Plant Parts and Function

Day 1- Introduction to Plant Parts

Target Grade Levels
2nd – 4th

Essential Questions
"How do different plant parts contribute to their plants survival?"

Objectives
Students will learn the 6 major plant parts be able to identify them on a plant and explain their simple function which aids in plant survival.

STE(A)M Integration
Students will look at the structure and function of varying parts of a single organism.

NGSS and/or Common Core Standards:

4-LS1-1 Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction

Lesson Length
40 minutes

Materials
- White board
- Cutting board and knife (optional)
- Salad dressing ingredients (optional)
- Harvest Trading Cards (rainy day)

Preparation
Assess produce in garden for Plant Part Wrap

Summary

Students will gain a basic understanding of the six main plant parts and their function through verbal instruction, games and a tasting activity in the garden.

Background

During this unit students will gain an understanding of the six main parts of a plant and their function. It is important for students to understand the function of the various plant parts in order to have a deeper understanding of environmental factors For example, plants must be watered enough for the water to soak into the soil and down to the roots, and plant leaves need access to the sun. Below are the six main plant parts we will be focusing on with students and their key function which supports survival.

Roots: found underground, absorb nutrients and water for growth, anchor the plant in the soil and can store food.

Stems: connect leaves to roots, support buds and leaves, carry water, minerals and food

Leaves: absorb sunlight, which gives energy through the process of photosynthesis for plants to grow, release moisture and oxygen

Flowers: where fruits and seeds come from; attract pollinators through fragrance and color to help ensure reproduction

Fruits: protect the seeds until they are ready for dispersal

Seeds: produce more plants to ensure survival of the species

Procedure

Introduction
Begin the day by drawing a picture of a leaf on the board. Ask

Key Vocabulary
root, leaf, stem, flower, fruit, seed, function

Evidence of Learning
Students will be able to identify and define the basic function of parts on a living specimen.

Garden Related Activities

students to name your drawing (write leaf next to the drawing). Next, tell the students that, like humans, plants have many different parts to their body which all contribute to their survival. To begin getting students thinking about plant parts, ask them to tell you where plants come from (*seeds)*, you now have two of the six plant parts named. Continue having students brainstorm other plant parts until all six of them are on the board.

Next, put the plant parts in order of how they develop: seeds, roots, stems, leafs, flower, fruits, and seeds. As you go through each plant have students brainstorm how each part supports plant survival.

Plant Evolution Game
In order to better learn the plant parts, students will be playing a game similar to "evolution: egg, chicken, dinosaur." In this game students will be growing from a seed to a fruit one plant part at a time. Each plant part has a body motion to let the other students know in which plant phase you are at:

Seed: crouched down like a rock with hands around knees,
Roots: crouched down with fingers spread out like tree roots
Stem: Hands straight up above the head palms together
Leaf: Hands to the side with elbows in and hands pointed out
Flower: Hands around head with fingers making pedals
Fruit: Hands in circle at stomach making a big belly gesture

To begin the game, explain to students that they will be growing through all of the plant parts with the goal of being the first plant to become a seed again. Each student will begin the game as a seed; they will then find another seed and play rock paper scissors with that seed, whoever wins will get to become the next plant part, a stem. Students will need to play others of their same plant part, (flowers can only play flowers) in order to evolve. It is a good idea as the adult to play students who may be stuck on a plant part for awhile *(if someone has been a seed for a bit, go be a seed and play them*). This game can continue on indefinitely as fruits become seeds again or you can end the game once the first person becomes a seed again.

Plant Part Wrap
For the main activity students will be learning more about their garden space by making a plant part wrap. As a group, begin by having each student pick a leaf to use as the base for their wrap (like a tortilla). Next, find an example of each of the other plant parts to put into their wraps. For bigger fruits pick only one which can be cut for the group to share. It may also be helpful to

pick and chop roots and stems ahead of time, depending on how long you have with the group. If you have time, you can also make honey mustard or vinaigrette dressing to put on the wraps as found in the extension section. Remember, this is also a great time to review tasting etiquette with your group.

Wrap-up

If there is time, you can wrap up the day by doing the "Plant Part Pageant" activity. For this activity you will choose student volunteers to come up in front of the group one at a time and act out a part of a plant with a motion and a sound.

You will be calling up students one at a time in the following order. Once you have your first volunteer tell the group that this person is the root of your plant. Next, ask students what roots do to help the plant (absorbing nutrients and water for growth, acting as an anchor for the plant, and storing food). Show the volunteer their body motion and noise and have them practice. Now, call up the next volunteer/plant part and repeat the same process until you have all six plant parts.

1. **Roots**: lay on the ground, spreading out their arms and legs while making slurping noises
2. **Stems**- stand up straight and bend up and down (much like doing squats) while pretending lift an object (like an elevator). Make a "*wooo000OOOP"* sound from the squatting to standing beginning low and raising the pitch.
3. **Leaves (2 students)**- stand on either side of the stem using their hands and arms to make a leaf shape. Have them sing out *"Here comes the sun do't dut do do"*
4. **Flowers** this students should stand behind the stem, using their hands and fingers to make petals around their face while singing out, "*I feel pretty! So so pretty!*"
5. **Fruit (2 students)**- These two students should stand next to the flower facing one another and holding hands to make a big circle in between them. The will make a "tough" voice, flex their arms and say "*protecting the seed, protecting the seed."*
6. **Seed**- This student will position them self in between the two fruit students (between the arms) and in a "tiny" voice say "*I'm the baby of the plant."*

Once all the parts are up and know their movements, begin a narrative by introducing the roots:

> *"Welcome to the _____ School Garden. Here we have a wonderful plant made completely of very important parts! First, we have the root! (*Have student begin motion and noises- they will continue these throughout the pageant*), sucking up water, nutrients and minerals the root helps its plant survive by keeping it in the ground and providing plenty of water! Growing out of the root you find the Stem! (*student begins motion and

noises*) Connected to the root, you can find the stem brining up water and nutrients and supporting the Leaves! (*Leaves can begin their motion and song*)…"*

Continue introducing each plant part until everyone is doing their motion and noise together as a large group. Have the audience generously applaud and the plant parts bow to their audience.

Adaptations

To simplify

Rather than having students begin by brainstorming plants, begin the day by drawing a plant up on the board and having students label it. Then move into an instructor driven lesson around what each of those parts do for a plant.

To add complexity

To add complexity you can have students make salad dressings for their plant part wraps. Simple dressings include Honey Mustard and Vinaigrette. To make simple dressings, mix together the following ingredients.

1. Honey Mustard Dressing
   - ¼ cup Mustard
   - ¼ cup Olive Oil
   - 1/8 cup honey
   - Dash of salt

2. Vinaigrette
   - ½ cup Olive Oil
   - ¼ cup Balsamic Vinegar
   - Dash of salt

Rainy Day:

If it's raining you can either bring in materials to make the Plant Part Wraps or do plant parts relay game instead. For the relay game, divide the group into two single file lines facing each other. In front of each line is a deck of veggie cards (see Harvest Trading Cards in materials). When the game facilitator counts to three the two students at the front of each line will take the top card off their deck and show it to the opposing student. At this point the two students at the front of the line are looking at the card not in their hand but the card across from them. Their goal is to say the plant PART (not the name of the plant) before the other person. The winner of the round goes to the end of their own line joined by the "loser" of the other team. Now this line is bigger. The game ends when all of the students are on one team.

From the Ground Up!
Plant Parts and Function

Day 2- In the Beginning There Were Seeds

Target Grade Levels
2nd – 5th

Essential Questions
How does the size and shape of a seed affect how it may begin to grow?

Objectives
Students will make observations, compare and contrast structure and make informed explanations of the effectiveness of varying traits of similar species.

STE(A)M Integration
Students will compare, contrast and evaluate information to create a comparative statement regarding plant reproduction.

NGSS and/or Common Core Standards:

3-LS4-2 Use evidence to construct an explanation for how the variations in characteristics among individuals of the same species may provide advantages in surviving, finding mates, and reproducing

4-LS1-1 Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction

Lesson Length
30-45 minutes

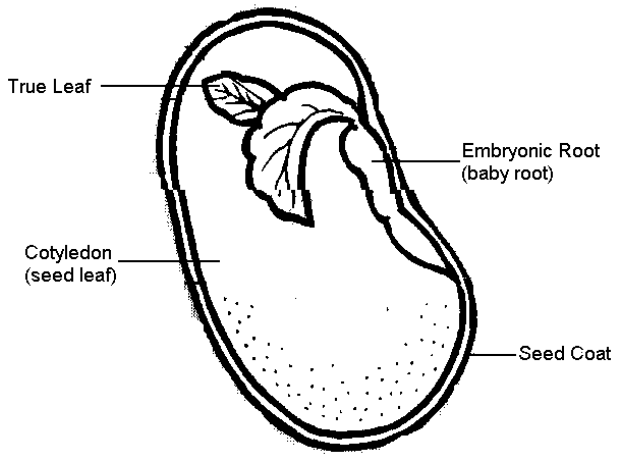
Summary

During this lesson students will gain a basic understanding of seed structure, make observations of various seed types, and set up a simple experiment. They will be asked to compare physical differences of seeds, make a hypothesis and create an experiment to determine germination variations based on seed size.

Background

Seeds contain all of the information and parts to become a new plant. Before seeds, plants used spores to reproduce which was more complicated as spores do not have the ability to store in the ground. When spores are released they need to land almost immediately in an optimum spot with the right temperature and moisture levels. Seeds however are great storage devices. They can stay in one compact package, waiting until they find themselves in an optimum environment before starting to sprout and grow- giving them a much higher success rate. Some seeds can stay dormant for years before sprouting- one experiment has had successful germination after 120 years of dormancy!

Seed Structure and Function



http://faculty.ycp.edu/~kkleiner/fieldnaturalhistory/PlantRepro.html

Materials Needed
- Soaked bean seeds
- Set of loupes or magnifiers
- Seed structure diagram
- Seeds for sprouting (dry beans, vetch and clover)
- Plastic baggies (with zip lock)
- Napkins or paper towels
- 1-3 spray bottles

Extension materials
- Color cards or poker chips for game
- Various seeds for observation
- Coloring materials for coloring seed diagram

Preparation
Pre-soak beans for dissection at least 12 hours

Key Vocabulary
trait, observation, cotyledon, embryo, monocot, dicot

Evidence of Learning
Students will be able to share in a group setting observations which describe the possible advantages and disadvantages of varying physical structures of similar species.

Garden Related Activities

Plant seeds of various shapes or sizes in the garden and label them with the date planted.

The **seed coat** protects the seed and keeps it from drying out. Some seed coats are thick and strong to prevent injury to the seed. Others are merely a thin layer. Either way, they help hold in all the parts of the seed and protect it from weather and temperature variations, allowing the seed to sprout when conditions are optimal.

In many species, the **cotyledon**, or seed leaf, stores nutrients that the embryo of the plant will use in order to sprout and start growing. Seeds need these nutrients to be able to send up leaves out of the soil and start photosynthesizing. The **embryo** is the baby plant within the seed. It has a tiny root and leaves. One of the main ways that plants are split up into different family groups is by the type of seed they have. The "older" types of plants are **monocots**. When their seeds sprout, they have just one leaf that comes up. All of our grains are monocots- corn, wheat, barley, rice. The "newer" types are called **dicots**. They have two seed leaves that appear when the seed sprouts.

Procedure

Introduction
Show the students a seed. Ask them what the seed will turn into. Emphasize how one tiny seed has the potential to create a very large plant- such as a sunflower. To get students thinking about seeds, have them brainstorm as many varieties as possible and write these down on the board. Once you have a decent list, let students know that each plant in the world has a different seed but each seed has the same main parts.

Seed Dissection
For this activity it is important to give students clear instructions that they will be doing a scientific dissection and observation. This means that they are not just taking something apart, but carefully doing so as to be able to see what may be inside. *Lima beans or kidney beans are highly recommended as they are large enough for students to see all of the parts without a loupe or magnifying glass.* Instruct students to follow a step by step process as an entire group or class so that they can have the opportunity to see what is inside of their bean seed. You can print out the seed diagram or draw the parts step by step as you go along. Use the following steps for the dissection:

1) Distribute one soaked bean seed to each student. Ask students to look closely at their seed and make an observation. Have students share their observations with someone next to them.

2) Have the students gently remove the seed coat and display it on their finger. Explain that a **seed coat** protects everything else inside. It keeps out bacteria and makes it harder for bugs to eat the seed. Sometimes these are really soft coats (like on peanuts or beans) but sometimes they're really hard like in peaches or walnuts.

3) Ask students to gently pry open the two halves of the bean seed, and look for the embryo. The **embryo** is the plant's first leaves and root. Ask students what they think will emerge from the seed coat first—the root or leaves. The root comes out first, establishing the plant's foundation and then come the leaves. (If it's an older group you can share with them that the first leaves are actually not photosynthesizing leaves but the second pair are, called "**true leaves**." When we harvest leaves to eat, we are eating "true leaves.")

4) So what is all of that other stuff? Ask students to hypothesize why there is a bunch of extra mass to their seed other than the embryonic root and leaves.

5) The mass, or main part of the seed, is called the **cotyledon,** which is essentially made up of food which the seed can use to sprout and grow into a plant. (Seeds are considered a healthy food because the cotyledon contains all of the nutrients, proteins, fats, and carbohydrates used to create a new plant.) Ask students for examples of seeds we eat (sunflower, pumpkin, nuts, beans, corn, peas, wheat). By the time the seed has used up all the food stored in the cotyledons, it is able to make its own food using sunlight.

Experimenting with Germination

Next, students will be setting up a small experiment to see what differences seed size may make in how quickly a seed germinates (sprouts). For this experiment begin by brainstorming plant needs: water, sun, soil, air. Each student will be setting up an experiment using three types of seeds.

1) Hand each student three seeds of various sizes. (Beans, vetch and clover seeds work well but most viable seeds will do). Ask students to compare and contrast their seeds verbally with a partner or in a small group.

2) Hand each student a paper towel or paper napkin. Inform students that you will be dampening the napkin to hold the seeds in place, simulating moist soil. Ask students to fold their napkin in half, reopen it, and set all three of their seeds a few inches apart across the seam they have created.

3) Now that you have the seeds tucked into the dry napkin the only thing missing is water. Moisture on the seed coat is what initially signals the germination process which is why when we purchase seeds they are

packaged dry. Use a spray bottle to moisten the napkin around the seeds. Make sure that the napkin is completely damp (you should be able to see the seeds somewhat through the napkin).

4) Students will now be asked to make a hypothesis as to which of their seeds will germinate (sprout) the quickest- including roots and leaves- based on what they learned through their dissection. How do they think seed size will affect how quickly their plants emerge from the seed coat?

5) Hand out a sandwich bag to each student (preferably with a zip top). Students will be instructed to write their name on the top of the bag. At the bottom of the bag have students express their hypothesis by placing the numbers 1-3 below the seeds in order of which they think will germinate first.

6) These experiments can be stored anywhere, however, if you have access to window space, you can tape the baggies up so that students can see when the first roots emerge (light will come through the damp napkin).

Mystery Plant Drawings
This activity reinforces the parts of plants. Each student starts with a paper. Have them fold it accordion-style 3 ways (length-wise). They all draw the bottom seed and root system of a plant. The papers are then passed on to the next person (the paper is folded so that they can't see what was in the section below) and in the next section they draw the stem and leaves of the plant. The papers are passed again to the next student who will draw the flower and fruit of the plant. Then each plant drawing is unfolded and shared between all three students to see what their plant ended up like.

Wrap-up
To wrap up the day, you can take students into the garden to plant various seasonally appropriate seeds. Students should be sure to read seed packets to see when the average germination times are for their crops. Have students compare and contrast different seed sizes and what their packets say to inform their hypothesis.

Adaptations

To simplify
1) Lima bean seeds are best to use for younger students because the large size makes it easier to see the parts.

2) In addition to seeds that have been soaked overnight, some seeds can be soaked then rolled up in a paper towel and placed inside a plastic bag for 3-7 days. Being able to show the students the embryo as it emerges from the seed helps to establish the concept.

3) Younger students can make a "living necklace" to sprout a seed individually in a tiny plastic bag.

4) Use the life cycle cards in the materials section to put seeds in the context of a plants lifecycle. Hand out one card to each student. Students will then put themselves into the correct order of the plant lifecycle based on the picture card they're holding.

To add complexity
1) For older students you can talk more about the difference between monocots and dicots.

2) Have the students draw a picture of the life cycle of the seeds they planted by folding a paper into 6-8 sections and having them make a cartoon like progression from seed to seed.

3) Plant some seeds in a clear plastic cup so the students can watch their growth in progress.

Rainy Day:
This entire lesson can be done inside

Enrichment Activities

Plant Space Game

This game teaches students about the needs of plants with a focus on what happens when seeds are planted too close together.

1) Begin the game by having students stand in a small area. In this game they will be plants. To help get students settled you can choose to make chalk or taped spots for them to stand on. Ask students "*If you are a plant, which plant part are your feet*?" roots! If roots are pulled out of the soil the plant will die and be sent to the compost bin- thus students cannot move their feet in this game.

2) Have students remind you of the three main plant needs: sun, water and soil. Students will need to collect one card/poker chip for each of these plant needs (ex. Poker chips: blue=water, red=sun, white=soil/air) during each round of the game without moving their feet.

3) Tell students not to move until you say the word "Grow." Toss the cards/chips around the students on the ground sparingly. When you say "Grow", they will be trying to collect as many of their "needs" as possible. In order to survive, they have to get at least one card/chip of every color. They can bend down to pick up cards but they can't move their feet. When you say, "Freeze," they must stand up and count their cards.

4) Play a round. At the end of each round, have them hand their cards in to you. Anyone who didn't get all of their needs dies, becomes compost, and goes to join with another plant (they will stand next to each other).

5) When a plant grows (2 or more students) they get to collect cards as a team. As a bigger plant, they require more resources to survive so each student in the plant will need their own set of all the colors at the end of each round, otherwise, the entire plant will die.

6) Spread the cards/chips out again and continue playing rounds until there is only one plant left.

7)) Wrap up the game by discussing plant competition. Some plants will grow larger faster; shading out the other plants, some plants feed more heavily on water or nutrients in the soil. That's why it is very important to seed plants with enough space around them to avoid too much completion for resources.

From the Ground Up!
Plant Parts and Function

Day 3- Here to There: Seed Dispersal

Target Grade Levels
2nd – 5th

Essential Questions
How do seeds move from one place to another and why?

Objectives
Students will use built knowledge to design, test and evaluate a simple model which mimics how seeds move away from plants to improve survival rates.

STE(A)M Integration
Students will use a set of materials to engineer a functioning model which mimics a chosen method of seed dispersal.

NGSS and/or Common Core Standards:

K-2-ETS1-2 Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.

K-2-ETS1-3 Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs.

Summary

Students will make observations and assess various dispersal methods. They will then build and test a model based on one real life dispersal method using recycled materials.

Background

All living things have some system for reproducing members of their species. Most plants reproduce using a system that includes flowers and seeds. In general, seeds develop within the ovary of the plant's flower after either being fertilized by pollen from another plant of the same species or being self-fertilized.
For a seed to germinate and grow into a mature plant, environmental conditions must be just right.

Each plant needs a certain amount of sunlight, air, water, and nutrients from the soil. If a seed simply drops from the parent plant, it might compete with the parent for those essentials and have difficulty growing. Therefore, most seed-bearing plants have developed a way to disperse seeds away from the parent, giving the new plant a better chance to find what it needs to grow.

The six main dispersal methods:

Burs: These seeds have hairs and barbs which make them sticky and capable of traveling via animal fur, or socks! Examples include forget-me-not, agrimony and burdock.

Wind: These seeds can be fluffy, flat and thin. They often have specialized feathering to help them fly through the air, or a flat sail to glide to the ground. Examples include maple, dandelion and milkweed.

Float on water: These seeds have a waterproof seed coat, and are hollow with air inside. They also need to be light enough to float. Examples include coconut, willow and water lilies.

NGSS and/or Common Core Standards continued:

2-LS2-2 Develop a simple model that mimics the function of an animal in dispersing seeds or pollinating plants.

3-LS4-2 Use evidence to construct an explanation for how the variations in characteristics among individuals of the same species may provide advantages in surviving, finding mates, and reproducing

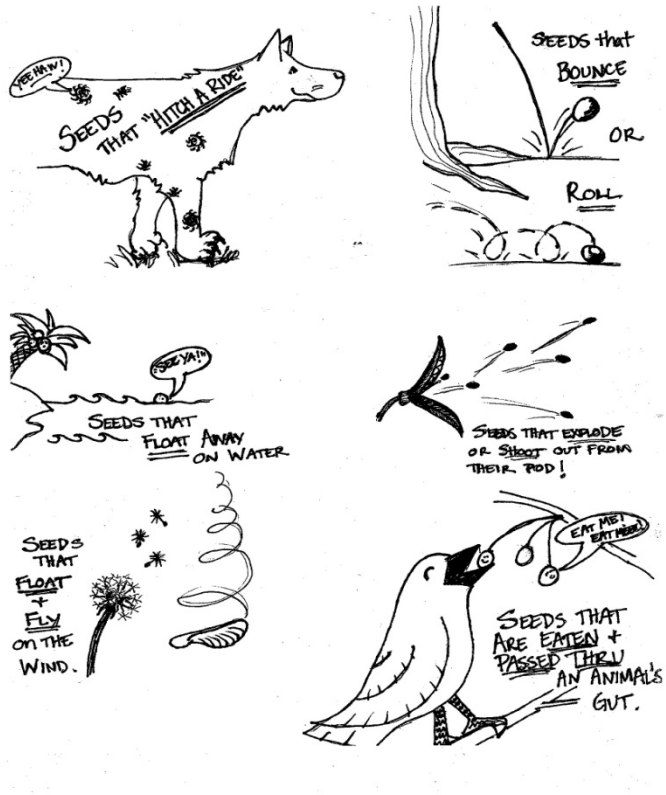
4-LS1-1 Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction

Lesson Length
40- 60 minutes

Materials
- Precut recycled materials
- Scissors
- Tape
- 3-4 small tubs
- Water access
- Varying seed types for observation
- Loupes/magnifiers
- Various screens
- Old seed for optional open inquiry activity
- Old blanket or socks for optional seed hunt activity

Preparation
1) Precut recycled materials for students to use for engineering.
2) Collect and dry seeds for observation station.

Key Vocabulary
dispersal, variation, floatation



Bounce & roll: These seeds have a soft pod and a hard shell. They are often round and heavy enough to bounce. Examples include peas, all brassicas (broccoli family) and walnuts.

Exploding: These often have long seed pods with small round seeds. Examples include, peppergrass, some oxalis species and witch hazel.

Eaten: These seeds are found inside of fruit. They are small enough to be swallowed by an animal and have a thick enough seed coat to protect them through the digestive process. Examples include berries, grapes and many small fruit varieties.

Procedure

Introduction

To introduce the concept for the day bring in either a dandelion seed head or a maple seed. Begin by silently showing students how your seed moves by either blowing on the dandelion or tossing the maple seed into the air. Wait until students begin asking questions to introduce your essential question for the day: "How do seeds move from one place to another and why?" Let students brainstorm different ways in which seeds move and write/draw each example on the board.

Now that you have a list of dispersal methods, have students think and share in pairs as to why moving is so important to plants that they have evolved to have very sophisticated structures to get away from their parent plant. Once students have shared in pairs discuss the why's as a whole class.

Garden Related Activities

- Save seeds
- Search for weeds in the garden that are starting to form flowers or seeds discuss why it is important to pull weeds before the seeds fall.
- Plant seeds
- Harvest and prepare sunflower or squash seeds to be dried or roasted(you'll need salt, jars and water)

Seed Observations

Seeds for this activity can be found anywhere in the world, in the Pacific Northwest we use mostly common plants and weeds including agrimony, forget-me-not, wild carrot (Queen Anne's Lace), maple, dandelion, milkweed, lupine, artichoke, linden, horse-chestnut, pinecones, thistle, and bay laurel. It is also great to bring in a coconut if possible for a floating seed.

For this activity students will be building knowledge by observing different types of seeds to determine how they think each one disperses from its parent plant. Your observation station should include trays to keep seeds separated in, magnifiers or microscopes, and as may seed varieties as possible. This activity is aimed at getting students familiar with as many shapes and sizes of seeds as well as encouraging them to think about varying seed structures and how these traits may affect dispersal.

Students should be given 5-10 minutes to observe the different seed types. It is helpful to instruct them to keep the different seed varieties separate (to the best of their ability) but they should look and feel, using observation to learn something about the seeds in front of them.

Build a Seed

The main activity for this lesson will challenge students to design and engineer their own seed with specialized dispersal mechanisms based on their observations. Students will be given a small seed to use as the base of their design, along with recycled materials (such as cut popsicle sticks, , cardboard, egg cartons, cotton balls, string, tissue paper, bubble wrap, tin foil, bottle caps etc), to design a seed. Each student will need to choose only one dispersal method to engineer for.

1) For larger classes you will want to break students into smaller groups. Provide each student with a "base" seed (which they have to move) and each small group with a bag of building materials, scissors and tape.

2) Each student should choose one dispersal method and be given 10-15 minutes to complete their design and engineer their seed.

3) Once the allotted time is up (some students will want more time, others less), gather back together as a whole group. If

your group is smaller you can have each student share their design individually and test them one at a time. For larger groups you can test by category (ex. anyone who made a floating seed must float them at the same time).

4) To create a greater challenge (especially for older students) you can add restrictions to their tests including:

- Float in water for at least five minutes
- Attract an animal to carry them away
- Float in air for at least 5 feet
- Stick to an animal and can be carried at least 10 feet
- Are thrown at least 2 feet away from the parent plant

Wrap-up
Conduct a short group discussion on the challenges and successes of their engineering projects. How do these challenges relate to engineering processes used for human travel including air, land and water?

Adaptations

To simplify
1) Rather than the seed observation station, bring in labeled example seeds for each dispersal method.

To add complexity

1) Add an open inquiry station for students to learn more about seeds and how they differ. Include seeds of all shapes and sizes (add in chia seeds for a surprise!), various sizes of screens, tubs with water, tubs without water, sand, toilet paper tubes, etc. Have students use the materials to discover something without any prompts regarding how to use them.

2) Go on a seed hunt through the garden dragging blankets across the ground to see what may stick to them. See if students can identify some of the seed types and how they move.

Rainy Day:
This lesson can be done indoors without adaptation.

From the Ground Up
Plant Parts and Function

Day 4- The Scientific Method & Root Function

Target Grade Levels
3rd – 5th

Essential Questions
What is the main function of a root for plant survival and how do roots differ between species?

Objectives
Students will use the scientific method to determine the results of their germination experiment and begin a fair experiment about root function.

STE(A)M Integration
Students will learn to use the scientific method to determine the outcome of an experiment.

NGSS and/or Common Core Standards:

4-LS1-1 Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction

Lesson Length
60 minutes

Summary

Students will learn the scientific method while determining the results of their germination experiment (Lesson 2). Students will utilize their gained knowledge to set up a new experiment to determine how roots function.

Background

In this lesson students will learn the scientific method by assessing the results of their germination experiments (lesson 2). It is important to take time to unveil the different layers of a fair experiment so that students can effectively set up an experiment to investigate roots and determine their function in keeping a plant alive.

Procedure

The Scientific Method
During this activity students will be learning about the scientific method while working with their germination experiment (Lesson 2). Below we will look at the steps to the scientific method and how to utilize the germination experiment to teach these steps.

1) **Ask a Question**: For the seed experiment our question regarded how seed size may affect germination. This can be framed in a few different ways; "Does the size of a seed determine how quickly it will germinate?" "How will different sized seeds differ when they germinate?" "Can seed size affect germination?" (Looking at different ways, grammatically, to ask a question can be added here to meet writing standards if applicable to your classroom).

Lesson Length
60 minutes

Materials

- White board
- Germination experiments
- Rulers with millimeters
- Loupes or magnifiers
- Calculators (optional)
- Knife and cutting board
- Measuring cups
- Food coloring
- Clear jars for experiment
- Toothpicks
- Cabbage leaves (green or white)

Preparation

1. Gather all needed materials and secure a space to leave experiments in
2. Review the scientific method

Key Vocabulary
observation, scientific method, variable, millimeter

Evidence of Learning
Students will be able to assess data and set up a fair experiment based on knowledge gained

Garden Related Activities
Have students plant seeds in the garden or dig up roots for observation.

2) **Make an Educated Guess**: An educated guess, or hypothesis, utilizes built experience or knowledge to predetermine the outcome of an experiment. For our seed experiment it was asked: "How will seed size affect germination?" Ask students to recall their hypotheses, which should be written on their experiment bags (numbers 1-3). How did students determine which seed would germinate first? What did they take into consideration based on our seed dissections: size/amount of cotyledon (plant food), seed coat thickness, seed shape, etc. Built knowledge can be a difficult concept, especially for younger students. It is important to take time here to emphasize that as we gain knowledge it is often difficult to remember that at one point we didn't know certain things. Science is a great opportunity to not only discover but to also see what we already know about the world.

3) **Make an Experiment**: For the germination experiment we used three seeds of various sizes to determine if their size might have an affect on how quickly they germinate. It is important to now look at variables within a test. For elementary aged students using the terms fair and unfair will work best. Begin by writing the words fair and unfair on the board in two columns. You will be asking students a series of questions and adding answers to these two columns

- "Would it be fair if one of you had a different seed than everyone else?"
- "Would it be fair if one of your experiments was in the dark while the others were hung in a window?"
- "Would it be fair if one person began their experiment a day before everyone else?"
- "Would it be fair if extra water was added to one experiment and not the others?"
- "What would be fair?" (The same seeds, same time, same amount of water, same location for the experiment).

4) **How can you tell?** Making scientific observations requires a little bit more than just looking at something for a moment. For this portion students should retrieve their experiments and work as a whole group/class to assess the results. It is very important here to remind students to be very gentle, we are now being scientists so we want to avoid accidently breaking any pieces of our experiment otherwise our results may be compromised. Follow the steps below:

a) Have students carefully open their experiment bags and gently pull out the napkin, which should still be damp and folded.

b) What do they notice with the napkin still folded, can you see any changes to the seeds, and is the napkin still damp?

c) Next, students will carefully unfold their napkins- encourage them not to touch their seeds while doing so. The first roots and cotyledon (false first leaves) are very delicate and can easily break which would make it difficult to determine an outcome from their experiment. Students should look at the seeds, do they have any roots of leaves showing, do the seed coats look any different then before? *(You can have a set of un-soaked seeds for them to look at with their experiments to help younger students determine visual differences).*
d) Ask students how they can tell which seed germinated the earliest. *Students should be able to see that the root was the first plant part to emerge from their seeds and use the presence of the root to determine germination results amongst the seeds*. The smallest seeds will most frequently germinate the quickest as they have the thinnest seed coat and the least amount of cotyledon- this means that they also need to produce true leaves above the soil the quickest as there is not as much food stored within the seed to promote survival.

5) Making sense of our results: In science it is very important to go beyond a black and white answer *ex: "Smaller seeds germinate more quickly than large seeds."* Scientists make hypothesis and share results based on many tests repeated again and again. In our germination experiment each student ran a test using the same materials, space and time. Comparing results between students will help us to determine how accurate our outcomes may be. For this portion students should focus on utilizing math skills to determine accurate results. Follow the steps below to determine the outcome of the experiment:

a) Ask students if each of their experiments were exactly the same. The answer is no. There will always be a few variables, including the amount of water, the exact placement in the windows or cupboards and the fact that their seeds were much alike, but all different.
b) Next you will introduce using math to make sense of your scientific results. To accurately communicate results, scientists need to gather as much data as possible to determine an accurate outcome. During this section students will be taking measurements to gather accurate data- using measurements can tell us exactly how the first roots differed and is more accurate than just looking at them and making an approximation. Each student should have a ruler marked with millimeters (the initial roots will be very small) and a loupe or magnifier. Go over how to read the ruler with students and have them measure the varying root lengths- using the loupes to make reading the measurements more easy.
c) Gather the data as a group. On the board write the name of each seed in three columns. Have students tell you how long their initial roots are (as accurately as possible) and record these numbers under each category.
d) Next you will be working on finding an average number for each root length. Students should add up all of the numbers in each

category and divide the total by how many experiments were run. This will give you the average of root growth for the group.

e) To put it all together ask students if the average measurements differ from their own measurements and how great the difference is. Does this data help to support our hypothesis? How does this information tell us if we were correct or incorrect? Remember, scientists are incorrect all the time. Creating experiments is how we discover more about the world around us; being right or wrong is not the objective of experimenting.

6) **Communicating our findings:** Now that we have completed our experiment it is time to share our results with others. Have students brainstorm ways of telling other people what they learned. Are people going to just believe students when they share this information? Acquiring as much data as possible will help to show other people the accuracy of your findings. What if people don't understand your experiment? Ask students to try and explain the experiment in pairs to one another with one student explaining and the other student asking questions as if they did not participate in the activity. Remind students that if they made a fair experiment, it should be able to be repeated again by others with the same or similar results.

Introduction to Root Function

Now that you have completed the seed germination experiment it should be known to students that the first plant part to emerge from the seed is a root. Roots play the first essential role in preparing a plant for life above ground. For the remainder of the day students will be focusing in on the function or roots. Roots play three major roles in the survival of plants

- Absorbing and storing water
- Absorbing and storing nutrients
- Acting as an anchor for the plant

Students should be able to communicate that roots absorb water from the soil and act as an anchor for the plant based on previously gained knowledge. Roots not only play these major roles but they also absorb minerals and nutrients, which provide essential food for the plant. For our root experiment we will be learning more about this process in order to determine exactly how the structure of roots support this process.

Root Function Experiment

For this activity, students will be utilizing the scientific process to set up a simple experiment to gain a better understanding of root function. For this experiment you will need clear jars, a carrot for each student, *Napa Cabbage* leaves (optional), toothpicks, water and a box of food coloring.

1. Introduce the experiment by discussing nutrients and minerals. Nutrients are invisible in the soil but for today you will be simulating them with food coloring in water. Nutrients and minerals are not only important to plant health but also to human health. Our human bodies are unable to access these things from the environment, which is why it is very important to eat plants including fruits and vegetables.
2. Have each student fill their jar half way full with water, add 10-20 drops of red, green or blue food coloring to the water. Ask students to decide what would be fair in setting this experiment up (use the same amount of water, and the same amount of food coloring each).
3. Give each student a carrot (ask students to make observations about this type of root). For this experiment the tip of each carrot will need to be cut off. If you have gone over knife safety with your group, you can have students do this themselves, otherwise cut off the bottom ¼" of the carrot at a slightly diagonal angle. Students should also measure and mark their carrots for cutting in order to control the experiment. Emphasize variables while setting this up by asking students if it would be fair if one carrot had 1" cut off and another had 1/4" removed.
4. Give each student 2 toothpicks. A toothpick should be secured in each side of the carrot about 1" down from the top. (Again, this is a great time to measure and ensure that the experiments are controlled for variables).
5. Place the carrots into the water and dye solution and set it in a windowsill for 4-7 days.
6. **Optional:* Next, as a group, place Napa cabbage leaves into a jar with food coloring (you can do multiple jars/colors if desired). Show students that the stem and leaf are both present. As a group we are going to see how the roots and leaves may differ with water and nutrient absorption.
7. Leave time in a further lesson to cut carrots in half and observe their internal structure and how the water and "nutrients" were absorbed. You will see more of a change in the cabbage leaves. This is due to roots acting as a siphon, bringing water and nutrients out of the soil and distributing them into the aerial plant parts, maintaining less for itself.

Plant Part Relay

This activity is an active way to reinforce the parts of plants. Divide the group into two single file lines facing each other. In front of each line is a deck of plant cards (found in the materials section). When the game facilitator counts to three the two students at the front of each line will take the top card off their deck and show it to the opposing student. At this point the two students at the front of the line are looking at the card not in their hand but the card across from them. Their goal is to say the plant PART (not the name of the plant) before the other person. The winner of the round goes to the end of their own line joined by the "loser" of the other team. Now that line is bigger. The game ends when all of the students are on one team.

Wrap-up
To end the lesson, ask students to share their hypothesis regarding what will happen in the root experiment. What previous knowledge do they have about roots to inform their hypothesis? How do they know that their results will be as fair as possible? What steps did they take, based on assessing their germination experiment to design the experiment fairly?

Adaptations

To simplify
1) Stick to the scientific method as the main activity for the day and eliminate setting up a root experiment. Fill in any extra time with garden work.

To add complexity
1) For older students you split into small groups and let each group utilize provided materials to design a root experiment. These groups should each be given two sets of materials- one to act as a control and the other as the experiment. Once they have designed and set up their experiment, share as a group which different strategies were used to begin the experiment.

Rainy Day:
This lesson can be completed indoors without adaptation.

From the Ground Up
Plant Parts and Function

Day 5- Underground Plant Parts

Target Grade Levels
3rd – 5th

Essential Questions
What is advantage or disadvantage of varying underground plant part structures?

Objectives
Students will compare and contrast different root structures and evaluate an experiment to assess the function of roots and the variation of function between differing underground plant parts.

STE(A)M Integration
Students will assess visual changes and draw conclusions from a science experiment.

NGSS and/or Common Core Standards:

3-LS4-2 Use evidence to construct an explanation for how the variations in characteristics among individuals of the same species may provide advantages in surviving, finding mates, and reproducing

4-LS1-1 Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction

Summary

Students will investigate different underground plant parts and their functions. Students will evaluate their experiment to determine root (and stem) function, compare underground plant parts, and discuss the advantages and disadvantages of varying structures.

Background

Below the surface we not only find roots, but also specialized leaves and stems. These special structures each act to support plant survival in different ways. Below we will examine roots, stems and leaves that grow beneath the surface to gain a deeper understanding of how and why plants have adapted in so many ways.

Underground Roots

When we consider roots we often imagine those of a tree, branching out underground, or a carrot drilling straight into the earth. These images alone represent two very different root structures. There are three main types of roots: fibrous roots, taproots and tuberous roots. Roots absorb water and nutrients, which are then taken up into other parts of the plant where they can be utilized for survival.

Fibrous Roots: These are thin and interlocking. Their job is to absorb water and nutrients from the soil, then transfer it to the rest of the plant. We don't eat many fibrous roots because they are small, stringy and contain few nutrients. Plants with only fibrous roots are usually annuals, which means they die in the winter. *For example, clover, marigold, corn, peas.*

Lesson Length
60 minutes

Materials

- Underground root cards
- Weed cards
- Paper, pencils and clipboards
- Roots for observation and/or tasting

Preparation
1. Gather underground plant parts for observation ahead of time or arrive early to the garden to harvest them.
2. Prepare any cooking or tasting supplies

Key Vocabulary
nutrients, absorption, fibrous, rhizome, bulb.

Evidence of Learning
Students will be able to verbally communicate the differences between varying root structures and their potential advantages and disadvantages for survival.

Garden Related Activities
1.Harvest underground crops to taste or take home
2. Weed in the garden
3. Plant potatoes or strawberries.
4. Take mint cuttings to propagate

Taproots: These are thick and hearty with plenty of room for stored nutrients that make them good for us to eat. Plants with taproots usually have one main root with only a few small secondary roots. Many of these plants can live through the winter and are either biennials or perennials. *For example, carrots, beets, parsnips, radish, turnip.*

Tuberous Roots: These are fleshy, swollen roots. Unlike taproots, with only one thick root, these plants will have many thick roots. They also are usually perennial plants. *For example, sweet potato, cassava, yam.*

Underground Leaves

Each year in the Pacific Northwest spring is announced by the vibrant colors of crocus, daffodil and tulip arising from beneath the soil. Each of these plants return yearly from bulbs found beneath the soil which store water and nutrients throughout the winter months when photosynthesis is not a possible means of survival.

Bulbs are modified underground leaves. To gain a better mental picture, consider an onion comprised of many layers; each layer is an underground leaf. Instead of photosynthesizing, bulb leaves store nutrients and water. Plants with bulbs are usually perennials. Many people consider bulbs to be roots, but if you pull one from the soil, you'll see the true roots hanging from the bottom. The roots are responsible for the uptake of nutrients and water; the bulb acts solely as a storage device. *For example, onion, garlic.*

Underground Stems

Underground stems include rhizomes, true tubers and corms. Plants developed them as another way to store nutrients and water. They can also reproduce through these parts by making clones of themselves. This is how strawberries reproduce and also why many herbs, including all mints, can quickly take over a garden bed.

Rhizomes are usually fairly straight and segmented. Each individual segment can break off and grow into another plant. *For example, quack-grass, ginger, asparagus.*

True tubers are thickened underground stems that have buds "eyes" on them. New plants can grow from these "eyes". True tubers are different from Tuberous roots because of these "eyes". *For example, potato.*

Corms are thickened, vertical underground stems. At first glance

they look a little like bulbs, but when you cut them open you'll see that they don't have layers the way that bulbs do. *For example, banana, iris.*

Procedure

Introduction
Begin the day by checking in on the root function experiments set up in Lesson 4. Ask students to recall the scientific method to gather results from their experiment. Depending on how much time has passed between these lessons you can either make observations and continue the experiment or take time to assess findings and draw conclusions regarding the function of roots in supporting plant life.

Underground Plant Parts
For this activity you will want to have as many different root types as possible for students to observe. You can bring these in, or harvest from the garden ahead of time. This observation works well with onions, potatoes (preferably sprouting), grass varieties, dandelion, ginger, and mint.

1. Place the roots in groups of root type at different tables or areas in the garden for students to rotate through.
    - Clover and lawn grass for fibrous roots
    - Carrots and dandelions for taproots
    - Sweet potato for tuberous roots
    - Onion and garlic for bulbs (leaf)
    - Mint and quack-grass for rhizomes (stem)
    - Potato for true tubers (stem)
    - Iris and Jerusalem artichoke for corms (stem)
2. Place the matching underground plant part card (found in the materials section) at each station.
3. Give each student a loupe or magnifier, a piece of paper, clipboard and pencil. Assign students to small groups and send each to a different station. At the first station one student should read the information on the card aloud to the group. After they have learned the information, they should make observations and draw a small picture of one of the plant parts they observe. Have students label the drawing *(for example, draw the onion and label it "Bulb" on your sheet).*
4. Once enough time has been given have students rotate through stations, repeating the process until they have a drawing of each root type labeled on their paper

Search beneath the soil
For this activity students will be using the information gained during the observation activity to identify underground plant parts in the garden while pulling out weeds or edible underground crops. You can use the weed cards (found in the materials section) to assign plants to students, or let them work

on an area with multiple varieties that are ready to be removed. Students should be instructed to remove a weed (or edible crop such as radishes, onions or potatoes) carefully as to get all of the roots out of the soil *(remember roots are an anchor for the plant so it is important not to yank on them, otherwise they will break off at the top).* Once their plant has been removed, they can shake any excess soil back into the garden and use their drawings to determine which type of underground parts their plant utilizes for survival. To make this activity a bit more of a challenge, you can turn it into a competition to get as many underground plant parts (and their aerial parts) as possible.

Underground Plant Parts Tag

This game is a variation on blob tag. In this game there are three different roles:

1. Three students are underground plant parts: bulb, tuber and root
2. One student is winter (or a natural disaster). *This student will stand outside the playing field until called in*.
3. Everyone else is water and nutrients in the soil.

During the game, the underground parts will try to tag the water/nutrients. When they do, they link arms and grow bigger. When you call out winter, drought, windstorm etc. the student representing natural disaster gets to come in and try to tag people. Anyone tagged goes to stand outside the playing field. If an underground part is tagged they lose the last person who joined them. Call an end to the natural disaster. They have to go back outside the boundaries and anyone who was tagged gets to come back in as nutrients/water again. Do this a few times. At the end of the game whichever underground part is biggest wins.

Wrap-up

End the session by reviewing underground plant part function with the following questions:

- Which types make the best anchor for a plant and why?
- Which types can access water from deep underground?
- Which types have the best chance of surviving through the winter?
- Which types can create a new plant?

Adaptations

To simplify

1) For younger groups focus only on different types of roots rather than all underground plant parts.

2) Skip the observation and drawing activity. Instead have students harvest roots from the garden and separate them into groups based on their structure.

To add complexity

1) Take time in the beginning of the lesson to assess the root function experiment and draw conclusions.

2) Have students harvest roots that are ready in the garden such as potatoes or carrots and make a root snack to share. (Potatoes need to be cooked so you will need to plan ahead).

3) Take cuttings of mint or willow and place in water to see how roots can emerge from the leaf nodes of these plants.

Rainy Day:

1) Omit the garden portion and spend more time on plant part drawings or do a tasting table with various types of underground plant parts.

From the Ground Up
Plant Parts and Function

Day 6- Here Comes the Sun
Leaves and Photosynthesis

Target Grade Levels
2nd – 5th

Essential Questions
What is photosynthesis and how do leaves utilize this process to support plant life?

Objectives
Students will learn the basic function of leaves and their importance to the survival of plants.

STE(A)M Integration
Compare and contrast varying traits of similar species. Set up an experiment to investigate plant needs.

NGSS and/or Common Core Standards:

1-LS3-1 Make observations to construct an evidence-based account that young plants and animals are like, but not exactly like, their parents.

2-LS2-1 Plan and conduct an investigation to determine if plants need sunlight and water to grow.

4-LS1-1 Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.

Summary

Students will gain understanding of leaf function and how it directly supports survival and make comparisons between varying species from different climates.

Background

Photosynthesis is the process of converting light energy into chemical energy that can be used by biological systems (specifically plants but also algae and bacteria).

Light rays from the sun strike the leaf and are absorbed by the chlorophyll present, which traps the light energy. Chlorophyll cannot absorb green light so is reflected back; this why we see green. Water molecules, which have been absorbed by the roots and transported to the leaves, are split into hydrogen and oxygen, as a result of the light energy. Carbon dioxide is taken in from the air through openings in the leaf called the stomata— which are essentially tiny pores.

Within the leaf structure, hydrogen combines with the carbon dioxide to form glucose (sugar for the plant). The oxygen left over from the water molecules is released into the atmosphere through the stomata. As the stomata releases oxygen, it allows more carbon dioxide in which allows photosynthesis to continue.

Plants transform light energy much like a solar panel. Instead of creating electricity, however, solar energy is converted into glucose (a type of sugar), which is stored in the leaf (much like charging a battery). In order to be utilized, glucose must be broken down which happens during respiration. This releases the energy stored in the glucose molecules.

NGSS and/or Common Core Standards continued:

LS4-2 Use evidence to construct an explanation for how the variations in characteristics among individuals of the same species may provide advantages in surviving, finding mates, and reproducing.

Lesson Length
60 minutes

Materials
- Yellow object
- Four plant starts
- Loupes or magnifiers
- Various leaves
- Crayons and paper
- Field microscopes
- Leaf shape key

Preparation
3. Gather materials for the lesson
4. Collect various leaves ahead of time if it is raining or you would like to stay inside with students.

Key Vocabulary
photosynthesis, margin, vein, stoma, cell, variation

Evidence of Learning
Students will be able to communicate the process of photosynthesis and how it supports plant survival.

Garden Related Activities
Collect different leaf types in the garden. Taste leaves such as brassicas to point out the sweetness caused by the leaf making glucose (sugar) during the process of photosynthesis.

Procedure

Leaves are engineering marvels. Their prime purpose is to capture light, the energy source needed for photosynthesis to occur. In order to understand how photosynthesis works, students should begin the day by learning the different parts of a leaf and how their structure supports leaf function.

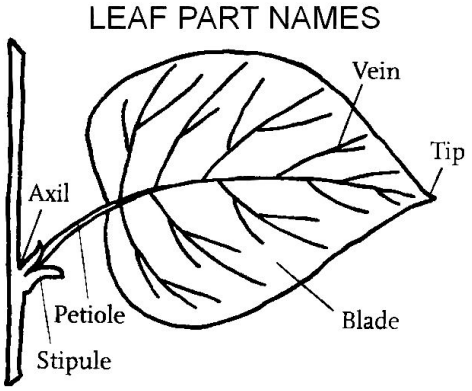
Introduction

Start by showing the group a really large leaf and a really tiny leaf. Ask the students what plant part they are, and what their role is in supporting plant life. Recall the Plant Part Pageant (Lesson 1) if need be. Explain that during this first activity students are going to examine leaves closely to learn more about them.

Leaf Observations

For this activity you will want to have a leaf for each student to observe and a loupe or magnifier for each student as well. You can either have students choose a leaf from the garden, or collect leaves ahead of time. Leaves are made up of many different layers, which are not visible to the naked eye. During this observation students will be locating the visible parts of their leaves and learning about each one's function.

http://www.norbeckkids.com/gpage7.html



1) Leaf Margin: These come in many shapes and sizes, but fun from the petiole to the leaf tip. The margin is much like an artery, bringing water and nutrients to the veins from the stem and circulating food made through photosynthesis back to the rest of the plant.

2) **Leaf Veins**: The veins are also responsible for circulating water and nutrients into the leaves and transporting the food energy made through photosynthesis back into the rest of the plant. Leaf veins also play a very important role in providing a solid structure for the entire leaf, enabling it to defy gravity, and even turn towards or away from the sun (depending on plant type).

3) **Guard Cells:** In order to see the guard cells students can hold their leaf up toward the sky to let light shine through it.

(*WARNING: do not let students hold their leaf towards the sun, looking through magnifiers at the sun can cause permanent eye damage*). Using loupes or magnifiers, students should be able to see hundreds of pairs of sausage shaped cells surrounding small holes throughout their leaf surface. These are called guard cells, which surround the stomata to protect it. Throughout the day they change shape and size depending on light and humidity. This action controls whether the stoma is open or closed, affecting respiration.

4) **Stomata**: The stomata can be seen as small holes within the guard cells. These holes are responsible for leaf respiration: bringing water and air into and out of the leaf body.

When I say "photo", you say "synthesis"

Students have now seen that plants can breathe through their surface, but do they know that plants also use their leaves to make food a plant? Explain to students the process of photosynthesis in a way appropriate to your age group.

Race to the Sun

During this game students will be gaining a deeper understanding of the process of photosynthesis. To begin with, split students into two single file lines. One line will be Carbon Dioxide (CO2- the air we breathe out) and the other will be Water (H20). Now, choose two students to be leaves. Their job will be to photosynthesize the quickest.

Now that you have your two leaves, explain the game to students:

1) In this game the each leaf will have a plant. You can choose to draw or tape a line in the playing field or to simply designate where the plant will grow from.

2) Leaves can only photosynthesize when the sun is out. For this game the instructor should bring a yellow or orange object to represent the sun. When the object is held above the instructors head, it is daytime and the leaves can work on photosynthesis. When the object moves below the instructor's head, the sun is now down and the leaves must stop their process (freeze on the playing field).

3) The leaves will be collecting H2O and CO2 from the lines. Ask students "Can a plant photosynthesize with just water?" No, the leaves need to build a chain with CO2 then H2O repeating in that order to photosynthesize. When the sun is up, the leaves can run to the first line (whichever line they begin with doesn't matter) they will collect the first person in line and bring them to their "plant." Now, they will run to the other line and bring that person to the plant, having the two students link arms and stretch toward the sun.

4) The leaves will continue to alternate between adding CO_2 and H_2O to their chain with the goal of building the longest chain the quickest. Whichever chain can tag the sun first with the first person still connected to their "plant" will win.

5) To add in more of a challenge have the sun go up and down throughout the game. If the leaves are still moving when the sun is down then the last person added to their chain will need to leave and return to their original line.

Sun and Water for Plant Life

Students have already learned that plants create their own food through the process of photosynthesis. Utilizing solar energy, plants combine energy (in the form of photons), water and carbon dioxide in the leaves to create glucose sugar. The CO_2 and H_2O combine with the photons to create carbohydrates (glucose) and the O_2 is split from the Carbon, which is the O_2 released back out of the leaves to create the air we breathe. In this activity students will be planning and conducting an investigation to find out if sun and water are really essential for plant life. You will want to bring in at least four plants of the same type and size for this activity.

Begin by asking students whether they think that water and sunlight are essential for plant life. Next ask them how they know. Conducting an experiment can help to confirm their thoughts and give new insights to the concept. Whether or not students already understand that these are essentials for a plant, it is important to be able to communicate concepts with data and gathered information. How can students show others through an experiment that water and sunlight are important to a plant?

Students will now be asked to design a fair experiment utilizing their knowledge to communicate the importance of water and sunlight to plant life. A very simple way to do this experiment is to keep one plant as your control: this plant will be given water and sunlight. Next, choose a plant to receive sunlight but no water: this should be placed near the control plant to keep conditions as similar as possible. Next you will have a plant which gets water but not sunlight: be sure that students water the plants with the same amount of water to keep the experiment as controlled as possible. You can choose the fourth plant to receive no water and no sunlight. It should be kept in the same conditions as the other plants.

Have students make hypothesis as to what will happen with each plant. Write these down to return to when making observations during the next lesson.

Leaf Rubbings

During this art activity students will be using crayons and white paper to make an example of different leaf shapes and sizes. Head out into the garden (if you have not already been there) go on a leaf walk with students and have then collect at least five different types of leaves. Make sure you have peeled the

paper off of the crayons so that they can be used on their sides. Demonstrate the process to students.

1. Place a leaf under a sheet of paper and gently rub the crayon over it on the topside. You should begin to see the margin, veins and leaf outline on your paper.
2. Once you have your leaf outline remove the leaf and place another one under the paper in a different spot. Repeat the rubbing process until all of the leaves have been used.
3. To extend this lesson have students label the different parts of their leafs based on their initial leaf observations.

Wrap-up

End this lesson by discussing how different leaves may function differently. Thick leaves such as pine needles or rhododendrons are often evergreen; their thickness can help to protect them from the cold. Thinner leaves can often flex more, following the sun throughout the day to maximize photosynthesis.

Adaptations

To simplify

1) Skip the photosynthesis lesson and stick with leaf observations and drawings. Do garden related tasks or tasting with any extra time you may have.

2) Rather than having students design the experiment, explain it to them and go over the scientific process.

To add complexity

1) During the leaf rubbing, have students identify the leaf shape of their specimens and label them on the paper. For example, linear, oblong, lancolate, elliptical, etc.

2) Bring in field microscopes for students to use. Look more closely at the guard cells and discuss chlorophyll. If possible, show students slides of leaf segments and identify the different internal structures, which are utilized during the process of photosynthesis.

Rainy Day:

1) Bring in leaves for students to observe and do rubbings with. Make sure that the leaves have been dried before you do the art project.

From the Ground Up!
Plant Parts and Function

Day 7- Putting Together the Pieces

Target Grade Levels
2nd- 5th

Essential Questions
How do seeds, roots and leaves work together to support plant life?

Objectives
Students will analyze and assess information gained regarding the three major plant parts, their function and overall impact of the survival of vegetative life.

STE(A)M Integration
Students will assess information gained from experimentation and communicate results verbally in a group setting.

NGSS and/or Common Core Standards:

2-LS2-1 Plan and conduct an investigation to determine if plants need sunlight and water to grow.

3-LS4-2 Use evidence to construct an explanation for how the variations in characteristics among individuals of the same species may provide advantages in surviving, finding mates, and reproducing.

Summary

During this lesson students will review the three major plant parts they focused on during this unit. Students will review science experiments and outcomes to create an explanation of how seeds, roots and leaves function together to support plant life.

Background

During this unit students have conducted simple experiments and inquiry activities to assess three major plant parts and how their structures support specific functions.

Seeds: Seeds have all of the information inside of them to create a new plant. Seeds also have specialized structures to disperse away from their parent plant. The role of a seed is to create new plants.

Roots: Roots are the first plant part to emerge from the seed. They come in many forms, all with the primary purpose of collecting water and nutrients to feed the plant as well as providing an anchor for the plant to withstand natural forces such as wind and rain. Roots act like a siphon, pulling water and dissolved nutrients and minerals from the earth and pumping them into the aerial plant parts.

Leaves: Leaves are the food factories of the plant. Acting as solar panels, leaves utilize solar energy to complete the process of photosynthesis, which provides food for the plant. Leaf structure varies greatly between species in order to gain the most out of the available light within their climate.

Seeds begin their journey away from the parent plant, flying, floating, or falling. They eventually find their way into the soil and once conditions are just right, they germinate. Within the seed are the embryotic root and leaves. During germination the seed coat opens and the root begins to make its way into the soil, creating an anchor. The root immediately begins to collect water and nutrients, triggering the leaves to begin their emergence. The first leaves are white, as they peek their way up towards the

NGSS and/or Common Core Standards continued:

4-LS1-1 Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.

Lesson Length
30 minutes

Materials
- Silly costumes can be brought in for the plant part presentations.

Preparation
Check on plant experiments ahead of time to make sure you have a good set of questions to encourage student observations and to help them analyze the results

Key Vocabulary
photosynthesis, system, germination, sprout, hypothesis.

Evidence of Learning
Students will communicate clearly the importance of three main plant parts and their function (seeds, roots, and leaves)

Garden Related Activities
Plant seeds or starts in the garden and check for sun and water access to make sure the new plants will get their needs met.

sunlight. Once they have reached the soils surface they immediately begin to expand. Chlorophyll production rapidly increases and photosynthesis begins. The cotyledon (fist leaves) begins to send food back through the hypocotyl (stem) and into the roots to provide energy for them to continue growth and to uptake water and nutrients to continue supporting photosynthesis. Working together, these plant parts create a sprout or sapling and thus begin the potential for growth and survival. As they support one another through function, plants are then able to create flowers, fruits and seeds of their own.

Procedure

During this lesson, students will be recalling what they have learned about each plant part in order to create a better picture of how the isolated parts work together to support vegetative life.

Introduction

Begin the day by reviewing the three plant parts which students have focused in on throughout the unit. Students should all have a basic understanding of how each part functions to support plant life. During this lesson students will be asked to draw conclusions as to how these parts all work together based on previous knowledge.

Working Together- Plant Parts in Action

During this activity students will be asked to work in teams of three to create a small presentation which explains how the seed, root and leaves are connected in supporting plant life. Each student will be one of the three plant parts, the seed, root or leaves; as a group they will be creating a short skit which explains the function of each part and how they work together to become a sprout or seedling.

Sun, Water and Plant Life

Students should now be given time to look at their plant needs experiments from Lesson 6. Bring all of the plants to a table and have the students take turns making observations aloud to the group. What do these observations tell us about plant needs? How can we explain the differences between the plants based on the science we know? For example, leaves without sun cannot photosynthesize to create food for the plant. This causes them to become pale from chlorophyll reduction and droopy as the internal structures do not have enough food to be strong.

Wrap-up
To end the lesson head out into the garden to plant seeds or starts, making sure students are taking into consideration placement and accessibility to sun and water for their new plants.

Adaptations

To simplify
1) Do the plant part presentation as a whole group. Choose a few students to be each part and encourage the class to narrate what each part is doing to support plant life.

To add complexity
1) Take extra time with the plant needs experiment. Go through the scientific process step by step as found in Lesson 5.

Rainy Day:
1) Plant seeds or transplant starts into pots indoors for students to take home at the end of unit.

Plant Parts and Function

Day 8 & 9 Build a Plant

Summary

Target Grade Levels
2nd – 5th

Essential Questions
How can we design and build a model which represents plant part function?

Objectives
Students will utilize gained knowledge to inform a design process.

STE(A)M Integration
Students will integrate concepts to inform and engineer a design which mimics real life function of varying plant structures.

NGSS and/or Common Core Standards:

K-2-ETS1-2 Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.

4-LS1-1 Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction

Lesson Length
30-60 minutes

Materials
Straws, pipettes, bike tubes, sponges, paper towel/toilet paper tubes, construction paper, tissue paper, pens, markers, wire,

Students will begin a two to three day project during which they will engineer and build a plant with functioning parts. Students will overview the six main plant parts and their functions, choose materials and begin designing their "plant" considering function throughout the engineering process.

Background

Throughout this unit, students have focused in on plant parts and how they function to support vegetative life. Now that students have learned the different plant parts their goal will be to build a plant which can function in a similar way to a real plant. The three main parts we learned about include seeds, roots and leaves. Students should also learn about the importance of the stem in supporting the plant as well as flowers, which get pollinated and become fruit with seeds inside.

You will need to have materials to support plant part functions available for students. Below is a quick list of some items which may be helpful for students during the engineering process.

Roots: straws, pipettes, old bike tubes, hose pieces, sponges

Stems: paper towel/toilet paper tubes

Leaves: construction or tissue paper (green), wire, pipe cleaners, toothpicks

Flowers: small paper cups, q-tips, construction or tissue paper, pipe cleaners, double sided tape

Fruits: cotton balls, tin foil, modeling clay, paint

Seeds: cotton balls, tin foil, modeling clay

Materials continued
toothpicks, paper cups, q-tips, tape, hot glue, cotton balls, tin foil, modeling clay, paint and painting supplies.

Preparation
Acquire and pre-cut any necessary items for the build a plant activity

Key Vocabulary
function, experiment, structure

Evidence of Learning
Students will demonstrate the ability to apply scientific concepts to inform the design process and engineering of a model which mimics and functions in a similar way to a living organism (plant).

Garden Related Activities
Plant starts in the garden

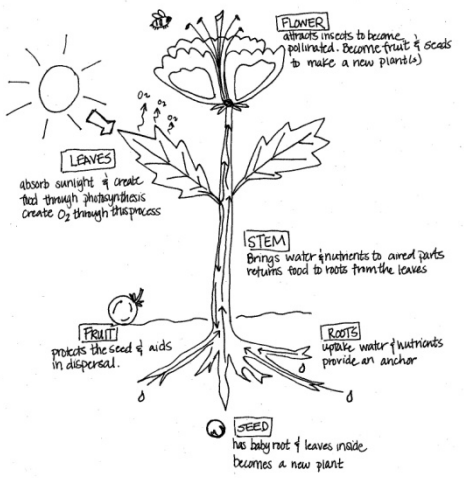
Weed out plants and identify their different parts

Dissect plant parts in the garden to gain a better sense of their internal structures

Procedure

Introduction

Begin by giving each student a piece of paper and a pencil. You are going to review the plant parts with them through drawing and labeling different parts and their functions. Example: Begin with a seed. Have students draw a seed and then tell you what parts it has in it, as well as how it functions to support plant life. Continue through the plant parts:



Seed: Has the embryonic root and leaves in it and becomes a new plant
Root: Uptakes water and nutrients and provides an anchor for the plant
Stem: Brings water and nutrients to the aerial plant parts and returns food from the leaves to the roots
Leaves: Absorb sunlight to complete the process of photosynthesis, making food for the plant
Flower: Becomes pollinated and creates a fruit/seed.
Fruit: Protects the seed.

Next, explain to students that they will be making a plant which can do some of these things. For example, we cannot create something that photosynthesizes but we can make a leaf with veins that can help to support it and hold it upright. Roots absorb water so we can create our roots out of something that can pull water out of the soil.

Build a plant activity

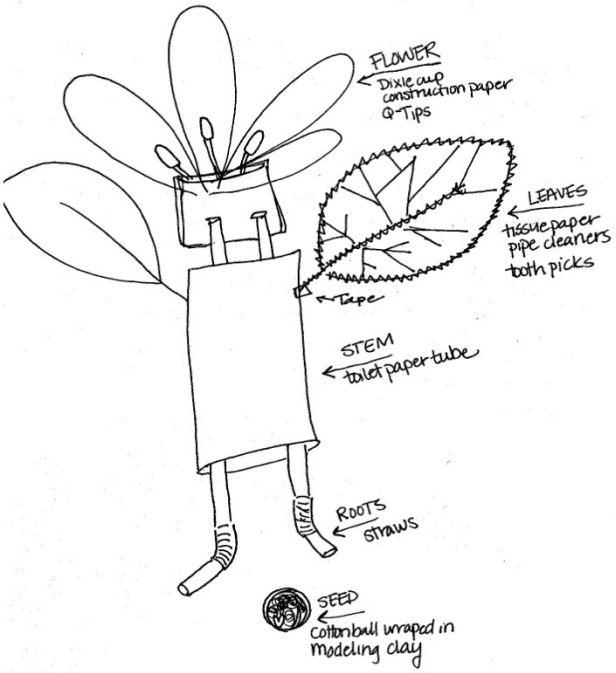
Students will now be given the chance to design and build their plant out of the provided materials. This portion should be split into different steps to be sure that each student is putting some thought into the engineering process.

Assess your materials

Before allowing students to begin working with the materials it is important to have them take some time to look at what they have available to them and come up with ways to use them to serve a function. For example, "*Which parts of the plant are like a straw? How could you use straws in your design and why would you use them that way?*" Go through the various materials as a group and have students begin to brainstorm which materials they will use.

Design on paper

Next, students should be asked to create a list of the materials they would like to use. Once their list has been created, students should focus on making a drawing of their design. In the design, students should include the different materials, where they will use them and how they mimic the function of each plant part. Make sure to give students ample time to think through their material choices and use by asking questions. *Example: "Why did you choose to use straws for your roots?"*



Begin engineering

Now that students have created a viable design it is time to begin building. Students should be given the remainder of the first day, and possibly a good portion of the second day to really take time with their engineering process. During this time it is important to continue asking questions regarding function.

Test your plant parts

Once students feel they are finished with their plant it is time to test them. They will be looking for the following functions to make sure that their plant works well:

- A way to suck water and nutrients from the soil
- A solid base/anchor (their plant should be able to stand on its own)
- A stem which supports leaves and flowers
- Veining in the leaves to keep them from flopping over and are able to bend to follow the sun
- An attractive flower that looks pretty for pollinators
- A seed with a hard seed coat to protect it

Refine your design
Now that students have double checked their work, give time for any last minute adjustments or improvements to their models. Students can also choose to paint their plants at this point.

Wrap-up
To wrap up the day have students share in pairs. Assign each student to a buddy and have them take turns explaining their plant, its parts and how they work to support plant function. Once they have shared have students come up with other materials they could have used to show other functions, for example, if they had access to solar panels, they could have used those as leaves.

Adaptations

To simplify
To simplify, you can assign the different materials students will use for different plant parts and let them build based on the assigned materials.

To add complexity
1) Have students test their parts; is there a way they can make water move up through the roots and into the aerial plant parts?

2) Begin lesson 8 with the Flower Dissection lesson found in the Pollination Unit.

Rainy Day:
This activity can be done indoors without adaptation.

Plant Parts and Function

Day 10 Sharing our Projects

Target Grade Levels
2nd – 5th

Essential Questions
How did you design your plant to mimic real life function?

Objectives
Students will test the functionality of an engineered design, assess success and share understanding of concepts verbally in a small group setting.

STE(A)M Integration
Students will integrate concepts to inform and engineer a design which mimics real life function of varying plant structures.

NGSS and/or Common Core Standards:

K-2-ETS1-2 Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.

K-2-ETS1-3 Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs.

4-LS1-1 Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.

Summary

Students will spend this lesson testing the functionality of their plant design, assessing their own success as well as the success of others and sharing their design and process in a group setting.

Background

During the final lesson students will be asked to present their plant designs and share how they built parts to mimic real life functions. For this students should be given the following set of guidelines for assessing and sharing their own work:

- Show all six plant parts and explain specific functions.
- Explain your choice of materials, what was the thought process behind your choices?
- What modifications could be made to increase the functionality of your design?
- What limitations did you face during the design process?
- Which part of your plant do you feel the best about?

Procedure

Testing Functionality
For the beginning of the lesson students should be given time to finish up any tests they would like to do on their models to assess the functionality of their plant. Students should be encouraged to use their gained knowledge of plant parts to go through each part, seeing if their model represents how plants function in the real world.

Seeds: Students should have designed a seed which can disperse from its parent plant in order to reach optimum growing requirements. What parts of their design support this?

Roots: The roots of the plant should have internal structures which enable them to pull water out of the ground and disperse it into the aerial parts of the plant. What did they use for this design, does it work?

Lesson Length
40-60 Minutes

Materials
White board and pen

Preparation
Review the guidelines for assessing engineered designs.

Key Vocabulary
structure, function

Evidence of Learning
Students will demonstrate the ability to test a model, assess success within the boundaries of the project, create solutions to problems and communicate results verbally in a small group setting.

Garden Related Activities

Plant transplants or seeds into the garden

Do plant part tastings

Stems: Stems should contain internal structures which enable water to pass upwards from the roots and plant food (glucose) to move back down into the root for use or storage. Does the stem have a structure built in to aid in this process?

Leaves: Leaves are responsible for collecting sunlight and transforming it into food through the process of photosynthesis. What aspects of the engineered leaves support this function, how does the structure of the leaf support this important task?

Flowers: Flowers are the reproductive organ of the plant. They contain internal structures which support the process of pollination and the creation of a fruit and seeds. Does the plant have a flower which contains these internal structures? What materials were used based on the function necessary for pollination?

Fruits: Fruits protect seeds until they are ready for dispersal. They can also be a method of dispersal. How does the fruit of the plant protect the seed, what structure does it have, if any, in supporting dispersal?

Sharing our Findings

This is a great opportunity to bring in an audience from the school- think ahead of time of who may be available to come in and watch presentations.

This time will be dedicated to project presentations. It is important here to emphasize active listening. Students should be encouraged to listen quietly through each presentation and come up with one question to ask at the end. Students can be randomly selected to ask a question at the end of each presentation.

Wrap-up

Once students have completed their plant part presentations, take a moment as a group to review and share what they learned throughout the unit, play a game they enjoyed or enjoy a plant part snack from the garden.