Bubbles in the Cabbage Juice

Grades 6-8

English Language Arts, Science

Objectives

Students will conduct experiments with cabbage juice as an indicator to identify carbon in a variety of substances.

Vocabulary

acidic—having a pH below 7, any compound that reacts with a base to form a salt
anthocyanin—the soluble pigments that give red, purple and blue plants their coloring
basic—having a pH greater than 7, any base which can neutralize an acid
neutral—neither acid nor basic
pH—a number used in expressing acidity or alkalinity on a scale whose values run from 0 to 14 with 7 representing neutrality, numbers less than 7 increasing acidity, and numbers greater than 7 increasing alkalinity; also: the condition represented by such a number
pigment—a substance that gives color to other materials
soluble—capable of being dissolved in a liquid
solution—a liquid in which something has been dissolved

Background

Cabbage is a cole crop, related to broccoli, cauliflower, kale and Brussels sprouts. It is a cool weather vegetable that grows well in Oklahoma when planted very early in the spring or in the fall.

The cultivated cabbage is derived from a leafy plant called the wild mustard plant, native to the Mediterranean region. It is an excellent source of Vitamin C and contains large amounts of glutamine, an amino acid that has anti-inflammatory properties.

Red cabbage contains a **pigment** molecule called flavin (an **anthocyanin**). This water-**soluble** pigment is also found in apple skin, plums, blueberries, blackberries and grapes. Very **acidic solutions** will turn anthocyanin a red color. **Neutral** solutions result in a purplish color. **Basic** solutions appear greenish-yellow. Because of this it is possible to determine the **pH** of a solution based on the color it turns the anthocyanin pigments in red cabbage juice.

The color of the juice changes in response to changes in its hydrogen ion concentration. Acids will donate hydrogen ions in an aqueous solution and have a low pH. Bases accept hydrogen ions and have a high pH**.**

Additional Reading

Burnie, David. *Plant: Discover the Fascinating World of Plants from Flowers and Fruit to Plants that Sting*, Eyewitness Books, DK Children, 2011
Chambers, Catherine, *Drought* (Wild Weather), Heinemann, 2007.
Corning, Eli, Sadeghpour, Amir, Ketterings, Quirine, Czmmek, Karl, *The Carbon Cycle and Soil Organic Carbon*, Fact Sheet 91, Cornell Cooperative Extension Service, 2016
Desonie, Dana, *Geosphere:* The Land and Its Uses (Our Fragile Planet), Chelsea House, 2008.
Gifford, Clive. *The Kingfisher Geography Encyclopedia,* Kingfisher, 2003.
Lindbo, David, *SOIL! Get the Inside Scoop*, American Society of Agronomy, 2008.
Nardi, James B., *The World Beneath Our Feet: A Guide to Life in the Soil,* Oxford, 2003.
Reilly, Kathleen, *Explore Soil! 25 Great Projects* (Explore Your World), Nomad Press, 2015
Rosinsky, Natalie Myra, *Dirt: The Scoop on Soil* (Amazing Science), Picture Window Books, 2002

Websites

https://www.noble.org/news/publications/ag-news-and-views/2001/august/what-does-organic-matter-do-in-soil/
https://blogs.ei.columbia.edu/2018/11/27/carbon-dioxide-removal-climate-change/

REV 03/2021

Activity 1: Carbon, Agriculture and Climate Change, (English Language Arts)

1-2 50 minute class periods

Students will research methods to reduce carbon dioxide in the atmosphere, create an objective summary and write a research paper on one of the ways agriculture can help reduce carbon impacts.

Oklahoma Academic Standards

Activity 1: Carbon, Agriculture and Climate Change (English Language Arts)

6.2.R.1 7.2.R.1	Students will create an objective summary, including main idea and supporting details, while maintaining meaning and a logical sequence of events.
8.2.R.1	Students will summarize and paraphrase ideas, while maintaining meaning and a logical sequence of events, within and between texts.
6.2.R.3 7.2.R.3 8.2.R.3	Students will paraphrase or generalize main ideas with supporting details in a text.
6.6.R.1 7.6.R.1 8.6.R.1	Students will use their own viable research questions and thesis statements to find information about a specific topic.
6.6.R.2 7.6.R.2 8.6.R.2	Students will follow ethical and legal guidelines for finding and recording information from a variety of primary and secondary sources (e.g., print and digital).
6.6.R.3 7.6.R.3 8.6.R.3	Students will determine the relevance, reliability, and validity of the information gathered.
6.6.W.1 7.6.W.1 8.6.W.1	Students will write research papers and/or texts independently over extended periods of time (e.g., time for research, reflection, and revision) and for shorter timeframes (e.g., a single sitting or a day or two) .
6.6.W.4 7.6.W.4 8.6.W.4	Students will summarize and present information in a report.

Materials:

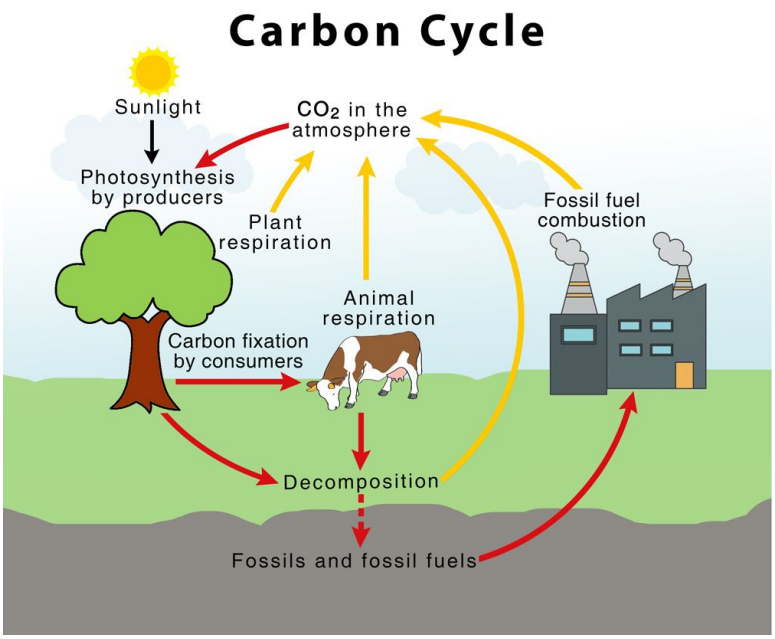
- Activity 1 Reading Page 1"**Carbon, Agriculture and Climate Change"**
- Activity 1 Worksheet 1 "**Objective Summary"**
- Activity 1 Reading Page 2 "**Are Your Sources Reliable?"**
- Activity 1 Worksheet 2 "**Are Your Sources Reliable?"**

Continued procedures:

Procedures

1. Provide copies of Activity 1 Reading Page 1 "**Carbon, Agriculture and Climate Change"**.
   —Students will read as a group or individually**.**
   —Discuss the information as a class.
   —Students will use Activity 1 Worksheet 1, "**Objective Summary"** to determine the main idea of the reading along with up to three details that support the main idea.
   —Students will write a summary of the text without personal opinions or judgments.
   —Students will determine the author's purpose and explain how it is conveyed in the text.
2. Students will use online search engines to research one of the following topics:
   - terrestrial carbon sequestration
   - no-till farming.

   —Students will gather relevant information from multiple print and digital sources.
   —Using Activity 1 Reading Page 1 "**Are your Sources Reliable?"** and Activity 1 Worksheet 2 "**Are your Sources Reliable**?", students should assess the credibility of each source.
   —Students will quote or paraphrase the data and conclusions of others while avoiding plagiarism and providing basic bibliographic information for sources.
3. Students will write research papers on the assigned topics and present information in a report.



Carbon dioxide gas is a colorless, odorless gas that is part of our atmosphere. It is formed by respiration (breathing), combustion (burning), chemical reactions and decomposition (rotting).

Carbon is present in all organic matter. For thousands of years the carbon cycle on Earth was in balance. Plants took carbon dioxide gas from the air through photosynthesis and converted it to food, which animals could eat. Animals converted it back to carbon dioxide and released it back into the air through breathing or through waste materials, which decomposed. Plants that died without being eaten released carbon dioxide back into the air as they decayed.

Millions of years ago, some of the plants and animals fell into wet, swampy places where there was little oxygen in the soil. Since the normal decay process is not possible without oxygen, these plants and animals released very small amounts of carbon as carbon dioxide and methane gas. Over time these masses of matter became oil, coal and natural gas, which still contained most of the carbon from the original plants and animals. About 200 years ago, people discovered they could burn these materials to produce tremendous amounts of energy.

When people first started burning fossil fuels, they didn't realize they might be causing an imbalance in the carbon cycle. Although there are some scientists who disagree, the majority of climate scientists believe this imbalance is the cause of changes that are gradually taking place in our climate, causing the oceans to warm up and melt glaciers and producing droughts, extreme heat and storms, like tornados and hurricanes, that are more severe than usual.

Once they identified the problem, scientists began looking for solutions. One of the things they found was that during the 1980s an average 5.5 billion tons of carbon dioxide was released into the air through the burning of fossil fuels. During those same years, the amount of carbon dioxide in the air only increased by an average of 3.2 billion tons. By looking at these figures, scientists figured out that about 2.3 billion tons of carbon dioxide were taken up by plant photosynthesis. Scientists now are working on ways to use plants to take up even more of the extra carbon dioxide in our atmosphere. One simple way is to plant millions of trees.

Agricultural researchers found another possible solution in programs that were put in place for other reasons. Fifty years ago, the government established several programs designed to help slow the erosion of farmlands. Farmers were taught that their topsoil was not so likely to blow or wash away if they kept it covered with some kind of plants. Farmers began using such erosion control methods as no-till farming, which leaves stubble in place instead of plowing up a field after harvest. Researchers found that on land where these programs have been in place for long periods of time, large amounts of carbon from the atmosphere have been trapped in the soil and in the plants growing on top of them. Since carbon is necessary for plant growth, keeping carbon in the soil is also an added benefit for the farmer.

Bubbles in the Cabbage Juice

Activity 1 Worksheet 1: Objective Summary

Name: _____ Date: _____

Topic:

Main Idea (A sentence that tells what the passage is about)

_____

_____

Key Detail #1	Key Detail #2	Key Detail #3

Summary (2-3 sentences about the passage)

_____

_____

_____

_____

_____

_____

_____

1. When conducting research, make sure you use reliable information from legitimate sources. Reliable information is well-researched from sources that are well-respected and as objective, or neutral, as possible. the best way to find legitimate sources is to go to the library and use scholarly journals, reference books and other well-researched sources.

2. Another place to find information is the internet. Conducting research on the internet is convenient, but it can also be tricky. There are many thousands of Web pages that have little actual content and are mainly links to other pages, which may be links to other pages, and so on. Anyone can post anything to the internet. To make sure you have found a reliable source of information, ask yourself these questions:

    - Who is responsible for the Web site? Is the Web page associated with a reliable organization, such as a university or a government agency?
    - What interest does the organization responsible have in the information presented.
      For example, will the organization profit from the information presented?
    - Who wrote the information? If the author is not listed or has no credentials, it may not be a credible source. Pay attention to the author's credentials or experience. Is the source really an authority on this particular matter or someone with an impressive title that has no connection to the subject matter?
    - When was the information written? Is it current? Is it still relevant?
    - Are there other sources that agree with statements made on the site, or do other sources contradict this source? In that case you may need to search further. It's always a good idea to gather more than one source.
    - Are any sources cited? If the author does not document anything, then the information may simply be someone's opinion.
    - If statistics used come from a survey, how was the data collected? Who conducted the survey or poll? Was the sample representative of the population? How many were surveyed? What percent of the population?

3. When choosing between the library and the internet keep in mind that up to 90 percent of the contents of college library collections are not on the internet. Because of copyright laws it is too expensive to put all scholarly work on the internet. This means that the most comprehensive source of information is still the library.

Bubbles in the Cabbage Juice

Activity 1 Worksheet 2: How Reliable are your Sources?

Name: _____ Date: _____

Website Name	What Organization is responsible for the site?	When was it written?	Who is the writer?	What sources are cited?	How did you find the site?	Is the site legitimate or questionable?

Activity 2: Detecting Carbon (Science) 1-2 50 minute class periods

Students will use cabbage juice to experiment with chemicals that will cause a reaction. Students should be careful and have adult supervision during procedure. Students will then observe and record what happened and learn from the activity.

Oklahoma Academic Standards

Activity 2: Detecting Carbon (Science)

6.ESS2.1	Develop a model to describe the cycling of Earth's materials and the flow of energy that drives these processes within and among Earth's systems.
7.PS1.2	Analyze and interpret patterns of data related to the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.
7.LS1.6	Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms.
7.LS2.3	Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.
7.ESS3.3	Apply scientific principles to design a method for monitoring and minimizing human impact on the environment.
8.LS1.5	Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.

Materials:

- Activity 2 Worksheet 1A "**Yeast and Sugar"**
- Activity 2 Worksheet 1B "**Baking Soda and Vinegar"**
- Activity 2 Worksheet 1C "**Club Soda"**
- Activity 2 Worksheet 1D "**Human Breath"**
- Activity 2 Recipe Page "**CO_2 in Food Preparation"**
- Activity 2 Worksheet 2 **"Scientific Study Format"**
- Activity 2 Reading Page 1 "**Carbon in Our Soil"**
- Activity 2 Worksheet 3 "**Soil pH"**
- 1 head purple cabbage, finely chopped
- 2 quarts distilled water
- pitcher
- clear plastic cups or small jars (4 and 8 ounce canning jars are easy to store and can be reused)
- funnel
- measuring cups and spoons
- yeast
- sugar
- 1 bottle of club soda

Materials (continued)

- baking soda
- vinegar
- 2 empty, clean 16-ounce soda bottles
- balloons
- drinking straws
- soil samples from three different places with varying amounts of organic content. If most of the soil in your area is similar (all river sand, red clay, etc.) consider buying sand, topsoil (without fertilizer) and compost or peat moss from a farm/garden store as additional samples to test so students can see some difference in soil pH.

Procedures

Advance Preparation:

(cabbage juice can be prepared ahead of time and stored in the refrigerator for several days)
—Bring distilled water to a boil.
—Chop the cabbage and add it to the boiling water.
—Remove the water from the heat and let it stand for about 30 minutes, stirring occasionally. A lid on the pan or container will help contain the odor as the liquid cools.
—Strain the liquid into a pitcher and let it cool.
—Label five clear cups or small jars: control, yeast/sugar, baking soda/vinegar, club soda, breath
—Pour about ½ cup of the cooled liquid into each of the cups.
—Set aside the remaining liquid to use later

1. Read and discuss the background information about cabbage. Explain that cabbage is an indicator—a substance that indicates the presence, absence or concentration of a substance or the degree of reaction between two or more substances by means of a characteristic change. In addition, explain that carbon dioxide makes an acid when dissolved in water.
2. Remind students of potential hazards when mixing substances together. As always, practice safety procedures in all science activities.
3. Divide the class into four groups
   —Pour ½ cup cabbage juice into each of the 5 cups (labeled control, yeast/sugar, baking soda/vinegar, club soda, breath).
   —Keep the "control" cup separate so all groups will be able to compare their results to it.
   —Give each of the groups one of the labeled cups and the appropriate materials
4. Group A - provide a copy of Activity 2 Worksheet 1A "**Yeast and Sugar"** and the items listed below. Students will follow instructions on worksheet and answer questions.
   —jar or cup with cabbage juice
   —funnel
   —16-ounce soda bottle
   —balloon
   —1 packet of yeast
   —1 teaspoon sugar
   —1/2 cup warm water (about 110°F)
   —drinking straw
5. Group B - provide a copy of Activity 2 Worksheet 1B "**Baking Soda and Vinegar"** and the items listed below. Students will follow instructions on worksheet and answer questions.
   —jar with cabbage juice
   —funnel
   —16-ounce soda bottle
   —balloon
   —1 tablespoon baking soda
   —2 tablespoons vinegar
   —drinking straw

Procedures, continued

6. Group C - provide a copy of Activity 2 Worksheet 1C "**Club Soda"** and the items listed below. Students will follow instructions on worksheet and answer questions.
   —jar with cabbage juice —balloon
   —bottle of club soda —drinking straw
7. Group D - provide a copy of Activity 2 Worksheet 1D "**Human Breath"** and the items listed below. Students will follow instructions on worksheet and answer questions
   —jar with cabbage juice —drinking straw
   —balloon
8. After all groups have concluded their experiments, line up all four cups.
   —Students will compare the four cups with the control cup and with each other.
9. Students will summarize the investigation using Activity 2 Worksheet 2 "**Scientific Study Format"**.
10. Students will answer the following questions in their summaries:
    • Did one source of carbon dioxide cause more color change than the other sources?
    • Which method would you use if you needed to make a large amount of carbon dioxide?
    • How is carbon dioxide formed?
11. Explain the relationship between organic matter and soil pH.
    —Soils rich in humus (organic matter) tend to be more acidic than others.
    —Decomposition and respiration of soil creatures makes carbon dioxide, which forms an acid when dissolved in water.
    —Alkaline(basic) soils have low organic content. However, some soils will test high for acid even though they do not contain much organic matter.
12. Have students read Activity 2 Reading Page "**Carbon in Our Soil"** before starting the experiment.
    —Distribute Activity 2 Worksheet 2 "**Soil pH"**.
    —Students will follow the directions on the worksheet and write their results in their journal.
    —Students will also copy and answer the questions from the worksheet into their journals.
13. Place a different soil sample in each of the three jars. If most of the soil in your area is similar (all river sand, red clay, etc.) consider buying sand, topsoil (without fertilizer) and compost or peat moss from a farm/garden store to provide additional samples to test so students can see some difference in soil pH.
    —Fill each jar about one-fourth full with soil.
    —Fill each jar halfway full with cabbage water. The water level should be higher than the soil level.
14. Compare the colors of each sample
    —The redder the water gets, the more acid the soil is. This usually means the soil is high in organic content.
    —The more blue the water, the more alkaline the soil. This usually means the soil is low is organic content.
15. Fill the two remaining jars halfway with cabbage water.
    —Add 1⁄4 cup of vinegar to one. The liquid should turn red indicating extreme acid conditions.
    —Add 2 tablespoons baking soda to the other jar. The liquid should turn blue indicating extreme alkaline conditions.

Procedures, continued

16. Use these last two jars to compare the acidity and alkalinity of the 3 soil jars.
17. Line up the jars from blue to purple to red.
18. Record your procedures and results from this investigation in a lab book or journal.
19. Copy the questions from the worksheet and answer them in the journal.

Activity Extension

20. Since blackberries, blueberries, plums and red/purple grapes have the same water-soluble pigment as cabbage, students will repeat the above activity, using a different juice as an indicator.
21. To illustrate how carbon dioxide formation is important in baking, use the yeast solution from the experiment to make pancakes. There is also a recipe for buttermilk (baking soda) pancakes, so students can compare the texture of the pancakes, based on the leavener (substance that causes gas to form in the dough) used.

Bubbles in the Cabbage Juice

Activity 2 Worksheet 1A: Yeast and Sugar

Name: _____ Date: _____

GROUP 1: YEAST/SUGAR

Materials:

- jar or cup with cabbage juice
- funnel
- 16-ounce soda bottle
- balloon
- 1 packet of yeast
- 1 teaspoon sugar
- 1/2 cup warm water (about 110°F)
- drinking straw

Procedure

1. Blow up a balloon and let the air out to stretch the balloon.
2. Use the funnel to put the warm water, yeast and sugar into the soda bottle, and let it sit for about 10-15 minutes. Be sure to add water to the bottle first and yeast last
3. When the solution has bubbles or foam on top, put a balloon over the mouth of the bottle and gently shake the contents.
4. Let the bottle and balloon sit until the balloon is inflated.
5. Twist the balloon closed and remove it from the bottle.
6. Insert a straw in the balloon opening to release some of the gas from the balloon into the cup of cabbage juice in the cup.
7. In a journal, record materials used, steps completed and results.
8. Compare your cup with the “control” cup to justify your results.

How long did it take for the balloon to inflate?

_____

Did the cabbage juice change color when the gas from the balloon was released into the juice?

_____

If there was a color change, describe the color.

_____

What does the color change mean? Is the gas an acid or a base?

_____

Bubbles in the Cabbage Juice

Activity 2 Worksheet 1B: Baking Soda and Vinegar

Name: _____ Date: _____

GROUP 2: BAKING SODA/VINEGAR

Materials:

- jar with cabbage juice
- funnel
- 16-ounce soda bottle
- balloon
- 1 tablespoon baking soda
- 2 tablespoons vinegar
- drinking straw

Procedure

1. Blow up a balloon and let the air out to stretch the balloon.
2. Use a funnel to place the baking soda in the bottle.
3. Use a funnel to place vinegar in the balloon.
4. Attach the balloon to the mouth of the balloon, and allow the vinegar to flow into the bottle with the baking soda.
5. When the balloon inflates, twist the opening, and remove it from the bottle..
6. Insert a straw in the balloon opening to release some of the gas from the balloon into the cup of cabbage juice in the cup.
7. In a journal, record materials used, steps completed and results.
8. Compare the “control” cup to justify your results.

How long did it take for the balloon to inflate?

_____

Did the cabbage juice change color when the gas from the balloon was released into the juice?

_____

If there was a color change, describe the color.

_____

What does the color change mean? Is the gas an acid or a base?

_____

Bubbles in the Cabbage Juice

Activity 2 Worksheet 1C: Club Soda

Name: _____ Date: _____

GROUP 3: CLUB SODA

Materials:

- jar with cabbage juice
- bottle of club soda
- balloon
- drinking straw

Procedure

1. Blow up a balloon and let the air out to stretch the balloon.
2. Open the bottle of club soda, and quickly put the balloon on the bottle mouth.
3. Let the balloon stay on the bottle until it inflates.
4. Twist the balloon closed.
5. Take the balloon off the bottle.
6. Insert a straw in the balloon opening to release some of the gas from the balloon into the cup of cabbage juice in the cup.
7. In a journal, record materials used, steps completed and results.

How long did it take for the balloon to inflate?

_____

Did the cabbage juice change color when the gas from the balloon was released into the juice?

_____

If there was a color change, describe the color.

_____

What does the color change mean? Is the gas an acid or a base?

_____

Bubbles in the Cabbage Juice

Activity 2 Worksheet 1D: Human Breath

Name: _____ Date: _____

GROUP 4: HUMAN BREATH

Materials:

- jar with cabbage juice
- balloon
- drinking straw

Procedure

1. Blow up a balloon and let the air out to stretch the balloon.
2. Blow up the balloon again and twist the opening.
3. Release some of the gas from the balloon into the cup of cabbage juice in the cup.
4. In a journal, record materials used, steps completed and results.
5. Compare with the “control” cup to justify your results.

Did the cabbage juice change color when the gas from the balloon was released into the juice?

_____

If there was a color change, describe the color.

_____

What does the color change mean? Is the gas an acid or a base?

_____

Bubbles in Cabbage Juice

Activity 2 Worksheet 2: Scientific Study Format

Name: _____ Date: _____

Title of Experiment or Study:

I. Stating the Problem: What do you want to learn or find out?

II. Forming the Hypothesis: What is known about the subject or problem, and what is a prediction for what will happen?

III. Experimenting: (Set up procedures) This should include: materials used; dates of the experimental study; variables, both dependent and independent (constant and experimental); how and what was done to set up the experiment; fair testing procedures.

IV. Observations: Includes the records, graphs, data collected during the study.

V. Interpreting the Data: Does the data support/defend the hypothesis?

VI. Drawing Conclusions: Justify the data collected with concluding statements about what has been learned. Discuss any problems or concerns. Use other studies to support the conclusion. Give alternative ideas for testing the hypothesis

Buttermilk (Baking Soda) Pancakes

Yield: Makes 12-14 pancakes

Ingredients

- 2 cups all-purpose flour
- 2 tablespoons sugar
- 1 teaspoon salt
- 1 teaspoon baking soda
- 2 eggs
- 2 cups buttermilk
- ¼ cup butter, melted

Instructions

1. Preheat a lightly oiled griddle or fry pan.
2. Sift together flour, salt and baking soda.
3. Beat egg in medium bowl.
4. Blend in buttermilk.
5. Add dry ingredients, beating until smooth
6. Blend in melted butter.
7. Cook on lightly oiled griddle or fry pan.
8. Turn pancakes when surface bubbles begin to break.

The Carbon Dioxide formed as yeast multiplies or baking soda reacts with an acid is important in baking. Carbon Dioxide bubbles form in the dough and baking stabilizes the gas bubbles to make pancakes light and fluffy.

For easier clean-up, mix dry ingredients together in a large zip-top bag by shaking the bag several times.

Pour liquids into bag and squeeze until all ingredients are mixed. Buttermilk pancakes should be cooked immediately.

Yeast Pancakes

Yield: Makes 12-14 pancakes

Ingredients

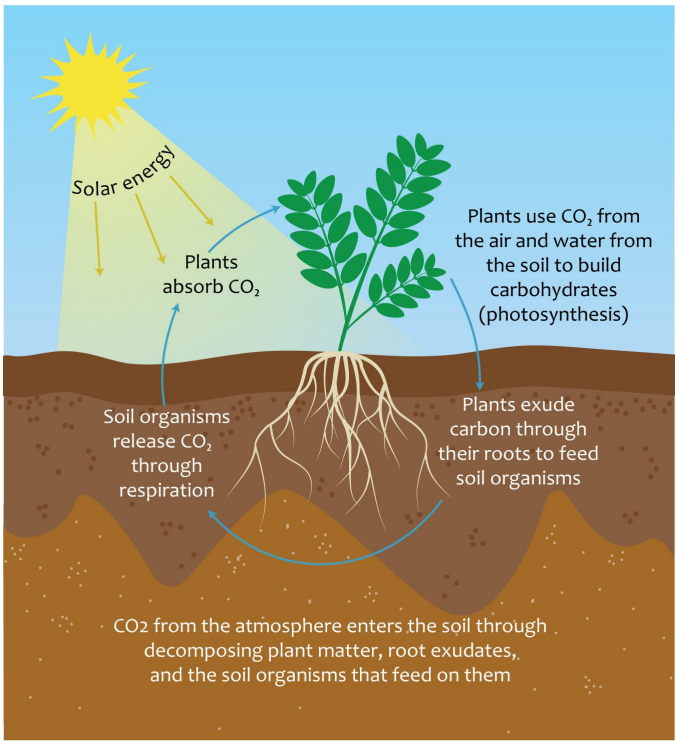
- 2 1/4 cups all-purpose flour
- 3 tablespoons sugar
- 1 teaspoon salt
- 1 teaspoon ground cinnamon
- 1 package yeast
- 1 teaspoon vanilla extract
- 1 1/2 cups warm milk
- 1/4 cup butter, melted
- 1 egg

Instructions

1. In a large bowl combine flour, sugar, salt, cinnamon and yeast; mix well.
2. Add vanilla, milk, butter, and egg until well blended.
3. Cover and place in refrigerator overnight.
4. Heat a lightly oiled griddle or frying pan over medium high heat.
5. Stir the batter with a whisk.
6. Pour or scoop the batter onto the griddle, using approximately 1/4 cup for each pancake.
7. Brown on both sides and serve hot.

To use the yeast solution from the experiment in this recipe, reduce the milk to one cup and add the yeast solution to the dry ingredients with the other liquids.

Yeast pancake batter should be refrigerated to allow the yeast to grow before baking.



The carbon plants absorb from the atmosphere during photosynthesis becomes part of the soil when they die and decompose. This carbon, in the form of organic matter, improves soil health and increases crop yields. This carbon can remain in soil for many years or it can be released quickly depending on how the soil is managed.

Some tilling is necessary, because it helps incorporate air and speeds up plant decomposition. However, too much tilling releases carbon into the atmosphere and decreases soil fertility. Reduced tillage, cover crops, crop rotation and leaving crop residues in the field or garden helps soil store more carbon.

The organic matter in soil was once living plants. As plants die and decompose, they become part of the soil. In a forest, dead leaves decompose and add organic matter to the soil. Plants that die back and decompose each year also add organic matter to the soil. Farmers plant cover crops after wheat and corn is harvested to provide grazing for livestock, prevent erosion and build or maintain organic matter in the soil.

It takes a lot of plant residue to increase organic matter in soil. About 90 percent of plant material decomposes quickly in or on top of soil. The residue continues to break down in the soil until it become stable organic matter.

Fertile soil is a blend of organic (carbon-based) matter, clay and sand.

- Organic matter improves the texture of soil because it is like a sponge. It can hold up to 90 percent of its weight in water. Organic matter releases most of that water to plants. Although clay soils hold water, because of the soil texture, much of it cannot be absorbed by plants. Organic matter helps loose, sandy soil hold onto water so plants can utilize it. It also provides nutrients, like nitrogen and phosphorus, that plants need for growth. Soils with the right amount of organic matter need less added fertilizer.
- Clay is fine mineral particles. By itself, clay soil is heavy and sticky. When mixed with sand, clay can improve the water-holding capacity of the soil.
- Sand is tiny rock particles. Some sand is coarse while other sand is fine. Sand has sharp edges that keep the particles from sticking together. When mixed with clay soil, sand improves drainage and helps plant roots get air.

Organic matter is an important component of good soil. But can you have too much of a good thing? The higher the amount of organic matter in a soil, the lower the pH. Most plants thrive in slightly acidic (5.5 to 7.0 pH) soils. Over hundreds of years, too much carbon in the soil has the potential to make it more acidic and less productive.

Source: *What Does Organic Matter do in Soil*?, Ag News and Views, Noble Foundation, August 2001
Can Removing Carbon From the Atmosphere Save Us From Climate Catastrophe?, State of the Planet, Columbia University, November 2018

Bubbles in Cabbage Juice

Activity 2 Worksheet 3: Soil pH

Name: _____ Date: _____

MATERIALS PER TEAM

- 1 cup red cabbage juice
- 5 baby food-size jars or 4 ounce canning jars
- ¼ cup vinegar
- 6 teaspoons baking soda
- 3 soil samples from 3 different locations
- log or journal

INSTRUCTIONS:

1. Place a different soil sample in each of the three jars. Label each jar with the source or location of each sample.
   —Fill each about one-fourth full with soil.
   —Set aside the remaining portion of each soil sample to compare texture once pH testing is complete
2. Fill each jar halfway with cabbage water.
   —Record color of each sample below
   —Circle whether the sample is more acidic or more alkaline
3. Fill the two remaining jars halfway with cabbage water.
   —Add 1⁄4 cup of vinegar to one. The liquid should turn red indicating extreme acid conditions.
   —Add 2 Tablespoons baking soda to the other jar. The liquid should turn blue indicating extreme alkaline conditions.
4. Use these last two jars to compare the acidity and alkalinity of the 3 soil jars.
5. Line up the jars from blue to purple to red.
6. Record your procedures and results from this investigation in a lab book or journal.
7. Copy the questions from the worksheet and answer them in the journal.

QUESTIONS:
Record the color of each sample:

Sample 1: _____ Acidic Alkaline

Sample 2: _____ Acidic Alkaline

Sample 3:_____ Acidic Alkaline

• If a soil tests acidic, does it have high or low organic content?

• Which would have more organic content—soil from a forest floor or soil from a plowed field?

• Would all plants grow well in highly organic soil?

Bubbles in Cabbage Juice

Activity 2 Worksheet 3: Soil pH

ANSWER KEY

Name: _____ Date: _____

MATERIALS PER TEAM

- 1 cup red cabbage juice
- 5 baby food-size jars or 4 ounce canning jars
- ¼ cup vinegar
- 6 teaspoons baking soda
- 3 soil samples from 3 different locations
- log or journal

INSTRUCTIONS:

1. Place a different soil sample in each of the three jars. Label each jar with the source or location of each sample.
   —Fill each about one-fourth full with soil.
   —Set aside the remaining portion of each soil sample to compare texture once pH testing is complete
2. Fill each jar halfway with cabbage water.
   —Record color of each sample below
   —Circle whether the sample is more acidic or more alkaline
3. Fill the two remaining jars halfway with cabbage water.
   —Add 1⁄4 cup of vinegar to one. The liquid should turn red indicating extreme acid conditions.
   —Add 2 Tablespoons baking soda to the other jar. The liquid should turn blue indicating extreme alkaline conditions.
4. Use these last two jars to compare the acidity and alkalinity of the 3 soil jars.
5. Line up the jars from blue to purple to red.
6. Record your procedures and results from this investigation in a lab book or journal.
7. Copy the questions from the worksheet and answer them in the journal.

QUESTIONS:

Record the color of each sample:

Sample 1: _____ Acidic Alkaline

Sample 2: _____ Acidic Alkaline

Sample 3:_____ Acidic Alkaline

- If a soil tests acidic, does it have high or low organic content?
  Acidic soils are usually high organic content, but not always. Sand may be acidic but contain low amounts of organic materials
- Which would have more organic content—soil from a forest floor or soil from a plowed field?
  There generally is more organic matter in a forest than in a plowed field. A forest canopy will continually drop leaves, sticks, and other debris, whereas a plowed field has no canopy. However, some agricultural fields can be rich in added material, and some forests, such as those containing cedar trees, can be low in organic material
- Would all plants grow well in highly organic soil? No - Desert plants grow best in low organic conditions.