, meeting periods.*)
- 3. Work with students to analyze and discuss their results.

Part E | Learners generalize and apply knowledge gained in Lesson 1 . . . 3

- 1. Have students and instructor complete the remaining column of the Carbon KWL.
- 2. Hold a group discussion of the Carbon KWL results.
- Have students complete a summary writing that explains in a Letter to the Editor format why carbon in agriculture is so important to our economy.







(Preparation time does not include the time needed to familiarize yourself with this curriculum.)

Total Preparation:30 - 90 minTotal Implementation:3 - 5 hrs

Time Breakdown

Part A |

Preparation: <10 min Implementation: 15 – 30 min

Part B |

Preparation: < 10 min Implementation: 30 – 60 min

Part C |

Preparation:10 - 30 minImplementation:30 - 60 min

Part D |

Preparation: 10 – 30 min Implementation: 60 – 90 min (over at least two days)

Part E |

Preparation: <10 min Implementation: 30 – 60 min

	Key Words
	Biofuels
	Biomass
	Biorenewable
	Carbohydrates
•	Carbon
	Energy cycle
	Fermentation
	New carbon
	Old carbon
•	Photosynthesis





Carbon KWL Chart

Your name: _____

What I know	What I want to learn	What I have learned

Adapted from <u>WorksheetWorks.com</u>



Carbon Comparison Activity Guide

Background

Carbon is one of the most abundant resources in the universe. It is a building block of life. Carbon is the element that nature, particularly plants, uses for storing energy from the sun, using the process of photosynthesis. There are two main sources of carbon that we use in our energy economy – old and new. Old carbon is fossil fuels, such as petroleum products (gasoline and diesel), natural gases, and coal. Products typically made from petroleum include plastics, human-engineered (synthetic) fibers, asphalt, cosmetics, drugs, gasoline, and more. New carbon is plant material, such as corn, soybeans, switchgrass, strawberries, and leaves. One benefit of new carbon is that it can be regrown when supplies are running low, but if the Earth runs out of coal or gasoline, it will be impossible to grow more. Additionally, the CO₂ released when consuming new carbon was recently removed from the atmosphere during photosynthesis.

solarschools.net/resources/stuff/advantages and disadvantages.aspx, and of using old carbon at: greenliving.lovetoknow.com/Advantages and Disadvantages of Non Renewable Energy

(So there is no net change in atmospheric CO₂ when using new carbon.) Whereas, the CO₂ released when consuming old carbon has been stored underground for thousands of years (resulting in a net gain in atmospheric CO₂ when using old carbon). The goal of this activity is to help students understand the benefits of using fuels derived from new carbon sources, such as bio-diesel and ethanol, as the energy sources in the future for running our airplanes, cars, spaceships, tractors, and combines.

Directions

- Show students the examples of new and old carbon. The examples can be shown as one group or two groups (one group of new carbon and one group of old carbon). Without giving them any hints, ask them to write down what is similar and different about the items. Think about where they came from, uses, textures, looks, and more.
- 2. Have students talk with each other about what was similar about the items in both groups.

Continued on back (Page 6)

Big ² Idea
Originally, they all came from something living.

(Student lists will contain more than the big idea)

Examples of old carbon (coal, plastic bottle, fossil, etc.) Something for students to write on (scratch paper, poster paper, etc.) Writing utensils <u>Handouts &</u> <u>Overheads</u> <u>Where is the Carbon?</u> activity sheet

Material's List

· Examples of new

carbon (leaves, corn, soybeans,

animals, people, etc.)

- New Carbon Frayer model
- Old Carbon Frayer model



- What is Carbon? game: isfair.herokuapp.com/
- Background on new carbon: <u>www.solarschools.net/</u> <u>resources/stuff/advantages</u> and disadvantages.aspx
- Background on old carbon: <u>greenliving.lovetoknow.</u> <u>com/Advantages and</u> <u>Disadvantages of Non</u> <u>Renewable Energy</u>

NGSS Based Concept

Transfer of energy can be tracked as energy flows through a designed or natural system. Life is dependent on energy flow from the sun through plants. The fundamental player in this process is carbon. Our energy economy is fundamentally carbon-based – wind energy, nuclear energy, and solar energy being the exception. In our lives, food, fuel, and fiber are the foundations of our carbon economy. All are necessary for human existence.



Directions (continued)

- 3. Ask students to discuss what was different about the items.
- Name
 Name

 Work is Garden Name
 Name

 Work is Garden Name
 Name

 Name
 Name
 </tr
- 4. Have students complete the <u>Where is Carbon?</u> activity sheet
- Ask students to use sticky notes to write down what they know about carbon, one idea for each note. Share these out as a group, allowing for discussion, questions, and group common ideas together.
- 6. Cluster sticky notes on the board. Generate a summary statement for each cluster. Using summary statements, have the students discuss the difference between old and new carbon.
- 7. This is a good time to play the online <u>What is Carbon?</u> game.
- 8. Have students complete Frayer models in small groups or individually.
- 9. Discuss the advantages and disadvantages of old and new carbon from a Central United States perspective?

Big 🔶 Ideas

- The old carbon is from dead [fossil fuels] materials, and the new carbon is from living materials.
- Plastics, synthetic fibers, and fossil fuels are all derived from materials that were once alive, but have undergone transformation over time.

(Student lists will contain more than the big idea)



Discussion Points to Consider

- Talk more about energy from new carbon, focusing on what plants ethanol and bio-diesel come from. You can also talk more about new types
 of energy are being developed from other new energy sources miscanthus, switchgrass, etc.
- · Why is carbon important? Some reasons to discuss include:
 - * It's in everything we use
 - * It makes up 18% of our body and 40% of plants
- * It's the 4th most common element in Galaxy, solar system, and on earth, etc.
- Geographically, which carbon source is more available in Iowa? Midwestern United States? (Answer new carbon)



Where is Carbon?

Your name: _____

Observations

What are the Similarities among all the objects?

What's different about:

Corn?	Soybeans?	Wood?	Cotton?	Coal?

Pencil?	Paper?	Pop?	T-Shirts?	Cup?

Reflection & Analysis

- 1. What do all of these items have in common?
- 2. What differs between these items?
- 3. How could each of these be used and what would you have to do to them to make them work?
- 4. Why is carbon important?







Carbon in the Energy Cycle Discussion Guide

Background

Energy transformation, particularly carbon transformation, between plants, animals, and the environment is essential to life. Plants collect the energy they need from the sun and use carbon dioxide from the atmosphere to form new molecules that store the solar energy in the form of chemical bonds. This process

× Find more background on the energy cycle in living things at: hyperphysics.phyastr.gsu.edu/hbase/Biology/enercvc. *html*. From there you can link to all kinds of great graphics and explanations of how cellular processes store and use energy.

is called photosynthesis and uses carbon dioxide and oxygen to form sugars that store energy for living things. Animals eat plants to acquire that stored energy. The sugars from the plants are oxidized to provide the energy animals need. The stored energy in plants can be eaten directly or indirectly by eating other animals. Humans are animals and participate in this cvcle. Humans and other animals exhale carbon dioxide. which plants use to start the photosynthesis process again. The entire cycle is driven by the energy from the sun. Carbon's unique chemical structure makes it an essential part of the process, as both raw material (carbon dioxide) and

product (sugar).



Directions

Show students the image Carbon Flow. (Project it onto a screen or print a 1. few copies for groups of students to examine.)



NGSS **Based Concept**

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Without materials cycling through Earth systems, energy would not reach plants, animals, humans, and essential parts of life. Our energy is based off of carbon nuclear energy, wind energy, and solar energy being the exception. It is important to understand how carbon flows through the Earth and atmosphere.

- 2. Working in small groups, ask students to generate their questions and understandings about carbon and the energy cycle.
- 3. Hold a class discussion about the energy cycle and carbon's role in it. During the discussion, identify an appropriate time to watch the YouTube video: What's the Deal with Carbon?



ON BACK (Page 12)







Discussion Points to Consider

- Ask students where plants get energy? (*Answer: the sun*) What form do they store energy in? (*Answer: Carbon based molecules such as sugars, starches, cellulose, and fats.*)
- What gas do plants release as a by-product of storing the sun's energy in sugar molecules (photosynthesis)? (*Answer: oxygen.*)
- What do animals breathe? (Answer: oxygen) What do animals breathe out? (Answer: carbon dioxide.) Where do animals get energy from? (Answer: eating plants and other animals.)
- As animals, what do humans breathe? (*Answer: oxygen*) What do humans breathe out? (*Answer: carbon dioxide.*) Where do humans get energy from? (*Answer: eating plants and other animals.*)
- Where do plants, animals, and humans get the energy they need to live from? (Answer: carbon compounds—sugars, starches, oils, fats, etc. that were created originally by plants through photosynthesis.)
- What impact does the carbon cycles have on climate change? (Answer: Carbon dioxide in the atmosphere affects climate. Plants remove carbon from the atmosphere through photosynthesis. By lowering the total plant mass, there will be less carbon dioxide removed from the atmosphere. [Deforestation, urban development, drought, etc.])
- Why is it important to use new carbon as opposed to old carbon? (Answer: old carbon increases atmospheric carbon.)
- How can we use less old carbon? What are different sources of energy we can use instead of fossil fuels? Discuss the advantages and disadvantages of each.
- · What happens when we run out of fossil fuels?





Material's List

6 pkgs of baking yeast (or at least 1oz total yeast)

7 Erlenmeyer flasks (250 ml) or

• Aluminum foil, plastic wrap, or

parafilm to cover 7 flasks

• 7 weighing boats or enough

Scale(s) (0.01 accuracy)

700+ ml of distilled water Incubator or water bath

7+ pieces of sugarless chewing

Saliva collection cup (5 oz)

10 ml of saliva mixture for

• 7 balloons to place over flasks

Handouts &

Overheads

flasks/cups 3,4,5,and 6

to capture gas (optional)

7 different colored markers

gum or canning wax

aluminum foil to create 7 boats

50+ g of corn starch

7 plastic cups (9 oz)

10+ q of sugar



Fermentation Lab Guide

Background

Background information and labs provided by lowa State University's Office of Biotechnology: <u>www.</u> <u>biotech.iastate.edu/biorenewables-</u> <u>curriculum-modules/</u>

Biomass is material that comes from plants. Plants use light energy from the sun to convert water, carbon dioxide, and other nutrients to complex compounds through a process called photosynthesis. These compounds include carbohydrates (sugars and more complex compounds derived from sugars). Organic waste is also considered to be biomass because it began as plant matter. Researchers are studying how sugars in biomass can be converted to high-value bioproducts and biofuels.

Directions

- 1. Divide your class into 7 groups and provide them with <u>Fermentation Lab</u> <u>Procedure</u>.
- Before starting the lab (this step can be competed a day in advance), make a 10 ml mark on a 5 oz plastic cup. Have students follow the saliva collection procedure to collect 10 ml of the students' saliva. Store the covered cup in a refrigerator until you are ready to complete the lab.
- 3. Prepare for the lab by replicating the <u>Lab Matrix</u> and the <u>Class Data Table</u> onto an overhead or by hand onto a chalkboard or whiteboard.
- 4. Assign each group of students one of the seven 250 ml flasks (or 9 oz cups) to preparing according to the lab matrix. Guide the students in following the lab procedure and taking and recording accurate measurements at the indicated time intervals. IMPORTANT—if you are using a water-bath instead of an incubator, make certain the students always wipe the water from the bath off their flask before massing it.
- 5. Allow the reaction to continue overnight, then have students record the final masses of their flasks in the ON (Over Night) column of their Data Table.
- 6. Have the students transfer their data to the Class Data Table and provide a graphing grid for the class to use (overhead, oversized paper, grid on whiteboard, etc.). Depending on your students' skill level, guide them in determining the scales, labels, and units for the X and Y axes. Provide each group with a different colored writing utensil and have them plot their data on the graph and add their color and flask number to the graph legend.
- 7. Have students work in their groups to complete the <u>Reflection & Analysis</u> questions and the <u>Enrichment</u> questions.
- 8. Lead the class in a discussion of the Reflection & Analysis questions.

NGSS Based Concept

Carbon-based resources include corn, soybeans, miscanthus, and switchgass. All of these biomasses are being researched to convert into energy resources, such as ethanol and biomass. One way that these carbon-based resources are being converted into energy is through fermentation, a way to transform sugars in biomass to high-value bioproducts and biofuels.







- Lab Matrix & Class Data Table
 overhead
- Graphing grid
- <u>Reflection & Analysis</u> questions



<u>Iowa State University's</u> <u>Office of Biotechnology</u> for background information

Career video: <u>Plant Engineer</u>

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Lab Matrix

	Empty Mass (g)	Sugar Mass (g)	Starch Mass (g)	Yeast Mass (g)	Water (ml)	Enzyme (ml) (saliva)
Flask 1		10	0	4	100	0.0
Flask 2		0	10	4	100	0.0
Flask 3		0	10	4	100	0.5
Flask 4		0	10	4	100	1.0
Flask 5		0	10	4	100	2.5
Flask 6		0	10	4	100	5.0
Flask 7		0	0	0	100	0.0

Class Data Table

Time (min)	Flask 1	Flask 2	Flask 3	Flask 4	Flask 5	Flask 6	Flask 7
0							
(3) 5							
(6) 10							
(9) 15							
(12) 20							
(15) 25							
(18) 30							
(21) 35							
(24) 40							
(27) 45							
Final (ON)							
Difference							



Fermentation Lab Procedure SPIT (saliva) Energy

Lab Overview & Purpose

Biomass is material that comes from plants. Plants use light energy from the sun to convert water, carbon dioxide, and other nutrients to complex compounds through a process called photosynthesis. These compounds include carbohydrates (sugars and more complex compounds derived from sugars). Organic waste is also considered to be biomass because it began as plant matter. Researchers are studying how sugars in biomass can be converted to high-value bioproducts and biofuels.

Fermentation is one way biomass can be converted into bioproducts and biofuels. In this lab you'll ferment some biomass (in this case, table sugar and corn starch) to learn about fermentation and see how an enzyme catalyst (a catalyst is a chemical that helps a reaction take place) affects the fermentation process.

Pre-Lab: saliva collection

- 1. Place a piece of sugarless gum or canning wax (grocery store) in your mouth and chew.
- 2. Place your name/group on a 5 oz plastic cup.
- 3. Expel the saliva you create by chewing into a plastic 5 oz cup. You will need 10 ml of saliva. Your teacher will give you a reference line on the cup.
- 4. Cover the cup with aluminum foil or plastic wrap and place in a refrigerator until the next lab day.

Material's List

- 10 g of sugar (flask 1 only)
- 1 pkg of baking yeast
- 10 g of corn starch
- 250 ml Erlenmeyer flask (or 9 oz plastic cup)
- Aluminum foil, plastic wrap, or parafilm to cover flask or (9 oz cup)
- Weighing boat or aluminum foil to create a boat
- Scale (0.01 accuracy)
- 100+ ml of distilled water
- Incubator or water bath
- Pieces of sugarless chewing gum or canning wax
- Saliva collection cup (5 oz)
- 10 ml of saliva mixture for flasks/cups 3,4,5,and 6
- Balloons to place over flasks to capture gas (optional)
- Colored marker

Lab Matrix

Your group will be assigned a flask (or 9 oz cup) to prepare and collect data on.

	Empty Mass (g)	Sugar Mass (g)	Starch Mass (g)	Yeast Mass (g)	Water (ml)	Enzyme (ml) (saliva)
Flask 1		10	0	4	100	0.0
Flask 2		0	10	4	100	0.0
Flask 3		0	10	4	100	0.5
Flask 4		0	10	4	100	1.0
Flask 5		0	10	4	100	2.5
Flask 6		0	10	4	100	5.0
Flask 7		0	0	0	100	0.0



Lab Procedure

- Each group of students will be responsible for preparing one of the seven 250 ml flasks (or 9 oz cups) according to the lab matrix. Label your flask/cup with the number you have been assigned.
- 2. Mass the empty flask/cup and record it on the table.
- 3. Mass the sugar, starch, and yeast as required for your part of the lab and add it to the flask/cup.
- 4. Add warm (37°C) water to the flask/cup and enzyme (saliva from the pre-lab prep) to your flask/cup in the amount indicated by the matrix.
- 5. Cover the flask/cup with parafilm, plastic wrap, or aluminum foil and poke 2 small holes in the cover.
- 6. Record the mass of your flask/cup on the table below. The class will later combine all the results of the lab for final analysis.
- 7. Swirl the flask/cup to mix and place the flask/cup in an incubator or water bath set at 37° C.

- Measure the mass of the flask/cup every 3 or 5 minutes. Swirl the flask/cup occasionally during the incubation.
 <u>IMPORTANT</u> Make sure to wipe the excess water from the side of the container if using a water bath.
- 9. Continue to measure the mass until the end of class.
- 10. Let the reaction continue until the next day.
- 11. Record the final mass the next day in the "ON" (Over Night) column.
- 12. Combine your data with the class data on the data table provided by your teacher and transfer these results to your table.
- 13. Follow your teacher's instructions for graphing your data alongside the data from the other groups.
- 14. Discuss in your group the data and answer the questions under Reflection & Analysis and Enrichment Questions.

Time (min)	Flask 1	Flask 2	Flask 3	Flask 4	Flask 5	Flask 6	Flask 7
0							
(3) 5							
(6) 10							
(9) 15							
(12) 20							
(15) 25							
(18) 30							
(21) 35							
(24) 40							
(27) 45							
Final (ON)							
Difference							

Data Table

Reflection & Analysis

Your name: _____

- 1. Which flask/cup(s) indicated the fastest rate of reaction? How would you use your graph to determine the rate?
- 2. Which flask/cup(s) showed the greatest change of mass?
- 3. What effect did the enzymes have on the reaction(s)?
- 4. Research and write a balanced chemical equation for the reaction in this exercise.
- 5. As the exercise is set up, which of the components is likely responsible for the change in mass?
- 6. What classes of enzymes (saliva) are being used in the exercise?
- 7. What is the chemical name of the product that has great commercial value?

Enrichment Questions

- 1. Draw a picture that shows what is happening in the fermentation process. Include energy and product reactions.
- 2. What is the range and value of products we can get from fermentation? In your answer, explain associated positives and negatives of each.



Meeting Educational Science Standards Using C6 BioFarm Curriculum: <u>Lesson 1</u>

Standard	Description	Students Will	Activity
arth's Systems <u>/S-ESS2-1</u>	Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process.	Learn how various forms of energy can be produced from carbon resources	Carbon Comparison Activity Carbon in the Energy Cycle
arth's Systems <u>IS-ESS2-6</u>	Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.	Understand the role of carbon in the environment, and how carbon cycles through the environment	Fermentation
cosystems: nteractions, Energy, nd Dynamics <u>4S-LS2-3</u>	Develop a model to describe the cycling of matter and flow and energy among living and nonliving parts of an ecosystem.	Understand the role of plants and animals in the carbon cycle	Fermentation





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Agriculture, Food, and Natural Resources Career Cluster Standards

Standard	Description	Students Will	Activity
Evaluate the nature and scope of the Agriculture, Food & Natural Resources Career Cluster and the role of agriculture, food and natural resources (AFNR) in society and the economy <u>CS.02.02</u>	Examine the components of the AFNR systems and assess their impact on their local, state, national, and global society, and economy.	Learn about how carbon surrounds them and how it impacts our economy	Carbon Comparison Activity
Analyze the interrelationships between natural resources and humans <u>NRS.02.01</u>	Analyze the interrelationships between natural resources and humans.	Learn how human actions impact the carbon cycles and the overall ecosystem	Fermentation
Analyze the interrelationships between natural resources and humans <u>NRS.02.04</u>	Examine and explain how economics affects the use of natural resources.	Learn how consumer preferences and markets impact demand and use of various carbon resources	Carbon Comparison Activity
Analyze the interrelationships between natural resources and humans <u>NRS.02.05</u>	Communicate information to the public regarding topics related to the management, protection, enhancement, and improvement of natural resources.	Be able to share information about best practices for stewardship and use of natural resources	Carbon Comparison Activity
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