The Science of Growing North Carolina Sweetpotatoes
Grades 6 - 8

Purpose: Students will identify scientifically relatable content to the process of planting, transplanting, growing, cultivating, and harvesting sweetpotatoes. Students will examine how abiotic and biotic factors, photosynthesis, soil, and fertilizer affect sweetpotato production in North Carolina.

Subject Area(s): Science

Common Core/Essential Standards

Science
6th Grade
6.E.2.4 Conclude that the good health of humans requires: monitoring the lithosphere, maintaining soil quality and stewardship.
6.L.1.1 Summarize the basic structures and functions of flowering plants required for survival, reproduction and defense.
6.L.1.2 Explain the significance of the processes of photosynthesis, respiration, and transpiration to the survival of green plants and other organisms.
6.L.2.3 Summarize how the abiotic factors (temperature, water, sunlight, and soil quality) of biomes (freshwater, marine, forest, grasslands, desert, Tundra) affect the ability of organisms to grow, survive and/or create their own food through photosynthesis.

7th Grade
7.L.1.2 Compare the structures and functions of plant and animal cells, including major organelles (cell) membrane, cell wall, nucleus, chloroplasts, mitochondria, and vacuoles).

8th Grade
8.L.1.1 Summarize the basic characteristics of viruses, bacteria, fungi and parasites relating to the spread, treatment and prevention of disease.
8.L.1.2 Explain the difference between epidemic and pandemic as it relates to the spread, treatment and prevention of disease.
8.L.3.3 Explain how the flow of energy within food webs is interconnected with the cycling of matter (including water, nitrogen, carbon dioxide and oxygen).
8.L.5.1 Summarize how food provides the energy and the molecules required for building materials, growth and survival of all organisms (to include plants).
8.P.2.2 Explain the implications of the depletion of renewable and nonrenewable energy resources and the importance of conservation.

National Agricultural Literacy Outcomes

Agriculture and the Environment

(b) Describe benefits and challenges of using conservation practices for natural resources (e.g., soil, water, and forests), in agricultural systems which impact water, air, and soil quality

(c) Discover how natural resources are used and conserved in agriculture (e.g., soil conservation, water conservation)

(d) Discuss (from multiple perspectives) land and water use by various groups (i.e., ranchers, farmers, hunters, miners, recreational users, government, etc.), and how each use carries a specific set of benefits and consequences that affect people and the environment

(g) Recognize how climate and natural resources determine the types of crops and livestock that can be grown and raised for consumption

(h) Recognize the factors of an agricultural system which determine its sustainability

Plant, Animals, Food, Fiber, and Energy

(d) Identify renewable and nonrenewable energy sources

Food, Health, and Lifestyle

(g) Identify agricultural products (foods) that provide valuable nutrients for a balanced diet

(i) Identify sources of agricultural products that provide food, fuel, clothing, shelter, medical, and other non-food products for their community, state, and/or nation

Science, Technology, Engineering & Mathematics

(b) Describe how biological processes influence and are leveraged in agricultural production and processing (e.g., photosynthesis, fermentation, cell division, heredity/genetics, nitrogen fixation)

(f) Explain the harmful and beneficial impacts of various organisms related to agricultural production and processing (e.g., harmful bacteria/beneficial bacteria, harmful/beneficial insects) and the technology developed to influence these organisms

Essential Questions

- What are the abiotic and biotic factors of a sweetpotato plant?
- How do plant and animal cells differ?
- What is the life cycle of a sweetpotato?
- Why do farmers use transplanting for growing sweetpotatoes?
- Why are soil and fertilizer essential to sweetpotatoe production?
- Why are sweetpotatoes important to North Carolina?

Materials

- *From Farm to School – Crops of North Carolina: Digging for Sweetpotatoes* by Heather Barnes and Karen Baltimore (book)
  Printed by North Carolina Department of Agriculture and Consumer Services
  Publication supported by U.S. Department of Agriculture's (USDA) Agriculture Marketing Service North Carolina
- Technology: Computer/iPad/Chromebook, etc.
- Chart paper

- Markers
- Sweetpotatoes, talk with a local sweetpotato farmer
- Microwavable sweetpotatoes
- pH soil kit (optional)
- Saran wrap/tin foil/cardboard box/plastic box/etc.
- Mason jar/plastic cup
- Water
- Soil types: clay, sand, dirt
- Tooth picks (5-6 per student)

Essential Files/Links

- From Farm to School – Crops of North Carolina: Digging for Sweetpotatoes (book)
- Activity One Note Sheet
- Abiotic/Biotic Comparison Chart
- Abiotic/Biotic Comparison Chart Answer Key
- Plant/Animal Cell Diagram Chart
- Life Cycle of a Sweetpotato
- Life Cycle of a Sweetpotato Note Taking Sheet
- Photosynthesis Note Sheet
- Photosynthesis Exit Ticket
- Photosynthesis Diagram
- Note Taking Sheet for Videos
- Diffusion and Active Transport Note Taking Sheet
- Answer Key for Diffusion and Active Transport
- Answer Key for Photosynthesis Exit Ticket
- USDA Natural Resource Conservation Service - Web Soil Survey (webpage)
- Link to find growers: https://ncsweetpotatoes.com/sweet-potato-industry/growers/

Vocabulary

Abiotic factors: non-living things in an ecosystem that include sunlight, wind, clouds, water, rocks, energy, temperature, and soil.
Active transport: the movement of a substance across a biological membrane against its concentration gradient; from a less-concentrated area to a more-concentrated area. Active transport requires the input of energy and uses specific transport proteins.
Adenosine triphosphate (ATP): a compound that has three phosphate groups and is used by cells to store energy.
Agriculture: the science or practice of farming, including cultivation of the soil for the growing of crops and raising animals to provide food, wool, and other products.
Agricultural commodity: a raw material or an agricultural product that can be bought and sold such as a sweetpotato.

Biotic factors: living things in an ecosystem that include plants, animals, trees, and microorganisms, such as fungi, bacteria, and algae.
Chloroplasts: plastids in green plant cells which contain chlorophyll. Photosynthesis takes places within the chloroplasts.
Chlorophyll: a green pigment, present in all green plants and in cyanobacteria, responsible for the absorption of light to provide energy for photosynthesis.
Concentration gradient: a difference in the concentration of certain molecules over a distance.
Diffusion: movement of a substance down its concentration gradient from a more-concentrated area to a less-concentrated area.
Fibrous roots: shallow, thin, branching roots growing from the stem that collect water for plant growth.
Flower: part of the plant for reproduction that can produce seeds.
Harvest: to gather or pick a crop when it has reached maturity.
Herbicide: a chemical substance (liquid or dry) used to control or manipulate undesirable vegetation.
Hill: a group of sweetpotatoes growing below the surface of the soil.
Hydrogen: a colorless, highly flammable gas containing the atomic number 1.
Leaves: part of the plant that uses energy from sunlight for photosynthesis.
Lignin: a non-carbohydrate polymer that binds cellulose fibers together. It adds strength and stiffness to plant cell walls.
Loamy soil: soil that is made up mostly of sand, silt, and a small amount of clay.
Nematode: a worm of the large phylum *Nematoda*, which also includes roundworms or threadworms.
Nodes: part of a plant stem where one or more leaves will emerge.
Oxygen: a colorless, odorless, reactive gas, and the life supporting component of air containing the atomic number 8.
Photosynthesis: process where green plants and other organisms use sunlight to synthesize foods from carbon dioxide and water. It takes place in the leaves of plants.
pH: the measure of the soil's **alkalinity** and **acidity** measured on a scale of 1 to 14. The higher the number the more **alkaline,** or basic, the soil. Seven is considered **neutral**. The lower the number, the more **acidic** the soil is.
Silt: sediment that has been deposited into the soil by running water.
Slips: shoots that are grown from a mature sweetpotato.
Stem: the body or stalk of the plant.
Stomata: small openings located on the underside of a plant leaf used for gas exchange of carbon dioxide and oxygen.
Storage roots: roots that are specifically modified for storage of starch, water, and nutrients including carrots, beets, and sweetpotatoes. They usually grow underground as protection from plant-eating animals.
Transplant: replant in a different location.

NC Ag Facts

- North Carolina grows nearly 60% of all United States sweetpotatoes (more than any other state in the United States).[1]

- The sweetpotato is North Carolina's state vegetable.[1] The single-word term helps differentiate the sweetpotato from the white or Irish potato, which is a tuber, not a root, and possess a different nutrient profile. Sweetpotato, *Ipomoea batatas*, a storage root is part of the morning glory family. [8]
- North Carolina sweetpotatoes are available every month of the year.[1]
- Most sweetpotatoes are grown in the piedmont and coastal plain regions of North Carolina because of the well-drained, sandy soil.[1]
- There are hundreds of varieties of sweetpotatoes and many are grown across North Carolina. Some you may see most often in grocery stores include the Japanese sweetpotatoes, the White sweetpotatoes, and the orange flesh Covington sweetpotatoes.[3]
- In 2017, nearly 89,500 acres of sweetpotatoes were harvested; 30,000 more acres than California, Louisiana, and Mississippi combined.[7]
- North Carolina has produced more than one billion pounds of sweetpotatoes for the last seven years; this is the only state to exceed one billion pounds.[7]
- In dollars, NC had the largest increase in 2017 at just over $37 million.[7]

Background Knowledge

Did you know that a sweetpotato is actually part of the morning glory family? It is a perennial (perennials grow for multiple seasons without having to be replanted); though it is cultivated as an annual (annuals live for one growing season, but often cannot be overwintered). The creeping stems of this amazing plant can grow up to 20 feet long and frequently send out roots at the nodes which, in favorable seasons, bear small potatoes. There are three main types of leaves: round, shouldered, and lobed or split. The color of the stems and leaves varies from dark green to light purple. No flowers are produced except in southern latitudes.[2]

The skin color of a sweetpotato can range from white to yellow, red, purple, or brown. The flesh also ranges in color from white to yellow, orange, or orange-red.[3]

So, is it a yam, a sweetpotato, or are they the same thing? The truth: yams and sweetpotatoes are not the same thing at all. There are thousands of sweetpotato varieties. Sweetpotato varieties are classified as either 'firm' or 'soft' – firm varieties were produced before soft varieties. When the soft varieties were grown there was a need to differentiate between the two (firm or soft). Africans actually named the 'soft' sweetpotatoes 'yams' because they resembled the yams in Africa. Their native word was 'nyami' and if the n & i are removed the term 'yam' remains. Despite this identification, this is not true. In fact, while the 'soft' varieties look like yams, they are not yams at all; it is just a variety of sweetpotato.

Yams are often imported from the Caribbean; they are rough and scaly—very different from our smooth, orange flesh variety sold in the United States. In the United States, people often use the word sweetpotatoes and yams interchangeably; however, this is not correct and often adds confusion for the consumer. When a consumer goes to the store and purchases 'yams,' they are more than likely

purchasing a different variety of sweetpotato. Today, the U.S. Department of Agriculture requires labels with the term 'yam' to be accompanied by the term 'sweetpotato.'[3]

According to the North Carolina SweetPotato Commission, North Carolina has ranked number one in sweetpotato production in the United States since 1971 (2018). North Carolina's hot, moist climate and rich, fertile soil are ideal for cultivating sweetpotatoes. Sweetpotato production in North Carolina averages nearly 60% of the U.S. supply.[4]

Climate
Sweetpotatoes can be grown where there is a long frost-free period with warm temperatures in the growing season.[4] Most cultivars require a minimum frost-free period of 90-120 days, with a minimum average daily temperature of 77 degrees Fahrenheit. Sweetpotatoes also require an inch of water per week uniformly distributed throughout the growing season for highest yields.[4]

Uses for Sweetpotatoes
Sweetpotatoes have many uses. They can be prepared in a number of dishes, canned, preserved and dried. For drying, clean washed potatoes are placed in a suitable basket and immersed in boiling water for a short time; when taken out of the basket, they are cut into thin slices and spread over mats and exposed to the sun for two or three days. In order to make a superior quality, the skin of the potato is peeled off before slicing. Instances were reported wherein the dried product was successfully ground into flour.[2] In North Carolina a company named Glean produces a sweetpotato flour.[5] Sweetpotatoes can also be used as food stock for animals. They have been successfully fed to hogs, cattle, horses and poultry. [2]

Student Motivator
Explain to students that the theme of their science lessons over the next few weeks will be based on an agricultural commodity that is very important to North Carolina. Actually, North Carolina produces 40% of the world's supply of this commodity and nearly 60% of the United States supply. Play Family Feud and pose different facts about this agricultural commodity for students to identify the sweetpotato. Questions can be created from the **NC Ag Facts** and **Background Information** sections of this lesson plan.

Family Feud Rules and Stipulations
Divide students into two groups. Allow the groups to come up with their group name. Example of how the teams may look: there are 15 students in each group and students will talk quietly amongst themselves. There will be 5 contestants with 2 alternates, 5 mediators, and 3 time keepers. Ideally all students will have a turn to go up to the podium (desk). You will need punch lights or 2 buzzers. Explain the procedures of the game:

- Face-Off: One member of each team faces the other in a face-off. Students are to come up to the podium, stand behind a taped line on either side of the podium. When the question is asked, the person to hit the buzzer first and correctly answers the question will take control of the game.
- The team that buzzed in with the correct answer receives control of the board and has the option of playing or passing control to the other team. This team gets home team advantage.
- The team that has the control tries to reveal all of the correct answers to the question before receiving three strikes. Each answer can be worth different point amounts.
- If the team receives three strikes without clearing the board, control is passed to the other team.
- The team that now has the control is able to give one answer in the hopes that it is found on the board.
    - If the answer is on the board, points are added to the team's score.
    - If not, the other team gets the points.
- Points are collected as each team finds its answers to the question on the board.
- Continue the game repeating steps two through seven, until all answers have been addressed.
- Each team tries to collect the most points. The team with the most points wins the game!

The teacher will go through different basic questions about scientific topics: photosynthesis, healthy eating (vitamins and minerals), energy (kinetic and potential), life cycle of a plant, and plant cells/animal cells. Then the teacher will finish up with the questions to have students guess what agriculture commodity will be the theme of the activities. At the end of the game explain to the students the theme for the upcoming lessons will be North Carolina's sweetpotatoes!

How to Play **KAHOOT!**

Let's play KAHOOT! If you do not have an account set up, please follow the link here: https://create.kahoot.it/register to register. Once you have registered you may begin creating an interactive game for your students to learn and enjoy. Log into KAHOOT and simply click discussion, survey, multiple choice, or jumble to start making a quiz. Then you will add your questions using the **NC Ag Facts and Background Knowledge** sections of the lesson plan. Once you have created your Kahoot game, launch the game so players can join. A unique game pin will be provided and players will enter this pin to join. Remember this link: https://kahoot.com/ to be put in the browser of your device (computer, phone, iPad, tablet, etc.) to join the game. Kahoot can be used in many ways to ignite learning in your classroom. The following link provides more step by step instructions on how to use Kahoot: https://kahoot.com/files/2017/07/Kahoot_guide_to_creating_and_playing_learning_games.pdf

Procedures

Activity 1: Abiotic and Biotic Factors

Objectives Covered: 6.L.2.3

1. Note Taking: students will need a notebook or *Abiotic/Biotic Comparison Chart* (see **Essential Files**). Begin by saying to students, "Today we are talking about abiotic and biotic factors." Ask a student to share what these words mean. Explain to students that biotic things are living and abiotic things are not. The question is, are both important? Tell the students that they will

determine the importance of both abiotic and biotic factors in biomes.

2. Pass out student *Activity One Note Sheet* (see **Essential Files**).
3. Put note sheet on the smartboard or document projector. The first row has space to write the meaning of both abiotic and biotic factors. Have students copy your notes.
   Biotic factors: living things in an ecosystem. Examples plants, animals, trees, and microorganisms such as fungi, bacteria, algae.
   Abiotic factors: non-living things in an ecosystem. Examples include sunlight, the wind, clouds, water, rocks, energy, temperature, soil, etc.
4. Show students a sweetpotato or picture of a sweetpotato. Ask the students, "Do you think this sweetpotato is a living or a non-living thing?" Discuss the characteristics of biotic and abiotic—how do they work together to make things grow or change? *Students should identify that the sweetpotato is biotic, but abiotic factors such as the soil, water, and sunlight known as natural resources are necessary for growing sweetpotatoes.* Have students write in examples of abiotic and biotic factors (row two).
5. Next, explain to students the effects that abiotic and biotic factors have on the environment. Discuss how these factors play an important role for determining a farmer's yearly production rate. Provide examples and have students write into the note taking section for effects (row three).
6. What are limiting factors of the growth of sweetpotatoes? (row four)
7. Encourage student discussion by saying, "A sweetpotato is biotic, but it depends on abiotic factors (non-living things) like sunlight and nutrients from the soil to grow. What does a sweetpotato need in order to grow? What do you need in order to grow?"
8. After a discussion of biotic and abiotic factors, show students parts of a sweetpotato plant.

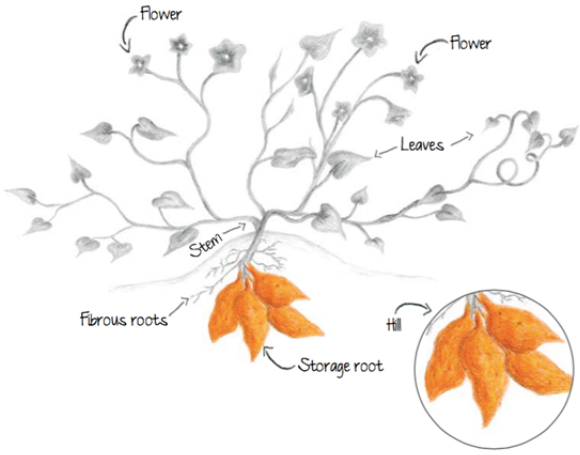


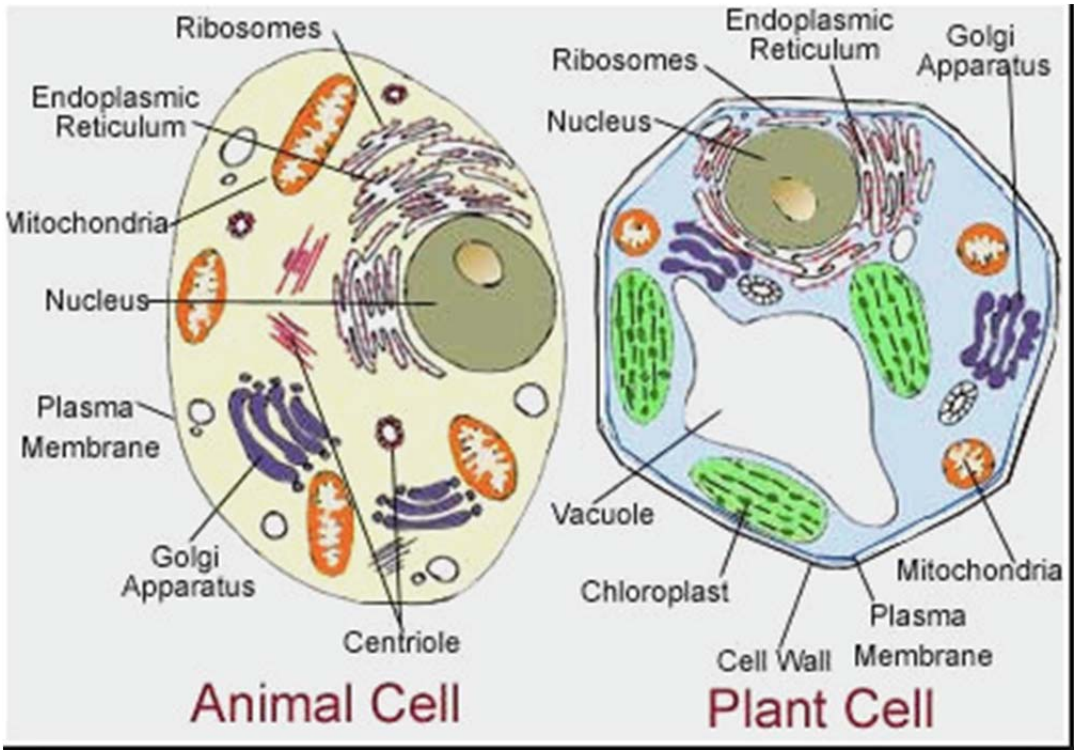
Photo credit Farm to School - Crops of North Carolina: Digging for Sweetpotatoes

9. Share the image above with students. Say, "This picture shows the parts of a sweetpotato plant. When looking at this image each part of the plant plays a vital role in its growth. Think for a moment what part of the plant is impacted by the abiotic and biotic facts we discussed earlier."

10. We have determined that a sweetpotato is indeed a living thing and living things are made up of cells.

Activity 2: Plant Cell vs. Animal Cell
Objectives Covered: 7.L.1.2, 8.L.5.1

1. After students have the knowledge of where their food such as sweetpotatoes comes from, it is important for them to understand how it originates. Farmers grow and raise many different **agricultural commodities** such as fruits, vegetables, nuts, and meat for sustaining human life. Say to students, "We as humans are made of cells that help us function and survive. We must receive nutrients from our food to feed our cells in order to live. Explain that although we are made up of cells there are so many other things made up of cells. Did you know plants and animals also originate from cells? Cells make up all living things such as sweetpotatoes and the sweetpotato plant."
2. Tell students: "Cells are very important; they have given us our existence of life – we all originated from a cell. Even this sweetpotato (hold up a sweetpotato) is made up of cells containing important nutrients for the human body's digestive system."
3. Show students a picture of a simple cell. Ask students, "What comes to mind when you see this picture?" Then say, "The picture you see is a simple cell. Did you know that each one of us, as well as plants and animals around us, are made up of cells?"
4. Show a picture of a human cell or draw it out on chart paper. Ask students, "What does a cell do? Cells have energy stored up inside of them. Where does the energy come from? It comes from the foods we eat, which is grown and raised by farmers/producers."
5. Show students a picture of a plant cell. Plants also have cells. A plant's cells tell it how to build itself. Ask students, "What do you see that is different about the plant cell?" Students should notice that the plants cells are shaped differently than the animal cell. Plant cells can be square or rectangular and tend to have distinctive edges.
6. Show pictures of plant cells and human cells. Allow students to see different live/still pictures of cells.
7. If possible have the students compare/contrast cells viewed underneath a microscope from a thin slice of a sweetpotato and the cells found from a human cheek swab.
8. Compare and contrast plant and animal cells. Put students into groups of 4-5 each and have them draw and label a plant and animal/human cell. Below is an example.



Source: http://thesaladopatio.com/building-plant-or-animal-cell-diorama/building-plant-or-animal-cell-diorama-admirable-animal-cell-3d-project-poster-google-search/

Extension: Students could create a model or drawing of a plant or animal cell. The above link is a resource for ideas of creations to support understanding of plant and animal cells.

Activity 3: The Life Cycle of a Sweetpotato

Objectives Covered: 6.E.2.4, 6.L.1.1, 6.L.1.2, 8.L.3.3, 8.L.5.1

1. We all know cells are amazing, but plant cells are extremely unique because they make their own food from abiotic factors and processes of the cell. So how do plant cells work and grow; how does the process help the growth of sweetpotatoes? What do these plant cells need to survive? What process do the sweetpotato plant cells undergo to produce the edible **storage root**, known as the sweetpotato, which humans eat?
2. Tell the students, "Today we are going to tie it all together and learn about the life cycle of a sweetpotato." Show students the life cycle of a sweetpotato, below.

Life Cycle of a Sweetpotato

3. As the students examine the images, they will begin to understand how sweetpotatoes are used to grow sprouts in order to grow more sweetpotatoes. Students will make note of the way sweetpotatoes grow. The edible **storage root** known as the sweetpotato grows under the ground

and has green leaves and flowers above the ground. Around August, farmers begin to harvest their crop. They use tractors and plows to lift up the soil so the sweetpotatoes can be dug up from underneath the soil.

4. Sweetpotatoes are grown for specialty dishes and are very healthy for us to eat. Farmers also feed parts of the sweetpotato plant and sweetpotatoes to livestock on their farms. After sweet potatoes are sold to markets and eaten, the leftover sweet potatoes are used to be planted in the ground again to make sprouts for new plants. The process goes full circle (life cycle). It is important that the farmer monitors and manages the soil properly for quality and stewardship of the land.
5. How do plant cells work in the growth of a sweetpotato? **Photosynthesis**. Explain to students that "photosynthesis" is a word that can be broken down for us to understand. "Photo" means light and "synthesis" means putting together. What is the process of photosynthesis and how does it work? Plants make their own food through the process of photosynthesis. In order for plants to make their own food they need the following to make it happen: carbon dioxide, water, and sunlight (abiotic factors).
6. Explain the process of photosynthesis – *Photosynthesis Note Sheet* (see **Essential Files**)
7. Show students example of *Photosynthesis Diagram* (see **Essential Files).** Place students in groups of two and have them discuss what they see using think, pair, share.
8. Next, explain in detail using the diagram that photosynthesis is the process in which carbon dioxide from the air passes through small openings in the leaves. These pores (small openings) are called the **stomata**. Water is absorbed by the roots and passes through the vessels in the stem on its way to the leaves. **Photosynthesis** takes place in the leaves of plants. The leaves are made of very small cells, called **chloroplasts**. Each chloroplast contains a green pigment called chlorophyll. **Chlorophyll** is what actually absorbs the sun's energy. This energy is what splits water molecules into **hydrogen** and **oxygen**. The oxygen is released from the leaves into the atmosphere and the hydrogen and carbon dioxide are used to form glucose (food for the plants).
9. Ask the students, "Why is photosynthesis important?" Photosynthesis is vital to life on earth, a process we cannot live without, and human cells are not capable of photosynthesis. Animals often eat plants, therefore obtaining energy from them, and plants obtain energy from the glucose made during photosynthesis. Human's energy for growth and development derives from eating foods supplied by plants and animals.
10. Have students review the lifecycle of a sweetpotato and briefly explain the process of photosynthesis and how it supports the growth of sweetpotatoes. Provide students with a *Life Cycle of a Sweetpotato Note Taking Sheet* (see **Essential Files**) following the different stages in the sweetpotato life cycle. Make a point to draw attention to the abiotic and biotic factors students see regarding the process and growth of sweetpotatoes. Have students take notes about the process.
11. **Extension Activity:** To incorporate project based learning, talk to students about creating a

hypothesis or making an educated guess. Show students a few sweetpotatoes and talk about the factors that could inhibit the growth of sweetpotato plants. *Students should identify no sunlight, no water, too much water, weather conditions, or poor soil quality.*

a. Using ideas from the discussion start an experiment by placing a sweetpotato in a dark room with no water and sun light. Have students predict what they think will happen.
b. Place another sweetpotato in a jar with no water, but in a well-lit area inside the classroom. Have students make an educated guess about the growth of this plant.
c. Lastly, place another sweetpotato in a glass jar with water and in a well-lit area inside the classroom.
d. After waiting about 7 days bring out the sweetpotatoes and compare each of them. If all goes well, you will see that a sweetpotato itself will grow sprouts; these sprouts are what can be used to grow more sweetpotatoes if **transplanted**. Observe and document changes that occurred.
e. Discuss why or why not processes of growth did or did not take place.
f. Why would sweetpotato farmers be concerned with abiotic factors?

Taking it a Step Further:

Students have learned that plants need carbon dioxide, water, and sunlight to survive. The following takes the process of photosynthesis more in depth. Front load the following key terms.

ATP: adenosine triphosphate; a compound that has three phosphate groups and is used by cells to store energy.
Active transport: the movement of substance across a biological membrane against its concentration gradient; from a less-concentrated area to a more-concentrated area. Active transport requires the input of energy and uses specific transport proteins.
Concentration gradient: a difference in the concentration of certain molecules over a distance.
Diffusion: the movement of a substance down its concentration gradient from a more-concentrated area to a less-concentrated area.
Lignin: a non-carbohydrate polymer that binds cellulose fibers together. It adds strength and stiffness to plant cell walls.

1. Ensure that students have a solid understanding of the process for the root system of a plant. Front load key terminology and explain to students the key terms associated with this activity. Provide students with the definitions of diffusion and active transport. **Diffusion**: molecules flow down the concentration gradient (area from higher to lower). **Active transport**: energy is used to move molecules against the concentration gradient (lower to higher). Both play key roles in moving nutrients from the soil into the plant roots. It is not necessary that middle school students be familiar with the details of these processes and how they are different.
2. While discussing the process of diffusion and active transport remind students that plants get their nutrients from the soil and pockets of air spaces filled with water. Many nutrients in the soil are dissolved and suspended in the water. So how does the plant get the nutrients it needs? *The plant's root system.*
3. Show video of how this works to give students a deeper look into the process of photosynthesis. Link: https://www.youtube.com/watch?v=3pD68uxRLkM Students may take other notes on

their *Life Cycle of a Sweetpotato Note Taking Sheet* (see **Essential Files**).

4. Provide students with *Photosynthesis Exit Ticket* (see **Essential Files**) as an Assessment of Understanding. Have students write an explanation of photosynthesis on the back of their exit ticket as an extra credit opportunity. *Answer Key for Photosynthesis Exit Ticket* can be found in the **Essential Files.**

Activity 4: Transplanting
Objectives covered: 6.L.1.1, 6.L.2.3, 8.L.3.3, 8.L.5.1

1. Introduction and Discussion: Say, "We have briefly touched on abiotic and biotic factors and the effects of biomes on an organism's viability, and identified how a sweetpotato undergoes the process of photosynthesis. Now, we will investigate transplanting within the sweetpotato life cycle."
2. Provide each group of students with a sweetpotato, plastic cup larger than the sweetpotato, and 5-6 toothpicks. Explain to students that they will be conducting observations of their sweetpotatoes and documenting their findings on the notes page in their journals based on the changes they see.
3. Allow each student in the group to carefully stick toothpicks mid-way into the widest portion of the sweetpotato. The toothpicks should be equally spaced around the sweetpotato. Students will carefully place the sweetpotato into a plastic cup. Then, carefully pour water into the cup, allowing the water to touch just the bottom of the sweetpotato. Students will sit the sweetpotato in a sunny spot in the classroom that is level and safe. Refer to the examples pictured below.

Growing Sweetpotatoes

Materials
Sweetpotato, tooth picks, and Large Mouth Mason jar or plastic cup – depending on the size of the sweetpotato you may need something more substantial to hold it up.
Make sure to fill the jar or cup up as close to the top as possible, you can see that half of the sweetpotato is submerged in water. You do not have to add water daily, just when it starts to drop down below the sweetpotato add more so that it can get the hydration it needs. Also, if the water starts to smell or mold you may change it to fresh water.
Enjoy and have fun observing!

https://www.thespruce.com/growing-sweet-potato-plants-in-pots-847888

4. Students will conduct initial observations and make an educated guess on what will happen in 2

days and in 2 weeks. *Note:* In approximately 4 weeks, sweetpotato sprouts will have reached about 8-10 inches tall and produce several leaves. At this point it is time for **transplanting**, or replanting in a different location. The teacher will carefully remove the sprouts by giving them a twist or cutting them with knife/scissors. Allow each student to receive a sweetpotato sprout. Remind students that because sweetpotatoes are not started from seed, farmers can grow sprouts in a greenhouse and transplant them in the field for harvest.

5. Transplant the sprouts. Have students make note of the soil type and test the pH of the soil before planting. As we have learned in earlier lessons, sweetpotatoes need to be grown in well-drained, sandy, loamy soil. Prepare the soil by tilling and applying fertilizer (Miracle-Gro will be sufficient). Plant the sprouts 9 to 10 inches apart in the center of a ridge row at a depth of about 3 inches with at least 2 plant **nodes** (part of plant that will become stem/leaf) underground and 2 or more leaves above ground. Plants will need water immediately after transplanting.
6. Discuss again with students the interaction between living and non-living things. Ask students to discuss the abiotic factors that farmers depend on for growing sweetpotatoes and other North Carolina crops. Questions: What abiotic factors are necessary to grow sweetpotatoes in either a greenhouse or field? *Some examples of non-living things include water, light, temperature. Students should explain the interaction between these things and that of the living/growing sweetpotato.*
7. As students complete the process of planting their sweetpotato sprouts, have them discuss the effect the plants have on the soil.
8. Explain the roles of **diffusion** and **active transport** in moving nutrients from the soil to the plant. Provide students with a *Diffusion and Active Transport Note Taking Sheet* (see **Essential Files**). *Answer Key* is provided (see **Essential Files**).
9. Students will identify and write the meaning of **ATP**, **active transport**, **concentration gradient**, and **diffusion** as listed in the **Vocabulary** section.
10. When discussing the process of diffusion and active transport remind students that plants get their nutrients from the soil and pockets of air spaces filled with water in the soil; many nutrients in the soil are dissolved and suspended in the water. So how does the plant get these nutrients it needs? *The plants root system.*
11. **Root System Demonstration**: This activity can be completed by the teacher or allow students to complete as partners or in small groups. You will need the following: small, clear, plastic cup, water, food coloring, and a white paper towel (Bounty brand is recommended because absorption is key to make this process visible for students).
    a. First, fill a small, clear cup with water and add a few drops of food coloring. Allow a moment for the food coloring to mix well with the water; it may have to be stirred a bit.
    b. Then take a rope or small piece of paper towel (twisted) and slowly dip into the cup of water. Allow students to watch closely as the paper towel absorbs the water up the paper towel. This is a great visual of how the root system works in plants.
    c. Explain to students that sweetpotato plants have **fibrous roots** that supply this function for the growth of the sweetpotatoes. Healthy plant parts on top of the ground grow the sweetpotatoes underground known as an edible storage root.

12. Show students chart of plant and root system.
13. Show students picture of a sweetpotato plant.
14. Students will take notes about the process of the plant root system and how important a good root system is to the growth of sweetpotatoes and all plants alike.

Activity 5: Soil, Fertilizer, and Sweetpotatoes
Objectives covered: 6.L2.3, 8.P.2.2, 8.L.1.1, 8.L.1.2, 8.L.5.1

1. Show students different examples of soils: potting soil, dark soil, sand, etc. If this is not an option, locate different images of soil examples and upload onto the smart board and/or computer. Contact your local Soil and Water Conservation office for soil samples, pictures, or a display.
2. Ask students to make an educated guess for the best type of soil for growing sweetpotatoes. Discuss reasons why they selected the soil type.
3. Show students pictures/examples of loamy soils. Have them compare this soil type to the soil examples you have shown in step 1.
4. Explain to students that research and farming practices in North Carolina confirm sweetpotatoes grow best in loamy soils. What are loamy soils? **Loamy soil** is soil that is made up mostly of sand, silt, and a small amount of clay. **Silt** is sediment that has been deposited into the soil by running water. Discuss where loamy soils would most likely be found in North Carolina from its three regions: coastal plains, the piedmont, or the mountains. Ask students if the soil type plays a role for which region of the state would grow the most sweetpotatoes?
5. Why can't sweetpotatoes grow in other soil types?
    a. Sweetpotatoes can grow in other soil types; however, those grown in heavy or clay soils result in rough, irregular roots. High (more than two percent) organic soils also reduce production. Coarse, deep, sandy soils are generally low in fertility, subject to moisture stress, and require more irrigation and fertilizer to grow a good crop. Poor aeration caused by poor drainage decreases yields. With severely impeded drainage, insensitive cultivars can cause either souring (tissue breakdown of the storage roots) or water blisters (enlargement of lenticels on the periderm) if the drainage problem is less severe.
    b. As a farmer, what type of soil would you want for growing sweetpotatoes? Why do you think North Carolina can grow of 60% of the nation's supply of sweetpotatoes? *This would be a great time to research land variation and soil types in North Carolina if time permits.* Select 2-3 counties in North Carolina and use the Web Soil Survey found on the USDA Natural Resources Conservation Service webpage found here: https://websoilsurvey.nrcs.usda.gov/app/ to access soil maps and data. Have students determine whether or not sweetpotatoes can be successfully grown in the school's county based on the soil conditions.
6. Sweetpotatoes will grow at a soil pH of 4.5 to 7.5, but 5.8 to 6.2 is optimal. Give students the definition of soil pH. **pH** is the measure of the soil's **alkalinity** and **acidity** measured on a scale of 1 to 14. The higher the number, the more **alkaline,** or basic, the soil. Seven is considered **neutral**. The lower the number, the more **acidic** the soil is.

7. To ensure that the soil is properly limed and fertilized, farmers or scientists will take representative soil samples from each field before planting for making good management decisions in soil health.
8. How do you test soil pH? Show students an example of testing soil samples and share with them the different tools farmers and scientists use in order to test soil pH.
   Watch video, **Crops for Kids: Soil Sampling**:
   https://www.youtube.com/watch?v=q4FDKCQFNqs
9. What do farmers do when their soil pH is not appropriate for optimal growth of their crop? They add certain materials to raise or lower the pH to ensure the soil has the adequate nutrients it needs.
   a. Agricultural lime, if needed and applied several months before planting, can effectively change the soil pH value. Lime can best be mixed into the soil by disking or chiseling before plowing or bedding. Addition of lime raises the pH which makes the soil more alkaline (basic).
   b. Farmers can add sulfur to lower the pH, making the soil more acidic.
   c. Farmers use dolomitic lime if the soil's magnesium level is low.
10. What do farmers do to prevent or remedy viruses, bacteria, fungi, or parasites from harming the sweetpotatoes and sweetpotato plants?
    a. In general, fields that have the proper soil characteristics and have not produced a crop of sweetpotatoes in the last 2 years are preferred. Ask students, "Why this statement is so important? What is the reasoning for using this practice?" **Answer:** Sweetpotato farmers have found that sweetpotato plants are more susceptible to disease caused by virus, bacteria, fungi, or parasites when planted one crop after another in the same location/field.
    b. Avoid fields that have been idle (high grass population), seriously eroded, or contain a high **nematode** population. Fields with a history of pox also known as soil rot should be avoided for 5 years. Before planting, determine which herbicide(s), if any, have been used on these fields for the past 2 seasons to be certain there will be no herbicide carry-over problems.
11. **Extension Activity**: Invite someone from your local soil and water conservation office to your classroom and discuss soil types and the importance of soil conservation, as plants can deplete the soil. Farmers have an important job while caring for the soil and using the correct additives and nutrients for good soil health. An example of an additive is agriculture lime. You could also test your own soil samples by purchasing a soil sampling kit or buying a soil pH meter (you can get these items for around $10.00 each at your local hardware store or a Wal-Mart garden center).

Here are some cool sweetpotato facts regarding soil to share with students:[4]

- Harvesting 1 ton (2,000 pounds) of sweetpotatoes removes 4 to 5 pounds nitrogen, 1.4 to 3 pounds phosphorus, and 7 to 11 pounds potassium from the soil. Sweetpotatoes only need moderate amounts of nitrogen and phosphorus but need significant amounts of potassium.

- Nitrogen is a colorless, odorless, unreactive gas that forms about 78% of the earth's atmosphere. It is the chemical element of atomic number 7. The most important use for nitrogen is creating ammonia, which in turn is used to make fertilizer.
- Phosphorus is a poisonous, combustible nonmetal which exists in two forms: white phosphorus and red phosphorus. It is the chemical element of atomic number 15. The most important role for Phosphorus in our body is aiding in the formation of bones and teeth.
- Potassium a soft silvery-white reactive metal of the alkali metal group. It is the chemical element of the atomic number 19. It is one of the most important minerals in the body. It helps regulate fluid balance, muscle contractions and nerve signals.
- What are the fertilizer recommendations for sweetpotato production? Fertilizer can be either banded or broadcast after transplanting. Application rates should be determined by a soil test. The general recommendation is 40 to 60 pounds of nitrogen per acre about 28 days after planting, 60 pounds per acre of phosphate at or shortly after planting, and 150 to 200 pounds of potash (50 pounds at or near planting and 150 pounds at layby). Beauregard requires even less nitrogen than other sweetpotato varieties. Low potassium reduces yields and increases the number of long, slender, malformed roots. Farmers have to ensure these ratios are placed back into the soil so the crop does not drain the soil in its crop production ability. Farmers' decisions play a very important role in caring for the land and the environment.[4]

Concept Elaboration and Evaluation

- **What are the abiotic and biotic factors of a sweetpotato plant?**
  Abiotic and biotic factors are both necessary in the growth and reproduction of plants. Biotic factors are living things in an ecosystem and abiotic factor are non-living things in an ecosystem. A sweetpotato is biotic, because it is an actively growing vegetable. The roots, the stems, the leaves, and the flowers are all biotic parts of the sweetpotato plant. However, a sweetpotato plant could not grow without the help of abiotic factors: sunlight, water, and nutrients from the soil. Both abiotic and biotic factors are necessary for an ecosystem to thrive.
- **How do plant and animal cells differ?**
  There are several differences between plant and animal cells. One noticeable difference is that plant cells tend to be larger in size than animal cells. Animal cells do not have a protective cell wall; whereas, plant cells have a plasma membrane surrounded by a rigid cell wall of cellulose. Plant cells have plastids and animal cells do not. Both plant and animal cells have vacuoles, but there are notably different: plant cells have a large central sap vacuole and animal cells have many, small vacuoles. Plant cells have a structure called chloroplasts, which give plants their green pigment; animal cells do not have chloroplasts. Another difference in plant and animal cells is that animal cells give off carbon dioxide which plant cells need to make food.
- **What is the life cycle of a sweetpotato?**
  A sweetpotato vine has a stem, leaves, flowers, and roots like other plants. However, the part of the sweetpotato plant we eat is actually the plant's storage root, which grows underground. Sweetpotatoes are grown from sweetpotatoes! Sweetpotatoes are grown from sprouts to grow more sweetpotatoes. Sweetpotatoes grow under the ground and have green leaves and flowers

above the ground. In August, farmers begin to harvest their crop. They use tractors and plows to lift up the soil so the sweetpotatoes can be dug up. After sweetpotatoes are sold to markets and eaten, the unusable roots are left in the fields to be disked back into the soil to replace lost nutrients.

- **Why do farmers use transplanting for growing sweetpotatoes?**
  Sweetpotatoes are not grown from seeds. They are actually grown from other sweetpotatoes. Farmers and scientists grow their sweetpotato slips (sprouts from seed sweetpotatoes) and once they have reached maturity they cut these slips and prepare them for transplanting. Farmers utilize transplanting to ensure slips are planted in a soil conducive to sweetpotato production (65 degrees). Transplanting also limits to occurrence of disease in the sweetpotatoes as they are growing and producing.
- **Why are soil and fertilizer essential to sweetpotato production?**
  Farmers have to ensure that soil types and nutrient levels are appropriate for the highest growth potential of their crop. Sweetpotatoes grow best in loamy soils. The best soil types are well-drained, fine sandy, or clay loams. Sweetpotatoes will grow at a soil pH of 4.5 to 7.5, but 5.8 to 6.2 is optimal. Agricultural lime, if needed, is applied to soil several months before planning. Agricultural lime can effectively change the soil pH value. The use of agricultural lime is to raise the pH of the soil to make it more alkaline (basic). Other forms of lime are used, like dolomitic lime is the soil's magnesium level is low. Another fertilizer farmers may use is sulfur. Sulfur is used to lower the pH making the soil more acidic. Sweetpotato farmers try to reach an optimal pH level of 5.8 to 6.2 for the soil. Other fertilizers that are used include nitrogen, phosphate, and potash. Harvesting sweetpotatoes takes a lot of nutrients out of the soil, so as a good practice, farmers put back into the soil what they sweetpotatoes use to grow. The general recommendation is 40 to 60 pounds of nitrogen per acre about 28 days after planting, 60 pounds per acre of phosphate at or shortly after planting, and 150 to 200 pounds of potash (50 pounds at or near planting and 150 pounds at layby). Beauregard requires even less nitrogen than other sweetpotato varieties. Low potassium reduces yields and increases the number of long, slender, malformed roots. Farmers have to ensure these ratios are placed back into the soil so the crop does not drain the soil in its crop production ability. Farmers' decisions play a very important role in caring for the land and the environment.[4]
- **Why are sweetpotatoes important to North Carolina?**
  North Carolina is the largest producer of sweetpotatoes in the U.S. and this export contributes to the revenue brought into the state and the country through agriculture. Sweetpotatoes are an important food, and historically was a staple food for Native Americans many years ago. North Carolina sweetpotatoes have become a large export to other parts of the world, especially Europe. The importance of the sweetpotato goes far beyond the fields it grows in, but the millions of consumers that eat them throughout the year.

Sources and Credits

1. https://statesymbolsusa.org/symbol-official-item/north-carolina/state-food-agriculture-symbol/sweet-potato

2. https://archive.org/stream/sweetpotatocultu00pric#page/12/mode/2up
3. https://www.loc.gov/rr/scitech/mysteries/sweetpotato.html
4. https://ncsweetpotatoes.com/sweet-potatoes-101/how-to-grow-sweet-potatoes/
5. https://demography.cpc.unc.edu/2017/11/17/nc-in-focus-sweet-potatoes-2017/
6. https://www.thepacker.com/article/export-demand-still-growing-us-sweet-potatoes
7. https://www.nass.usda.gov/Statistics_by_State/North_Carolina/Publications/County_Estimates/SweetPotato.pdf
8. https://cipotato.org/research/sweet-potato/sweetpotato-one-word-or-two/

Suggested Companion Resources

- *From Farm to School – Crops of North Carolina: Digging for Sweetpotatoes (*Activity Book) https://ncsweetpotatoes.com/wp-content/uploads/2013/03/Digging-for-Sweet-Potatoes-Activity-Book.pdf [ncsweetpotatoes.com]
- A Sweetpotato Tale (video) http://www.pbs.org/video/a-sweet-potato-tale-warnvs/
- The NC Sweetpotato Goes Abroad http://www.pbs.org/video/nc-sweet-potato-goes-abroad-jzu0ks/
- USDA Natural Resource Conservation Service (webpage) https://websoilsurvey.nrcs.usda.gov/app/

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