PULSE ON HEALTH

Garden-Based Pulse Nutrition and Biology

Grade 4 Curriculum

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PULSE ON HEALTH

Garden-Based Pulse Nutrition and Biology Grade 4 Curriculum

Spring and Fall Lessons for the School Garden and the Classroom

Next Generation Science Standards for States, by States (2016):

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

www.nextgenscience.org

Office of Superintendent of Public Instruction Health Standards (2016):

1.5. Understands foundation of health.

2.1. Understands relationship of nutrition and food nutrients to body composition and physical performance.

School gardens are a valuable tool for education. A school garden can serve as a biological classroom, where students use all their senses while increasing academic achievement (Desmond et al. 2004; Graham et al. 2005; WSU Vegetable Research and Extension School Garden Education 2016). Students learn by connecting to the earth, growing and eating new foods, and learning in a positive environment (Figure 1).

Figure 1. Students engaged in school garden learning activity.

School garden education has been shown to increase knowledge and consumption of fruits and vegetables (Heim et al. 2009). Healthful eating habits learned at a young age will likely be carried into adulthood (Birch et al. 2007).

The framework of this curriculum is based on pedagogy from garden-based learning: experiential education and environmental education (Bell 2001). The hands-on activities and project-based learning incorporated into this curriculum supports experiential learning. Environmental learning, such as how pulses impact the environment through nitrogen fixation, connects students with the concepts of soil quality and fertilization. Students will demonstrate grade-appropriate proficiency in: asking questions, developing and using models, planning and carrying out investigations, analyzing and interpreting data, constructing explanations and designing solutions, engaging in argument from evidence, and obtaining, evaluating, and communicating information.

What is a Pulse?

In these three lessons, we will be learning about pulse crops, which are in the legume family.

Pulses are nutritionally important grain legumes that produce dry, edible seeds in pods that include dry beans, dry peas, garbanzo beans, and lentils. Pulse crops are in the family Fabaceae, and consist of plants that fix (absorb) atmospheric nitrogen through nodules on roots in the soil. Pulses contain symbiotic bacteria, called rhizobia, within the nodules in their root systems, producing nitrogen compounds that help the plant to grow and compete with other plants. When the plant dies, the fixed nitrogen is released into the soil, making it available to other plants; this helps to fertilize the soil (Flynn and Idowu 2015). The term, "pulse," comes from the Latin, "puls," meaning "thick soup" (Pulse Canada 2015). Pulses provide protein, complex carbohydrates, dietary fiber, vitamins and dietary minerals, and, like other plant-based foods, pulses contain no cholesterol and little fat or sodium (USDA ARS 2016).

Planning and preparing to use the Garden-Based Pulse Nutrition and Biology Curriculum:

- Classroom discussion and activities can be taught during the FALL or SPRING.
- To start this curriculum at the beginning of the school year, plan in advance by planting bean seeds in the spring.
- If growing beans is not possible and you are interested in class field trips, collaborate with a local dry bean farmer (or home gardener) to arrange a farm tour or ask the farmer to contribute dry beans they are growing for use with this curriculum.

Use this school curriculum *with* or *without* school garden access:

> If your school ***has*** a garden, incorporate this curriculum along with the seasons using the **Outdoor** headings found throughout the curriculum.

If your school *does not* have a garden, explore the timing and spacing options that are more flexible by using the **Indoor** headings throughout the curriculum.

National Education Standards

This interdisciplinary curriculum will encourage students to engage their senses with hands-on lessons in, and out, of the school garden. Students will learn nutrition, biology, and math standards, including:

- Next Generation Science Standards for States, by States (2016)
- STEM Education Coalition: Science, Technology, Engineering, and Math (2016)
- Common Core State Standards Initiative (2016)

Science Journal Option

Science journals are a clear and concise way for students and teachers to record experiments and field notes throughout the school year. In this curriculum, there are options for using a science journal. Also, the student worksheets can be reduced in size and printed to be inserted into the students' science journal.

Glossary

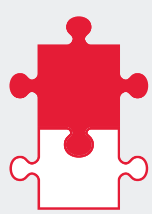
Key words are in bold throughout the curriculum and can be found in the beginning of each lesson and in the glossary at the end of the curriculum.

Icon Key:


Indoor Gardening Options


Science Journal Options


Outdoors Gardening Options


Curriculum Enhancement Options

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Next Generation Science Standards Expectations

Activities throughout the lessons are designed to reinforce the following expectations: students are expected to demonstrate grade-appropriate proficiency in asking questions, developing and using models, planning and carrying out investigations, analyzing and interpreting data, constructing explanations and designing solutions, engaging in argument from evidence, and obtaining, evaluating, and communicating information.

LESSON 1

Classroom Discussion and Activity: Predict and Observe Seed Germination

SPRING or FALL

Learning Target

How do water and sunlight affect a seed's ability to germinate?

Success Criteria: I can predict how water and sun affect the seed's ability to germinate.

Big Idea: Plants use energy from the sun to make food from water and air.

Time required for discussion and activity: 1 hour for the initial discussion and setting up the activity with 3 follow-up observations spread out over the following two weeks.

Key Words (The Morton Arboretum 2016):

Germination is the first stage in the process by which a plant grows from a seed.

Hypocotyl is the stem of a germinating seed.

Legumes are plants in the Fabaceae family that grow fresh or dry seeds in pods and form a symbiotic relationship with nitrogen-fixing bacteria on root nodules.

Photosynthesis is a process used by plants to convert light energy into chemical energy for plant growth, root development, flowering, and seed production.

Prediction is an estimation or statement about the ways things will happen in the future, often based on knowledge or experience.

Radicle is the first part of a seedling to emerge and is the young root of the plant.

Seed is the fertilized ripened ovule of a flowering plant containing an embryo and is normally capable of germination to produce a new plant; a propagative plant structure (such as a spore or small dry fruit).

Materials for setting up activity (for each group of 3 to 5 students):

3 plastic bags (sandwich size)

3 paper towels (thick paper towels that hold water)

9 beans of the same kind (e.g., all black or all orca beans)

Permanent markers

Water for wetting paper towels

Student Worksheet: *Predict and Observe Seed Germination,* (Appendix 1). One per student.

Curriculum Enhancement Options

PBS Learning Media (2016)

1. From Seed to Flower
   https://kcts9.pbslearningmedia.org/resource/tdc02.sci.life.colt.plantsgrow/from-seed-to-flower/

2. How to Germinate a Seed (PBC Learning Media Germinator 2018)
   https://kcts9.pbslearningmedia.org/resource/tdc02.sci.life.stru.germinator/germinator/

3. The Life Cycle of a Bean Movie—Smart Learning for All (2015)
   https://www.youtube.com/watch?v=9CrkJgxhjV8

4. The Seed Germination Process (2015)
   https://www.youtube.com/watch?v=TE6xptjgNR0

Science Journal Option

- Record the key points throughout the lesson.
- Predict outcome of experiment and reasoning for this prediction.
- Draw a schematic of the experiment (e.g., draw each bag and describe the different environments).
- Make observations throughout the experiment.

Background information

Legume plants fix (absorb) atmospheric nitrogen through a symbiotic relationship with bacteria in root nodules in the soil; this process is called nitrogen fixation (Colorado State Master Gardener Program 2016). Legumes are also high in protein and bear seeds in pods. Pulse crops include dry beans, dry peas, garbanzos (chickpeas), and lentils. The name, "pulse," comes from the Latin word, "puls," meaning, "a thick soup" (Pulse Canada 2015). Pulses provide protein, complex carbohydrates, dietary fiber, vitamins and dietary minerals; and, like other plant-based foods, pulses contain no cholesterol and little fat or sodium (USDA ARS National Nutrient Data Base 2016).

Dry beans are a model crop for school garden curriculum because they are:

- A healthy food choice.
- A protein source that is easily stored without further preservation required.
- An excellent source of dietary fiber.
- Contains little to no fat.

Biologically, beans are an interesting plant to grow and study:

- Pods house seeds, which have beautiful colors and patterns.
- Roots can form nodules, which are the site for nitrogen fixation (Figure 2).

Figure 2. Germinating bean with root radicle.

Instructional Process

Engage students by showing them bean seeds and asking them what ways they eat beans.

Ask Students: Why are plants important for people? What do plants provide?

Record ideas shared by students for all to see, such as on a flip chart.

Add any information missed by students from the list below.

Plants provide:

- Nutrition and medicine
- Oxygen into the atmosphere
- Habitat for animals, birds, and insects
- Beauty for landscapes
- Soil retention
- Fiber for clothing

Ask Students: What do plants need to grow?

Record ideas shared by students for all to see, such as on a flip chart. Add any information missed by students from the list below.

A plant is a biological system that needs:

- sunlight
- water
- air
- nutrients
- space for living and growing

Germination Activity

Step 1. How a plant grows.

Ask Students: What do you already know about **germination** and **photosynthesis**?

Turn to your elbow partner and share your ideas.

Background information

Green plants get their energy from sunlight in a process called photosynthesis. (Remind students that "photo" means light and "synthesis" means make.) **Photosynthesis** is a process used by plants to convert light energy into chemical energy for plant growth, root development, flowering, and seed production (Figure 3).

Many plants grow from seeds. **Germination** is the first stage in the process by which a plant grows from a seed. Students will conduct an experiment to determine what plants need to germinate (Photosynthesis Education 2016).

Step 2. Set up seed germination activity.

1. Organize students into groups of four or "table groups."
2. Give each group of students three bags and a marker.
3. Tell students to label bags 1, 2, and 3, and to write their names on all three bags.
4. Give each group three paper towels. Make sure paper towels are able to hold plenty of water.
5. Have students fold each paper towel into fourths.
6. Wet two of the paper towels. Place a wet paper towel in bags 1 and 3. Place the dry paper towel in bag 2.
7. Have students add three seeds to each bag on top of the paper towel (do not seal bag).

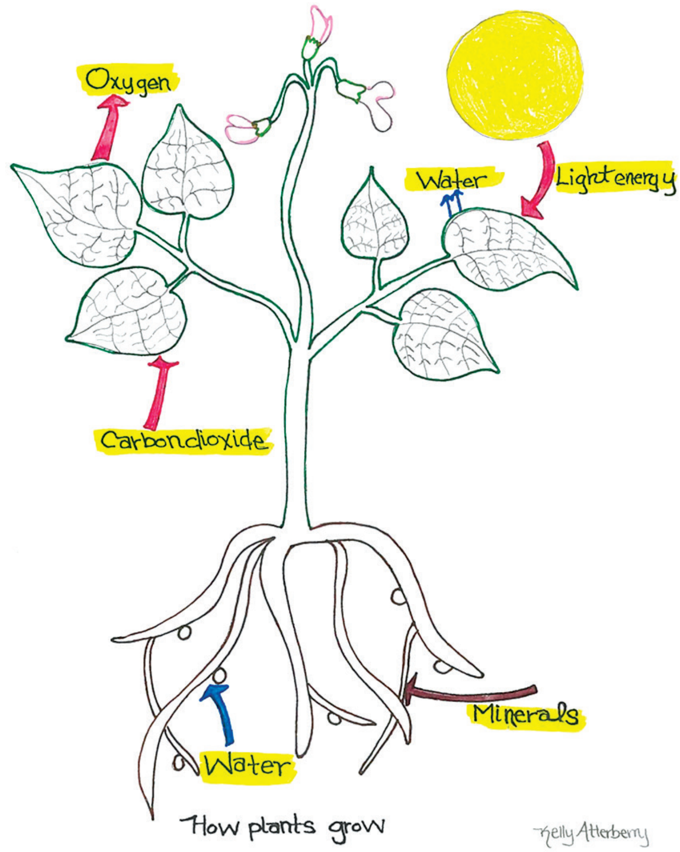


Figure 3. Legume life cycle illustration.

Ask Students:

1. Why is it important to use more than one seed in each bag for our experiment? Responses include: to increase our confidence in the experiment.

2. What are the major ways plants use water? What is the role of water in seed germination?

   Responses include:

   - Photosynthesis.
   - As a primary component within cells.
   - Leads to the swelling and the breaking of the **seed** coat.
   - Transporting nutrients from soil into roots, then throughout the plant's stems, leaves, and fruit.
   - Water is essential for all living organisms.

3. Do you think sunlight is important for seed germination?

   Responses include: no, water is the key to germination.

4. Where can bags be placed in the room to receive sunlight? Or no sunlight?

Step 3. Have students place bags 1 and 2 in the sun; place bag 3 in the dark.

Step 4. Distribute Student Worksheet: **Predict and Observe Seed Germination** ***(Appendix 1).***

Ask Students:

1. Which bag of seeds do you expect to germinate at the highest rate?
2. Next highest?
3. No germination at all?
4. Have students write their predictions on the worksheet.

Step 5. After starting the activity, check on seeds every four to five days (three times within two weeks).

Use the chart on Student Worksheet*: Predict and Observe Seed Germination* (Appendix 1) to record students' observations for each bag.

Step 6. After the seeds have germinated, around day 5, review the outcome of the experiment and discuss the following points:

Ask Students:

1. What do you observe? And why?
2. Why aren't the **hypocotyls** from seed in bag 3 green? (Response: lack of sunlight.)
3. Why haven't the **radicles** developed as much in bag 1? (Response: too much sunlight.)
4. Which bag did the best as defined by the highest number of germinating seeds?
5. What was it about the bags' environment that helped the seeds germinate and grow?
   (Responses include: sunlight, warmth, and water.)

Talking points

Seeds need water and warmth to **germinate** (Figure 4), while plants also need sunlight and nutrients to grow. Soil provides plants with structural support to grow. How well soil supports a plant depends on the soil's texture, water-holding ability, mineral content,

Figure 4. Bean germination. On day 8, seed in bags 1, 2, and 3 (from left to right) may look like this. Notice the green hypocotyl emerging from the seed from bag 1 and the radicle beginning to form root hair.

nutrients, acidity, and population of beneficial organisms (worms, nodule forming bacteria, etc.).

Plants also need space to grow. If plants do not have enough space, they will compete with neighboring plants for nutrients, light, and, water. Under stressful conditions, plants may find it difficult to grow or survive; some will grow poorly or die (Gaskin et al. 2013).

Ask Students:

1. What should we do next with these young plants to keep them growing and healthy?
2. What happens to a plant if it is kept in a very small pot? (Response: the plant would not grow very big, or it may even die because its roots do not have space to grow.)

Engage students by having them share their observations and conclusions with the class using evidence to support their conclusions, and share whether their prediction was supported or not.

Figure 5. Pulse plant with root nodules.

Fall School Garden Activity: Identify Root Nodules

FALL Session

Learning Target

What is the function of nitrogen-fixing nodules on the roots of bean plants?

Success Criteria: I can identify nitrogen-fixing nodules on the roots of bean plants.

Big Idea: bean plants have nitrogen-fixing nodules on their roots to support growth (Figure 5).

Time required for garden activity: 30 minutes.

Key Words

Nitrogen fixation is a symbiotic process between soil bacteria and legume plants by which gaseous nitrogen in the atmosphere is converted into a form that plants can use.

Root nodules house nitrogen-fixing bacteria on roots of legume plants.

Symbiotic relationships form between two organisms that mutually benefit from each other.

Materials

Exacto knife

Loupe magnifier

Hand trowel or shovel

Science Journal Option

- Draw and label the root nodule(s) that you located in the root system.
- Describe the root nodules that you observed.
- Draw the root nodule that you dissected. Be sure to include the correct color.

- What color was the inside of the nodule?
- Given the need of all green plants for nitrogen, how would you describe the relationship between the bacteria and the bean plant?

Background information

Encouraging nitrogen fixation through the symbiotic relationship between legumes and rhizobia bacteria is a way farmers can add nitrogen to the soil, without the cost of purchasing nitrogen fertilizer. Farmers can encourage nitrogen fixation by inoculating their seeds with rhizobium bacterium (Miles et al. 2014).

Plants can absorb nitrogen from the soil in a few different forms: nitrate (NO_3), ammonia (NH_3), or urea (CH_4N_{20}). Through symbiosis, plants can fix nitrogen (N_2) from the air, meeting much of its nitrogen needs. Humans obtain nitrogen by eating plants, or eating animals that have fed on plants.

The air is 79% nitrogen gas (N_2), but plants and animals (including humans) cannot use nitrogen in this form to make protein and nucleic acids.

In order for N_2 to be utilized to make protein and nucleic acids, the molecule must be broken apart, which takes a large amount of energy. (N_2 can be broken apart in the atmosphere by lightning.) For bean plants (and other legumes), it is the rhizobia that grow within the nodules on the plant roots that use their energy to assimilate N_2 into plant-useable nitrogen. This biological nitrogen fixation requires a complex set of enzymes and a large expenditure of energy (ATP) (McGraw Hill Education 2016).

Instructional Process

Step 1. In the garden, carefully dig up a bean plant using a hand trowel or a shovel.

Look for nodules in the root system (the location where nitrogen fixation occurs).

Have students draw and label the plant roots and its nodules.

Ask Students:

1. What do you think a root nodule does? Turn to your elbow partner and share your ideas.

Discussion Points

A healthy root nodule (Figure 6) will be pink to red in color on the inside, while an unhealthy nodule will be grey or white (slice root nodule in half and view the color with a loupe magnifier).

Most crops require more nitrogen than any other nutrient. Nitrogen makes up the plant's amino acids (amino acids combine to make proteins) and nucleic acids.

Dry beans, and all pulse crops, contain high levels of protein, which is made from nitrogen. However, beans do not contain all of the essential amino acids and are deficient in methionine and tryptophan. In a healthy diet, it is suggested to combine pulses with other foods such as grains or animal protein to obtain all of the essential amino acids.

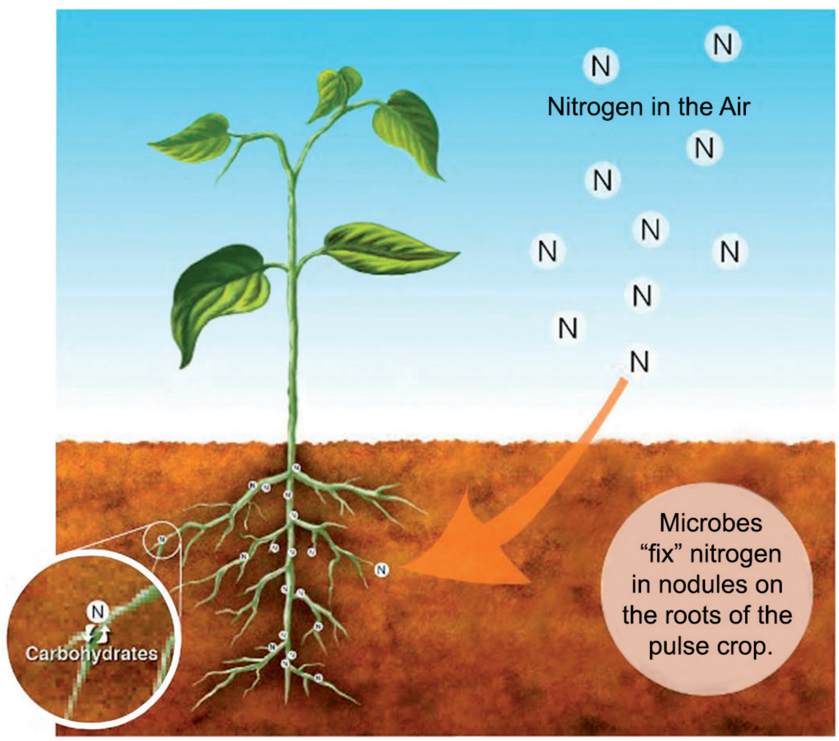


Figure 6. Pulse crops with root nodules.

Spring School Garden Activity: Plant Bean Seeds

SPRING Session

Learning Target

How are seeds planted?

Temperature conditions, depth the seed is placed in the ground, spacing between seeds.

Success Criteria: I can plant bean seeds at the correct soil depth and can measure spacing between seeds.

Big Idea: Plants need water and warmth to germinate.

Time required for garden activity: 15–45 minutes.

Outdoors

Dry beans are a warm season crop. In northwestern Washington, it is best to plant beans May 15–June 1. In other areas, plant when soil temperature reaches 60°F.

Materials for outdoor garden planting

Bean seed (approximately 60 seeds each of four different varieties; 240 seeds total)

Measuring tape

Rulers

Hoes

Gloves

Field markers

Permanent markers

Indoors

If outdoor garden space is not available, **seeds** can be planted in pots all year round (fall and winter require supplemental light).

Materials for in-classroom planting

Bean seed (approximately 60 seeds each of four different varieties; 240 seeds total)

1-gallon pot or bucket (Ideally, three to five pots per bean variety, minimum of one pot per variety if there are space constraints in the classroom)

Potting soil

Trowel

Key Words

Furrow means a long narrow trench made in the ground for planting seeds.

Science Journal Option

- Record names of different bean varieties, planting date, and the spacing and depth of seeds that were planted.
- Predict the number of days it will take for germination.

Additional bean planting information is available in Washington State University Extension Fact Sheet (FS135E): *Vegetables*: Growing Dry Beans in Home Gardens (Miles and Atterberry 2014). Online at:

http://cru.cahe.wsu.edu/CEPublications/FS135E/FS135E.pdf

Instructional Process

Outdoors

Step 1.

1. In the garden, measure length and width of bean rows to prepare for planting beans (Figure 7).
2. Using measuring tape, measure four 10 foot (3 m) rows (one row for each bean variety); space rows 30 inches (76 cm) apart.
3. Place field markers (each labeled with variety name, number of seeds planted, and planting date) at the ends of each row.
4. Using a hoe, make a **furrow** 2 inches (5 cm) deep starting from the field marker at the beginning of the row to the field marker at the end of the row.

Figure 7. Student planting activity.

Step 2. Planting Bean Seeds.

1. Engage students by having them show their elbow partner 2 inches on a ruler or with their finger to visualize the spacing.
2. Using a measuring tape (or ruler), have students place seeds 2 inches apart along the length of the 10-foot row (60 bean seeds per 10-foot row).
3. Using a hoe, cover seeds with soil (2 inches); designate one student per row to walk (do not stomp) over each row of seed to ensure firm seed-to-soil contact.

Indoors

Additional bean planting in a container instruction is available at Washington State University Extension Manual (EM057E): Home Vegetable Gardening in Washington for recommendations on containers, potting soil, and watering (Miles et al. 2013). Online at:

http://cru.cahe.wsu.edu/CEPublications/EM057E/EM057E.pdf

Step 1. Getting Ready.

1. In the classroom, fill a 1-gallon pot or bucket (e.g., empty plastic milk container) with potting soil (three to five pots per variety).

Step 2. Preparing for Planting.

1. Create planting holes in the potting container to prepare for planting beans.
2. Using a field marker or finger, create 4 planting holes about 2 inches from the side of the potting container and equally spaced apart.

3. Place field markers (each labeled with variety name, number of seeds planted, and planting date) in the pot.

Step 3. Planting Bean Seeds.

1. Have students place one seed in each planting hole in the planting container.
2. Using your hands, cover seeds with soil (2 inches); press down on seed to ensure firm seed-to-soil contact.

LESSON 2

Classroom Discussion and Activity: Experience the Life Cycle of a Bean Plant

SPRING or FALL Session

Learning Target

How to describe the life cycle of a plant.

Success Criteria: I can describe the different phases of a plant life cycle.

Big Idea: All living things have a life cycle.

Time required for discussion and activity: one hour.

Materials

Stages of the Bean's Life Cycle Cards (Appendix 4)

Student Worksheet: *The Life Cycle of a Bean Plant*, one per student (Appendix 3)

Pencils and colored pencils for worksheet

Preparation

Print Life Cycle Cards showing the stages of the life cycle of a bean plant.

Make room for a circle of nine students in the classroom.

Key Words

Cotyledons are the first leaves that emerge from a seed (The Morton Arboretum 2016).

Transpiration is a process by which moisture is carried through a plant, from the roots to small pores on the underside of leaves, where it is converted to vapor and is released to the atmosphere (Colorado State Master Gardeners 2016).

Stamens are the pollen producing part of a flower, usually with a slender filament supporting the anther, the part of the stamen where pollen is produced (The Morton Arboretum 2016).

Pistil is the ovule producing part of a flower. The ovary often supports a long style, topped by a stigma (The Morton Arboretum 2016).

Curriculum Enhancement Options

The Life Cycle of a Bean Movie (2016). Online at:

http://www.youtube.com/watch?v=9CrkJgxhjV8

Science Journal Option:

- Draw a T-chart and label one column "Plant Structure," and one column "Function."
- List each part of the plant and its function in the table.
- Draw an example of each part of the plant structure.
- Engage students by having them recall why people need plants and what plants need to grow.

Instructional Process

Step 1. Distribute the Student Worksheet: The Life Cycle of a Bean Plant *(Appendix 3).*

1. Have students identify the following plant structures: seeds, roots, leaves, flowers, and pods by coloring in each plant part on their worksheet a different color.
2. Keep the document projected throughout the following hands-on activity as a reference for students, if needed.

The different structures of the plant have different functions:

Seeds are a flowering plant's method of reproduction; a seed is capable of developing into another plant.

Roots are the part of a plant that are found in the ground. They provide support, water, nutrients, and are the location where nodules form to fix nitrogen.

Leaves attach to the stem or directly to a plant stalk and are the primary location for photosynthesis and transpiration.

Flowers (Figure 8) are the reproductive organs (stamens and pistils) that are typically surrounded by brightly colored petals (collectively called corolla) and green sepals (collectively called calyx), and their seeds mature into an enclosed ovary (called a pod).

Pods (Figure 9) provide protection for developing seeds of leguminous plants (e.g., dry bean, dry pea, lentil, garbanzo, etc.); a pod will split open when mature.

Engage students by having them count how many times they see each plant part on the worksheet. (The goal is to engage students in the upcoming activity, not necessarily provide right or wrong answers.)

Figure 8. Flowering pulse plant.

Figure 9. Pulse pod.

Step 2.

1. Have nine students stand in a line (while the remaining students will watch and direct).
2. Hand out all nine cards with life cycle stages (Appendix 4) on them, and instruct students to silently read their cards to themselves and place them on their foreheads for others to read.

Step 3.

1. Instruct students to stand next to each other in order of the bean life cycle; the students with cards must remain silent but can use non-verbal communication while getting in proper order. The students in the audience can use their voice to direct the students.

Step 4.

1. Once the students have completed this task, ask them to look at their cards and then the cards on either side of them.
2. Ask students in the audience if they think the students with cards are in the correct position for each spot in the bean life cycle. Starting at the beginning of the life cycle, have the class vote by showing a “thumbs up” or “thumbs down” to confirm the placement of each stage of the life cycle.
3. If a student is in an incorrect position, have the class decide as a group where to relocate that student.

Step 5.

1. Once the students are in the correct order, have them get into a circle to emphasize the lifecycle of a plant.

Note: The Plant Stages on the Teacher's Answer Sheet (Appendix 2) are in chronological order to guide your discussion with the students.

Step 6.

1. Once completed, have the students keep their cards and return to their desks.

Step 7.

1. Discuss each stage of the bean life cycle on the worksheet, asking students to raise their hand if they have questions about the stage being discussed.

2. For each blank box on the worksheet, decide where each stage of the life cycle fits.

3. Have students fill in their worksheet.

Step 8.

1. Challenge students to share the life cycle worksheet with family and friends at home and explain the life cycle to them.

Fall School Garden Activity: Identify Bean Plant Structures and Understand Their Functions

FALL Session

Learning Target

What are the functions of the bean plant structures?

Success Criteria: I can explain the functions of all the structures of a bean plant.

Big Idea: Bean plants have different structures that function to support survival, growth, behavior, and reproduction.

Time required for garden activity: 30 minutes.

Materials

Ruler

Calculator

Clipboards

Paper or Science Journal

Pencil

Key Words

Transpiration is a process by which moisture is carried through a plant, from the roots to small pores on the underside of leaves where it is converted to vapor and is released to the atmosphere.

Science Journal Option

- Draw a bean plant and label each structure and its function.

Background information

Functions of plant structures:

Seeds are a flowering plant's method of reproduction; seeds are capable of developing into another plant.

Stems allow for movement of water and nutrients, and they provide structural support.

Roots are the part of a plant that extend into the soil for support, water, and nutrients.

Nodules form on the roots. Rhizobia in the nodules fix nitrogen.

Leaves attach to the stem of a plant and are the main plant organs for photosynthesis and transpiration.

Flowers (Figure 8) are the reproductive organs (stamens and pistils) that typically include brightly colored petals (collectively called corolla) and green sepals (collectively called calyx), and their seeds mature into an enclosed ovary (pod).

Pods (Figure 9) provide protection for developing seeds of leguminous plants (e.g., dry bean, dry pea, lentil, garbanzo, etc.), which split open when mature.

Instructional Process

Step 1.

1. In the garden, identify bean structures and functions by having students team up with their elbow partner and take turns pointing out each structure and sharing ideas about the functions.

Step 2.

Assign a bean variety to each pair of students and have them:

1. Draw and label a table that is shown in Appendix 5 on paper or in science journal.
2. Measure and record length of pod.
3. Open pod; count and record number of seeds in the pod (Figure 10).
4. Using the measurements from two other groups counting the same variety, have students record the length of pod and number of seeds in *Length and Pod Count* worksheet (Appendix 5).

- Using a calculator, find and record the average pod length and seeds per pod and record in the *Length and Pod Count* worksheet (Appendix 5).

Spring School Garden Activity: Count and Calculate Germination Rates

SPRING Session

Learning Target

How do I determine which type of bean seed had the highest rate of germination when grown in the ground?

Success Criteria: I can calculate percentage of germinated seeds (germination rate).

Big Idea: Calculating germination is useful in determining how well bean plants perform.

Time required for garden activity: one hour.

Materials

Trowel

Clipboards

Student Worksheet*: Count and Record Germination Rates*, (Appendix 6). One per student.

Key Words

Denominator is the number below the line in a fraction showing the total number of parts.

Germination is the first stage in the process by which a plant grows from a seed.

Germination Rate is the percent of seeds that germinate.

Inference is a conclusion based on evidence.

Numerator is the number above a line in a fraction showing how many of the parts indicated by the denominator are taken.

Vigor describes the healthy, well-balanced growth of a plant.

Science Journal Option

- Germination rate equation for each variety planted in school garden.
- A bar graph to compare each variety's germination rate.
- Draw seed and plant.

Figure 10. Bean measurements.

Background information

Germination rate is the percentage of seeds that have germinated. It is important for determining the correct timing for planting seeds and to evaluate the seed vigor. Inferences can be made based on the germination rate. The higher the germination rate, the more plants will grow to produce more beans.

Instructional Process

Ask Students:

1. What is the meaning of germination?

Step 1. Distribute worksheet.

Before taking students to the garden, distribute the *Count and Record Germination Rates* worksheet (Appendix 6) and a clipboard.

Figure 11. Incorporating math and science learning activities. Counting the number of plants that have germinated (left); calculating the average germinated seeds (right).

Step 2. Count beans that have* germinated*. A bean should be counted as germinated when you can see at least a green or white stem sprouting from the ground. (Figure 11).

1. Have students write the number of seeds planted in the denominator of each equation on the worksheet (this number is written on the stakes on planting day).
2. In the garden, count the number of plants that are visible above ground (e.g., cotyledons) for each variety.
3. Have students write the number of plants counted in the numerator of each equation (worksheet provides one equation per variety or row).
4. Engage students by directing them to compare their counts of germinated seeds with two other students for accuracy.

Step 3.

1. Discuss reasons seeds may have germinated, or not (e.g., unhealthy/diseased seed, buried too deeply, birds ate seeds, seed rotted, too cold, too dry, seed too old).
2. Have them think about it, pair up with a buddy, and share their idea with their buddy. Ask a few students to share what they think.

Step 4.

1. With a **trowel**, dig up at least one seed in each row that did *not* germinate.
2. Have students draw seeds that did not germinate.

Step 5.

1. With a trowel, dig up at least one seed in each row that has germinated.
2. Have students draw seeds that have germinated.

Step 6.

1. Return to the classroom and have students calculate germination rate: (Number of visible plants) / (Number of seeds planted) x 100 = % of seeds that germinated.

Discussion: When we say percent, we are really saying "per 100" (e.g., 50% means 50 per 100). A percentage is calculated by dividing the numerator by the denominator and then multiplying that answer by 100. In determining the germination rate, the numerator must be less than the denominator. If the numerator were larger than the denominator, the germination rate of the beans would be higher than 100%, which is not possible (Math Goodies 2017).

Ask Students:

1. Can you infer, based on your germination rate data, which varieties will produce the most bean seeds in our region?
2. What can gardeners do to increase the number of seeds that germinate?
    a. Plant seeds later in the season (closer to June 1).
    b. If birds are eating the seeds, place row cover over the young seedlings. For more information on row covers, see How to Install a Floating Row Cover:

    http://cru.cahe.wsu.edu/CEPublications/FS089E/FS089E.pdf

LESSON 3

Classroom Discussion and Activity: Develop a Healthy Body through Nutritious Food!

SPRING or FALL Session

Learning Target

What are the five vegetable subgroups?

What foods contain fiber?

What are the health benefits of fiber?

How do fiber-rich foods and water work together for a healthy body?

Success Criteria: I can list the five vegetable subgroups and give two examples for each subgroup.

I can identify foods that have fiber and foods that do not have fiber.

I can name one health benefit of eating foods containing fiber.

I can describe how fiber and water work together in my body.

Big Idea: eating foods high in fiber are part of a healthy diet.

Time required for discussion and activity: one hour.

Materials

Teacher's Nutrition Handout: *Eat a Rainbow* (Appendix 9)

A living plant in a pot (a bean plant or any plant will do)

Become the Nutrition Expert! worksheet (Appendix 8). One per student.

Activity Materials

For the Fiber in Food Activity:

A variety of fiber-containing foods, for example, dry beans, celery, leafy greens, apples, berries, peaches, whole grains, and other fruits and vegetables.

A variety of foods that contain no fiber, for example, eggs, butter, olive oil, cheese, white bread, white rice noodles, and candy bars.

Note: If real food is not available, pictures of food, such as Washington Dairy Council Food Models (2016) may be used.

For the Water and Fiber Demonstration:

One rectangular, dry kitchen sponge

PVC pipe, 2-inch diameter with 45° elbow

Small bowl with ½-cup water

Small bowl to catch water during demo

For Bean Tasting Activity:

See Recipe and Taste Test section for ingredients.

Curriculum Enhancement Options

- Pulse Cooking Demo (Nikerson 2015) for students to watch during class and have access to at home.

  https://www.youtube.com/watch?v=41MjhEoa9K0

- Options for eating beans in the classroom:

  Bean Taste Test tasting in the classroom recipe, “Crunchy Bean Wrap.”

Key Words

Beneficial bacteria are microorganisms that live in our digestive system and help break down food and protect us from harmful bacteria.

Dietary fiber is an indigestible carbohydrate found in plants and is necessary in the human diet (Mayo Clinic 2016a).

Prebiotics are foods that serve as fuel for beneficial bacteria in our digestive system (e.g., dietary fiber, inulin, etc.).

Probiotics are live bacteria that are present in yogurt, other fermented foods, and in pills. They are promoted as a benefit to the human digestive system (Mayo Clinic 2016b).

Science Journal Option

- Make a T-table for the five vegetable subgroups and label one column “Subgroups” and one column “Vegetable”.
- Write down each of the five subgroups (see background information).
- Have students write examples of vegetables in each subgroup.
- Write down two examples for each subgroup.
- Draw one vegetable example for each subgroup.
- Write down that beans are an excellent source of fiber.

Background Information

Food provides essential nutrients and components for our body to stay healthy. Many Americans do not eat enough healthy foods such as pulses, fruits, vegetables, and whole grains (Fruits and Veggies, More Matters 2016; USDA My Plate 2016).

Eating foods that have a variety of colors provides the array of nutrients our bodies need. Red-colored fruits and vegetables provide different vitamins and minerals than green- or white-colored fruits and vegetables. The U.S. Department of Health and Human Services and U.S. Department of Agriculture, *Dietary Guidelines for Americans* 2015–2020 Eighth Edition (2015) have established the recommendation to eat a rainbow of colors every day (display Teacher’s Nutrition Handout: *Eat a Rainbow*, Appendix 9) and point out that beans and peas have their own vegetable subgroup.

School lunches must meet meal pattern and nutrition standards based on the latest Dietary Guidelines for Americans (2015). School lunch offerings include 3.75 cups of vegetables per week per student for grades K–8 and five cups for grades 9–12. To ensure an array of nutrients is offered, the vegetable meal pattern is divided into five subgroups: dark green, red and orange, legumes (pulses), starchy, and other vegetables. Each group has a minimum serving requirement. Schools are required to offer one-half cup of pulses per week per student. Colorful posters of vegetable subgroups and comprehensive listing is available at OSPI website (Washington State Office of Superintendent of Instruction, Child Nutrition).

http://www.k12.wa.us/ChildNutrition/Programs/NSLBP/pubdocs/VegetableSubgroupPosters.pdf

Instructional Process

Eat a Rainbow of Color Activity

Step 1. Ask Students:

1. What fruits and vegetables can we grow in a garden?
2. What are the health benefits of eating fruits and vegetables?
3. What do we mean when we say "we are what we eat".

Step 2. Discuss with students the vegetable subgroups. Point out the five vegetable subgroups (Appendix 10).

Ask Students:

1. Name foods that fit into each category.

   Examples of foods in each subgroup:

   - Beans and peas: black, kidney, pinto, and navy beans, lentils, split peas, etc.
   - Dark-green: kale, bok choy, spinach, romaine lettuce, beet greens, etc.
   - Red and orange: tomatoes, acorn squash, butternut squash, sweet potatoes, pumpkin, etc.
   - Starchy: corn, potatoes, green peas, etc.
   - Other vegetables: artichokes, asparagus, fennel, garlic, shallots, avocado, etc.

Step 3. Discuss with students the nutritional importance of beans.

Beans are so nutritious that they are included in their own vegetable subgroup. Beans contain 18% to 22% protein, which is high for a plant. They are also high in dietary fiber and low in fat. Beans contain vitamins (e.g., folate), minerals (e.g., zinc and iron), and antioxidants (darker colored beans have a higher content).

Step 4. Introduce the sources and benefits of dietary fiber to students.

Ask Students:

1. Where does fiber come from? Share your ideas with your elbow partner.

Fiber in the human diet only comes from plant-based foods. Fiber is the reason plants stand up straight. Show students a live plant to demonstrate the structural function of fiber. Dietary fiber is any edible part of a plant that cannot be broken down by our digestive enzymes (Mayo Clinic 2016).

Fiber helps reduce the risk of diet-based diseases (e.g., heart disease, diabetes, and obesity) by:

- Maintaining healthy body fat levels,
- Maintaining healthy blood sugar levels,
- Supporting regular bowel movement, which is the final act of digestion where the body excretes waste,
- Helps you feel full longer (you will not get hungry as quickly),
- Our digestive tract houses millions of bacteria needed to help digest the food we eat.

Dietary fiber acts as a prebiotic, meaning it provides food for beneficial bacteria. In addition to breaking down food, beneficial bacteria protect us from harmful bacteria in the digestive system.

What is a prebiotic? In short, the prebiotic is a specialized plant fiber that beneficially nourishes the good bacteria already in the large bowel or colon. While probiotics introduce good bacteria into the gut, prebiotics act as a food source for the good bacteria that are already there. They help your good bacteria grow, improving the good-to-bad bacteria ratio. This ratio has been shown to have a direct correlation to your health and overall wellbeing, from your stomach to your brain.

https://www.prebiotin.com/prebiotin-academy/what-are-prebiotics/prebiotics-vs-probiotics/

Ask Students:

1. What do foods that contain fiber have in common? (Response: they are all plants, e.g., fruits and vegetables.)

Engage students by showing them the Water and Fiber Demo (see materials list).

a. Hold up a dry kitchen sponge (sponge must be very dry and hard).

b. Tell students: imagine the sponge represents the fiber in a meal you have eaten, but you did not drink enough water.

c. Hold up PVC pipe.

d. Tell students: the pipe represents your intestines.

e. Try to push the dry sponge through the pipe and the students will see the sponge get stuck. When fiber does not pass through the intestines easily, constipation and bloating occur.

Water and Fiber Demo

Ask Students:

1. How can we help the fiber move through the intestines?

    a. Dip the sponge in a bowl of water and show students the sponge moving through the pipe.

    b. The sponge absorbs water just like fiber does. Now, the fiber is flexible and can easily bend to pass through the intestines.

Background Information

The positive effects of water and fiber:

- Cleans intestinal walls
- Feeds beneficial bacteria
- Triggers muscle contraction for healthy bowel movements and excretion of waste

Benefits of a high-fiber diet (Mayo Clinic 2016b):

Normalizes bowel movements. Dietary fiber increases the weight and size of your stool and softens it. A bulky stool is easier to pass, decreasing your chance of constipation. If you have loose, watery stools, fiber may help to solidify the stool because it absorbs water and adds bulk to stool.

Helps maintain bowel health. A high-fiber diet may lower your risk of developing hemorrhoids and small pouches in your colon (diverticular disease). Some fiber is fermented in the colon. Researchers are looking at how this may play a role in preventing diseases of the colon.

Lowers cholesterol levels. Soluble fiber found in beans, oats, flaxseed, and oat bran may help lower total blood cholesterol levels by lowering low-density lipoprotein, or "bad," cholesterol levels. Studies also have shown that high-fiber foods may have other heart-health benefits, such as reducing blood pressure and inflammation.

Helps control blood-sugar levels. In people with diabetes, fiber—particularly soluble fiber—can slow the absorption of sugar and help improve blood-sugar levels. A healthy diet that includes insoluble fiber may also reduce the risk of developing Type 2 Diabetes.

Aids in achieving healthy weight. High-fiber foods tend to be more filling than low-fiber foods, so you're likely to eat less and stay satisfied longer. And high-fiber foods tend to take longer to eat and to be less "energy dense," which means they have fewer calories for the same volume of food.

Fiber in Food Activity

Step 1. Distribute Student Worksheet: **Become the Nutrition Expert!** ***(Appendix 8).***

Step 2. In the classroom, place variety of foods on table for all students to see.

Step 3. Have students look at each food item that is set out and write down which foods contain fiber and which foods do not have fiber. Give students adequate time to complete this activity.

Step 4. As a class, discuss which foods contain fiber and which foods do not contain fiber (see Teacher's Key: **Become the Nutrition Expert!** ***Appendix 7).***

Background Information

Foods that contain fiber are plant foods, for example, beans, leafy greens, and berries (adjust as needed based on the actual foods set out).

Foods that have no fiber come from animals or refined grains, for example, eggs, butter, white bread, and white rice noodles (adjust as needed based on the actual foods set out).

While white bread and white rice noodles *do* come from plants, their fiber is removed during processing.

While foods without fiber *may* contain nutrients that our bodies need, the goal for this activity is to be able to differentiate which foods do, and do not, have fiber.

Taste Test and Recipe Preparation

Recipe for Bean Tasting Activity

Options for tasting beans in the classroom:

1. Canned beans (drained and rinsed) can be served and do not require kitchen appliances (Figure 12).
2. Use canned refried beans as a dip with vegetables or chips.

   Recipe: Crunchy Bean Wrap (no cooking)

Figure 12. White beans.

Ingredients include per student:

¼ of a tortilla

1 tablespoon black beans

1 tablespoon grated carrot

1 tablespoon shredded lettuce, spinach, or diced broccoli

1 teaspoon salsa

Directions:

Top the tortilla with all ingredients, fold tortilla in half, and enjoy!

Have students identify fiber-rich foods offered in the school cafeteria (Figure 13).

Describe a favorite menu item that is high in fiber. Figure 13 illustrates a cafeteria menu item that incorporates beans into school meal options.

Encourage students to find and make some pulse recipes at home.

Figure 13. Kid-friendly bean menu offerings.

Fall School Garden Activity: Harvest and Thresh Beans

FALL Session

Learning Target

What are the steps in harvesting and threshing bean plants?

Success Criteria: I can harvest and thresh bean plants from the school garden.

Big Idea: All living things have a life cycle.

Time required for garden activity: 1 hour.

Materials

Garden shears

Gloves

Burlap sack with variety label (up to five plants per burlap sack) OR paper grocery bag (one plant per grocery bag)

Note: Cafés and diners often receive potatoes in burlap sacks and may be willing to donate the sacks.

Preparation

Dry bean plants from the school garden or obtain dry bean plants from local farm or gardener.

Key Words

Harvest is the process or period of gathering in crops.

Threshing is the process of separating dry seeds from the plant.

Science Journal Option

- Measure and record average seed size.
- Line up ten seeds on a ruler (Figure 14d).

- Calculate average seed length by dividing the total length by the number of seeds.
- Draw the color patterns of each bean variety.

Figure 14. (a) Bean plants ready to harvest, (b) bean stomp—student threshing beans with burlap sacks, (c) bean pods at harvest, and (d) bean sizing.

Harvest

The beans will be ready to harvest when the pods turn yellow and papery, not fleshy (September to early October).

Step 1. In the school garden, check bean plants for proper time to harvest (Figure 14a).

Step 2. Harvest the bean plants by cutting them with pruners at the soil line.

Step 3. Place plants into appropriately labeled burlap sacks or paper grocery bags.

Drying

Step 1. Place bag of beans in a dry, sheltered area (e.g., classroom or greenhouse) so they can dry completely. Leave paper bags open during the drying process. The time it takes to dry beans depends on weather conditions.

You will know the beans are fully dried when the stem snaps when bent.

Threshing

Bean Stomp (Figure 14b)

Step 1. Outside, stomp on the burlap sacks to thresh the bean plants.

Step 2. Remove beans from burlap sack, break any remaining pods open, and harvest the seed (Figure 14c).

Step 3. Separate small bits of debris from the seed, and place debris back in the garden or in the compost pile.

Hand Thresh

Step 1. Pick pods off the plant and place them into a labeled grocery bag.

Step 2. Leave bag open and allow pods to dry in the classroom for two weeks or until pods open easily.

Step 3. When beans are dry, reach into paper grocery bag and shell individual pods by hand letting the seeds drop to the bottom of the bag and discarding the pod.

Step 4. After all beans are threshed, shake the bag gently up and down, and remove pod material that is on top of the beans. Remove beans from paper bag and clean the seed.

Cleaning

Sift beans from plant debris using a compost screen (Figure 15). Place debris back in the garden or in the compost pile.

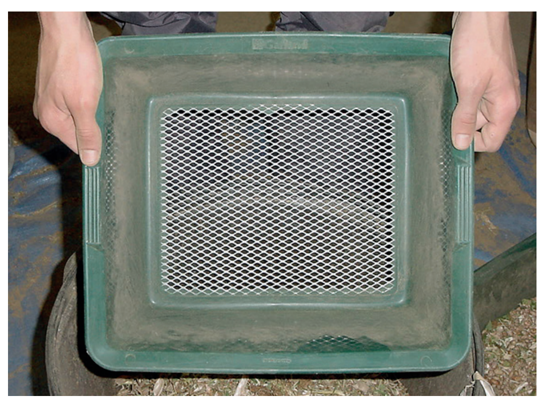


Figure 15. Garden screen used to clean beans.

Storage

Store beans in an air-tight container.

Ask Students:

1. What are the ways the seeds that we harvested can be used?

Share your ideas with your elbow partner. (Answer: some beans can be cooked and eaten, while others are saved for seed to plant next season.)

Spring School Garden Activity: Measure and Compare Bean Plant Growth

SPRING Session

Learning Target

How do I compare the growth rate of different kinds of bean plants?

Success Criteria: I can measure and graph the average height of each bean plant variety.

Big Idea: Bar graphs are useful to compare heights of different bean plant varieties.

Time required for garden activity: 30 minutes.

Materials

Twist ties (five for each bean variety)

Meter stick

Calculator

Colored pencils

Clipboards

Student Worksheet: *Plant Height Measurement Record Worksheet* (Appendix 10), one per student

Student Worksheet: *Measure and Compare Bean Plant Growth* (Appendix 11). (For teacher's use or to be distributed to students, teacher's discretion.)

Key Words

Average expresses the central or most typical value by dividing the sum of all of the values in the set by the number of values.

Science Journal Option

- Plant-height measurement equation to determine the average for each variety planted in the school garden.

- A bar graph to compare each variety's average height.
- Based on what you have learned about growing beans, which variety would you choose to plant next year?

Instructional Process

Step 1. In class, distribute Student Worksheet:* Measure and Compare Bean Plant Growth *(Appendix 11), and have students write the name of each bean variety on the worksheet.

Step 2. In the garden, choose five random plants within each variety to measure. Mark each designated plant with a twist tie.

Step 3. Using a meter stick, measure height (cm) of each of the five bean plants from the tip of the longest end of the plant. Record height of each plant on the worksheet* Plant Height Measurement Records *(Appendix 10). Students can take turns taking measurements as the teacher or students records the height of the five plants in each row (Figure 16).

Figure 16. Student plant measurement activity: students measuring bean plant height (left) and counting plants (right).

Step 4. Calculate the average height of each bean variety using the worksheet:* Plant Height Measurement Records *(Appendix 10).

Step 5. Once the average height has been calculated, have students use a different colored pencil to record the average height of each variety on their worksheet by drawing a bar graph.

Step 6. Repeat process after three to seven days to measure growth over time.

GLOSSARY OF KEY TERMS

average. Expresses the central or most typical value by dividing the sum of all of the values in the set by the number of values.

beneficial bacteria. Microorganisms that live in our digestive system to help break down food and protect us from harmful bacteria.

cotyledons. The first leaves that emerge from a seed.

denominator. The number below the line in a fraction showing the total number or population.

dietary fiber. An indigestible carbohydrate found in plants and is necessary in the human diet.

flowers. The reproductive organs (stamens and pistils) that are typically surrounded by brightly colored petals (collectively called corolla) and green sepals (collectively called calyx), and their seeds mature into an enclosed ovary (pod).

furrow. A long, narrow trench made in the ground for planting seeds.

germination. The first stage in the process by which a plant grows from a seed.

germination rate. The percent of seeds that germinate over time.

harvest. The process, or period, of gathering in crops.

hypocotyl. The stem of a germinating seed.

inference. A conclusion based on evidence.

leaves. Attach to the stem of a plant and are the main plant organs of photosynthesis and transpiration.

legumes. Plants in the Fabaceae family that grow fresh, or dry, seeds in pods and form a symbiotic relationship with nitrogen-fixing bacteria in root nodules.

nitrogen. A component of proteins and is involved in the metabolic processes required for plant growth. Nitrogen is also a component of chlorophyll and, thus, plays a role in photosynthesis. An adequate supply of nitrogen is associated with vigorous vegetative growth and the healthy, dark-green color in plants.

nitrogen fixation. A symbiotic process between soil bacteria and legume plants by which gaseous nitrogen in the atmosphere is converted into a form that plants can use.

numerator. The number above a line in a fraction showing how many of the population indicated by the denominator were present or measured.

ovary. A part of the female reproductive organ of a flower and is the part of the pistil that holds the ovule.

percentage. Calculated by dividing the numerator by the denominator and then multiplying that number by 100.

petals. Modified leaves that surround and protect the reproductive organs of a plant (collectively called corolla).

photosynthesis. A process used by plants to convert light energy into chemical energy for plant growth, root development, flowering, and seed production.

pistil. The female reproductive part of a flower and consists of an ovary, which contains the ovules, which will develop into seeds.

pods. Provide protection for developing seeds of leguminous plants (e.g., dry bean, dry pea, lentil, garbanzo, etc.); they split open when mature.

prebiotic. Foods that serve as fuel for beneficial bacteria in our digestive system (e.g., dietary fiber, inulin, etc.).

probiotics. Live bacteria that are present in yogurt, other fermented foods, and in pills. They are promoted as a benefit to the human digestive system. Normally, you have trillions upon trillions of bacteria within the colon. We ingest bacteria every time we swallow. Many of these swallowed bacteria may be beneficial, while most are simply innocuous and cause no problems.

predict. An estimation or statement about the way things will happen in the future, often based on knowledge or experience.

pulses. Crops in the legume family, Fabaceae, and consist of plants that fix (absorb) atmospheric nitrogen through nodules attached to roots in the soil, are high in protein, and bear seeds in pods. Pulses include dry beans, dry peas, garbanzos (chickpeas), and lentils. The name, “pulse,” comes from the Latin word, “puls,” meaning “a thick soup.”

radicle. The first part of a seedling to emerge and is the young root of the plant.

roots. The part of a plant that extends into the ground for support, water, and nutrients, and is where nodules form to fix nitrogen.

root nodules. House nitrogen-fixing bacteria on roots of legume plants.

seeds. A flowering plant’s method of reproduction, capable of developing into another such plant.

sepals. The outer-most part of a flower that protects the flower when in bud and supports the petals when in bloom (collectively called the calyx).

stamens. The pollen-producing reproductive organ of a flower.

stems. Allow for movement of water and nutrients, and provide structural support.

symbiotic relationship. Forms between two organisms that mutually benefit from the association.

threshing. The process of separating dry seeds from the plant.

transpiration. A process by which moisture is carried through a plant, from the roots to small pores on the underside of leaves, where it is converted to vapor and is released to the atmosphere.

vigor. Describes the healthy, well-balanced growth of a plant.

APPENDIX

APPENDIX 1

Student Worksheet: *Predict and Observe Seed Germination*

Name:______________________________ Date:________________

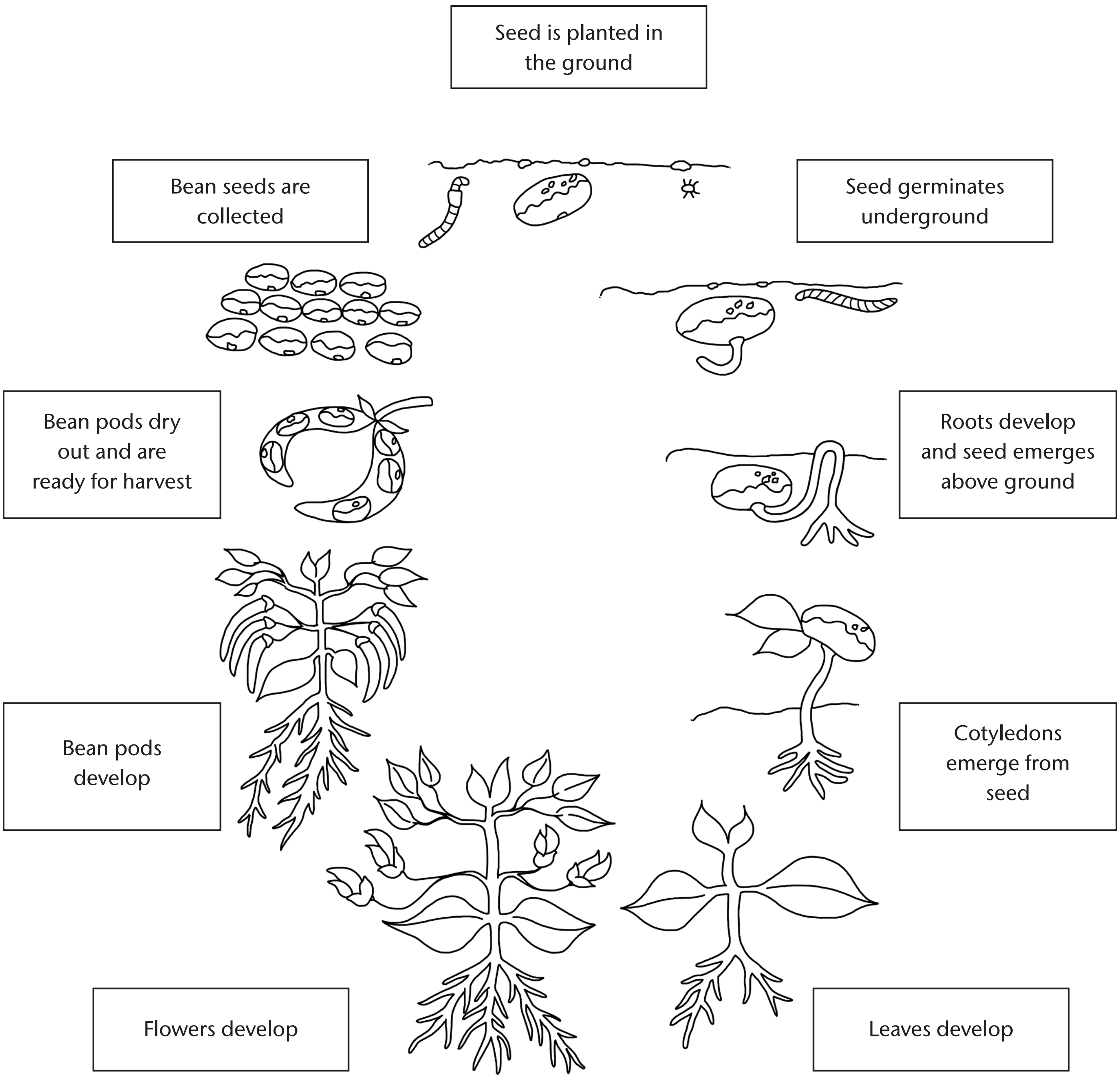
Predict which bag of beans will germinate best ____________________________

Explain the reasoning for your prediction ____________________________

Bag	Observation *Explain on the lines and draw in the box below*		
1. Wet, sunlight	Day_____	Day_____	Day_____
2.Dry, sunlight	Day_____	Day_____	Day_____
3. Wet, dark	Day_____	Day_____	Day_____

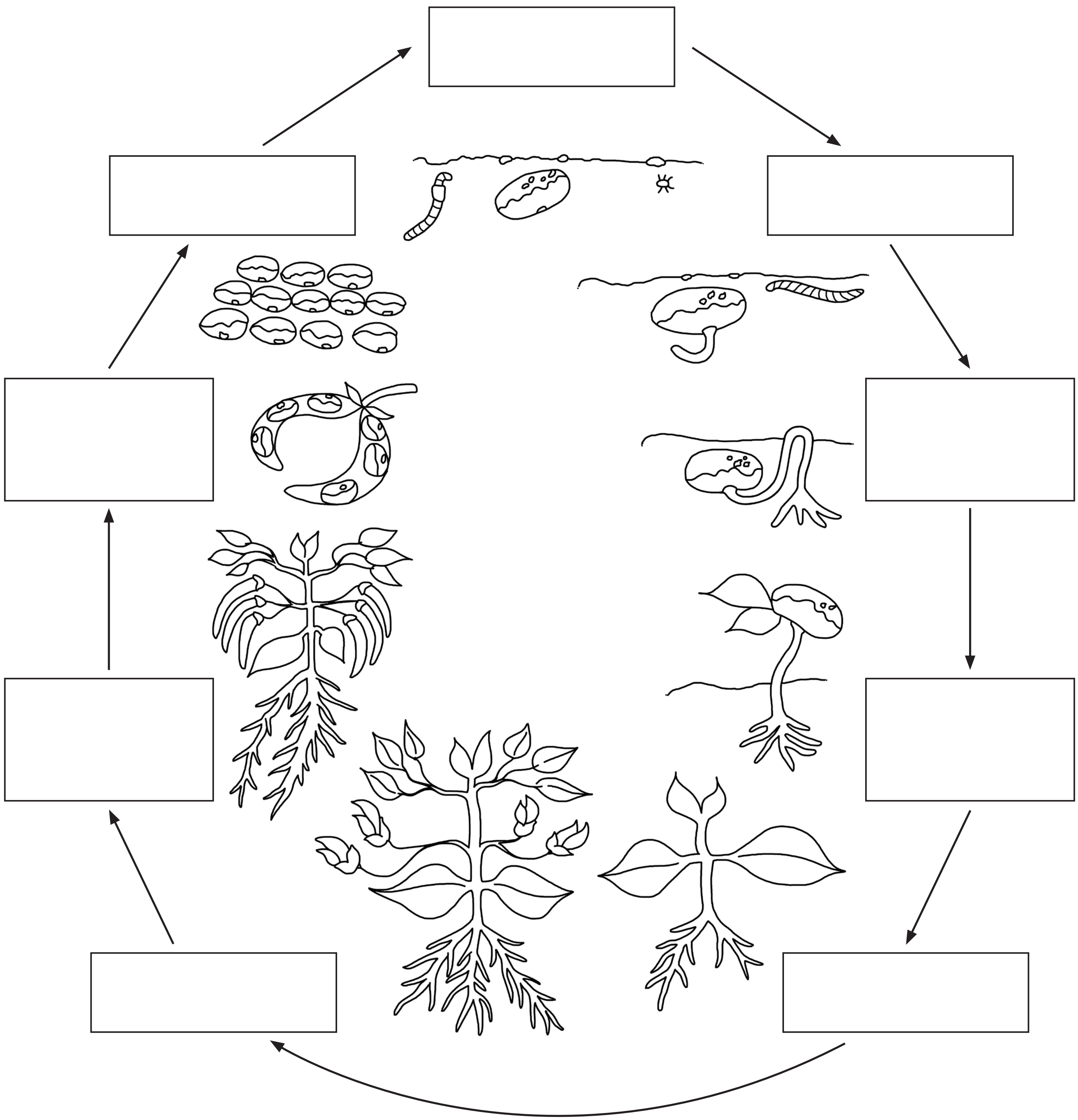
APPENDIX 2

Teacher Answer Key: *The Life Cycle of a Bean Plant*



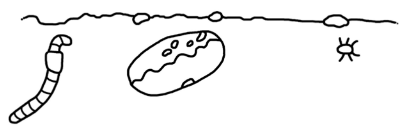
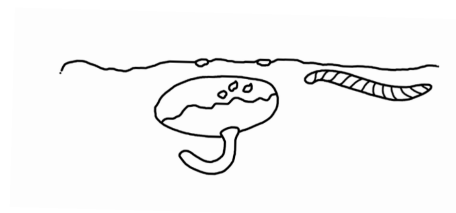
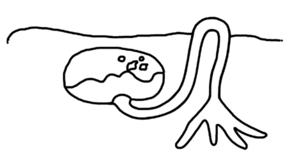
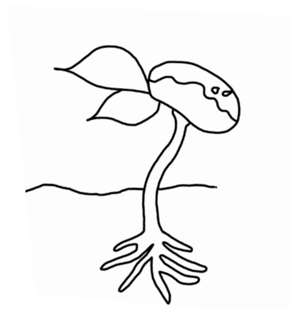
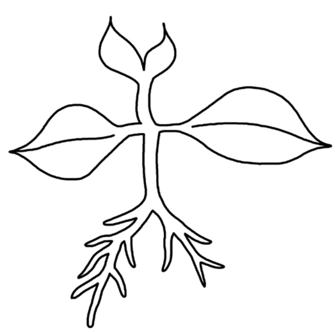
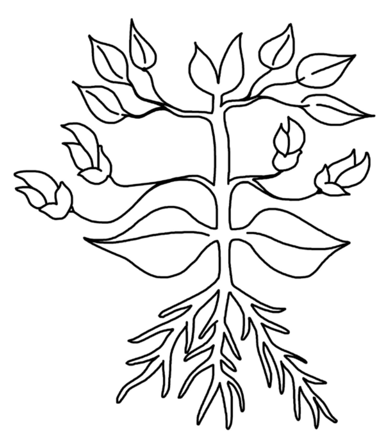
APPENDIX 3

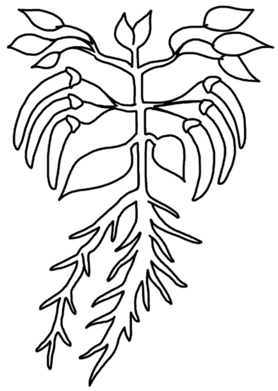
Student Worksheet: *The Life Cycle of a Bean Plant*



APPENDIX 4

Activity Cards: ***Stages of a Bean's Life Cycle***

Seed is planted in the ground 	Seed germinates underground 
Roots develop and seed emerges above ground 	Cotyledons emerge from seed 
Leaves develop 	Flowers develop 

<table>
<tr><td>Bean pods develop
</td><td>Bean pods dry
out and are
ready for harvest
</td></tr>
<tr><td>Bean seeds are
collected
</td><td></td></tr>
</table>

APPENDIX 5

Student Worksheet: *Average Pod Length and Seed Count*

Average Length and Seeds per Pod of ____

(Insert bean variety name)

Sample Pod	Length of Pod	Seeds per Pod
1		
2		
3		
Average		

APPENDIX 6

Student Worksheet: *Count and Record Germination Rates*

Name:____ Date:________________________

Garden numbers: How many seeds germinated per variety?

Equation: $\left(\frac{\text{number of germinated seed}}{\text{number of seed planted}}\right)$ **x 100 = germination rate**

Variety 1: ________________ = $\left(\frac{\quad}{\quad}\right)$ X 100 =

Variety 2: ________________ = $\left(\frac{\quad}{\quad}\right)$ X 100 =

Variety 3: ________________ = $\left(\frac{\quad}{\quad}\right)$ X 100 =

Variety 4: ________________ = $\left(\frac{\quad}{\quad}\right)$ X 100 =

Draw Seed	Draw Plant

What inferences can you make about which bean variety will produce the highest yield?

APPENDIX 7

Teacher Answer Key: *Become the Nutrition Expert!*

Which foods are high in fiber?	**Dry beans, whole grains, berries, leafy greens, celery, apples, and peaches**
Which foods have no fiber? **BONUS:** **What nutrients do they have?**	**Eggs, butter, olive oil, cheese, white bread, white rice noodles, and candy bars** **BONUS:** **Healthy fats and protein (eggs, olive oil, and cheese)**
How do the foods with fiber help your body stay healthy?	**Help reduce the risk of heart disease, diabetes, and obesity by:** • **Maintaining healthy body fat levels** • **Maintaining healthy blood sugar levels** • **Supporting regular bowel movement, which is the final act of digestion where the body excretes waste** • **Helping you feel full longer so you do not get hungry as quickly** • **Feeding the beneficial bacteria in the G.I. tract**
Additional observations	

APPENDIX 8

Student Worksheet: *Become the Nutrition Expert!*

Which foods are high in fiber?	
Which foods have no fiber? BONUS: What nutrients do they have?	
How do the foods with fiber help your body stay healthy?	
Additional observations	

APPENDIX 9

Eat a Rainbow: ***The 5 Vegetable Subgroups***

APPENDIX 10

Student Worksheet: *Plant Height Measurement Records*

Name:____ Date:____________________

Variety 1:

1 2 3 4 5

Height (cm): ______ + ______ + ______ + ______ + ______ = ______

Average height: $\frac{\_\_\_\_\_\_}{5}$ =

Variety 2:

1 2 3 4 5

Height (cm): ______ + ______ + ______ + ______ + ______ = ______

Average height: $\frac{\_\_\_\_\_\_}{5}$ =

Variety 3:

1 2 3 4 5

Height (cm): ______ + ______ + ______ + ______ + ______ = ______

Average height: $\frac{\_\_\_\_\_\_}{5}$ =

Variety 4:

1 2 3 4 5

Height (cm): ______ + ______ + ______ + ______ + ______ = ______

Average height: $\frac{\_\_\_\_\_\_}{5}$ =

APPENDIX 11

Student Worksheet: *Measure and Compare Bean Plant Growth*

Name:____ Date:__________________________

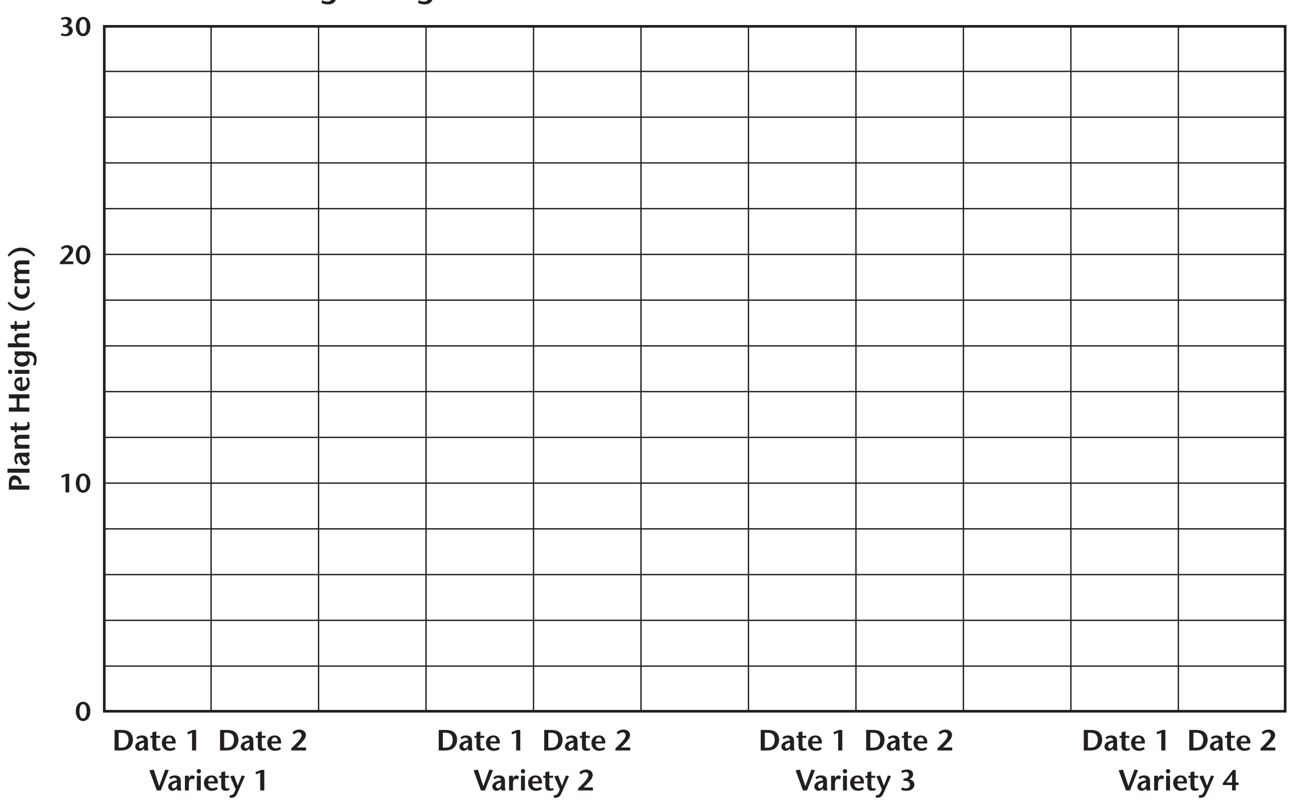
Instructions:

- Write the name of each bean variety in the legend.
- Write the date of each planting under Date 1 and Date 2.
- Graph the average growth measurements for each bean variety by measuring 5 random plants and calculating the average on two different days.
- Compare the growth between varieties.
- Compare the growth within each variety at two times.

Legend

Variety 1: ________________	Variety 3: ________________	Date 1: ________________
Variety 2: ________________	Variety 4: ________________	Date 2: ________________

Average Height of Bean Varieties Grown in the School Garden



Based on what you have learned about growing beans, which variety would you choose to plant next year?

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http://www.whatcomfarmtoschool.org/wp-content/uploads/2014/04/Lesson-1_Pulse.pdf

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Figures

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Appendices

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BIBLIOGRAPHY

Bell, A. 2001. The Pedagogical Potential of School Grounds. *Greening School Grounds: Creating Habitats for Learning*: 9–11.

Birch, L., J.S. Savage, and A. Ventura. 2007. Influences on the Development of Children's Eating Behaviours: from Infancy to Adolescence. *Canadian Journal of Dietetic Practice and Research: A Publication of Dietitians of Canada* 68.

Colorado State Master Gardener Program. 2016. Plant Growth Factors: Photosynthesis, Respiration, and Transpiration.
http://www.ext.colostate.edu/mg/gardennotes/141.pdf

Common Core State Standards Initiative. 2016.
http://www.corestandards.org/

Dairy Council of Washington Paper Food Model. 2018.
http://nutrition.eatsmart.org/products/food-models

Desmond, D., J. Grieshop, and A. Subramaniam. 2004. Revisiting Garden-Based Learning in Basic Education. *Food and Agriculture Organization of the United Nations*.

Flynn, R., and J. Idowu. 2015. Nitrogen Fixation by Legumes. Department of Plant Science, New Mexico University.

Fruits & Veggies, More Matters. 2018. Eat a Colorful Variety Every Day.
http://www.fruitsandveggiesmorematters.org/eat-a-colorful-variety-of-fruits-and-vegetables

Gaskin, J.W., P. Hartel, E. Little, and G. Harris. 2013. Soil Biology in *Soil Inoculants*. *University of Georgia Extension Fact Sheet* C990. University of Georgia.
http://extension.uga.edu/publications/detail.cfm?number=C990

Graham, H., D.L. Beall, M. Lussier, P. McLaughlin, and S. Zidenberg-Cherr. 2005. Use of School Gardens in Academic Instruction. *Journal of Nutrition Education and Behavior* 37 (3): 147–151.

Heim, S., J. Stang, and M. Ireland. 2009. A Garden Pilot Project Enhances Fruit and Vegetable Consumption among Children. *Journal of the American Dietetic Association* 109(7): 1220–1226. doi:10.1016/j.jada.2009.04.009.

Math Goodies. 2017. Understanding Percent.

Mayo Clinic. 2016a. Nutrition and Healthy Eating Dietary Fiber: Essential for a Healthy Diet.

Mayo Clinic. 2016b. Nutrition and Healthy Eating Dietary Fiber: Essential for a Healthy Diet.

McGraw Hill Education. 2016. Nutrition and Transport in Plants.
http://www.mhhe.com/biosci/genbio/raven6b/graphics/raven06b/other/raven06_39.pdf

Miles, C., and K. Atterbury. 2014. Vegetables: Growing Beans in Home Gardens. *Washington State University Extension* FS135E. Washington State University.

Miles, C., G. Sterrett, L. Hesnault, C. Benedict, and C. Daniels. 2013. Home Vegetable Gardening in Washington. *Washington State University Extension* EM057E. Washington State University.
http://cru.cahe.wsu.edu/CEPublications/EM057E/EM057E.pdf

Next Generation Science Standards for States, by States. 2016.
http://www.nextgenscience.org/

Nickerson, K.A. 2014. Kelly Ann's Pulse Cooking Demonstrations, YouTube video.
https://www.youtube.com/watch?v=41MjhEoa9K0

Nitrogen: What Does This Element Do for You? 2018. Healthy Philosophy Wellness Services.
https://ahealthyphilosophy.com/article/nitrogen-what-does-this-element-do-for-you

Office of Superintendent of Public Instruction. 2017. Health Standards State of Washington.
http://www.k12.wa.us/HealthFitness/Standards.aspx

PBS Learning Media Germinator. 2018.
http://www.pbslearningmedia.org/resource/tdc02.sci.life.stru.germinator/germinator/

PBS Learning Media. 2016. From Seed to Flower.
http://www.pbslearningmedia.org/resource/tdc02.sci.life.colt.plantsgrow/from-seed-to-flower/

Photosynthesis Education. 2016. Photosynthesis in Plants.
http://photosynthesiseducation.com/photosynthesis-in-plants/

Pulse Canada. 2015. Food & Health What is a Pulse.
http://www.pulsecanada.com/about-us/what-is-a-pulse

Seed Germination. 2015.
https://www.youtube.com/watch?v=TE6xptjgNR0

Smart Learning for All. 2015. *Seed Germination*, YouTube video.
https://www.youtube.com/watch?v=TE6xptjgNR0

STEM Education Coalition: Science, Technology Engineering and Math. 2016.
http://www.stemedcoalition.org/

The Life Cycle of a Bean Movie, YouTube video. 2009.
http://www.youtube.com/watch?v=9CrkJgxhjV8

The Morton Arboretum (The Morton Arboretum the Field Museum of Natural History, and the Chicago Botanic). 2016. The vPlants project. Garden Glossary of Plant Terms.
http://symbiota4.acis.ufl.edu/seinet/vplants/portal/plants/glossary/index.php

USDA HHS (U. S. Department of Health and Human Services and U.S. Department of Agriculture) *Dietary Guidelines for Americans 2015–2020* Eighth Edition.
http://health.gov/dietaryguidelines/2015/guidelines/

Pennisi, B. 2015. Gardening in Containers. University of Georgia Extension Publications Circular 787.
http://extension.uga.edu/publications/detail.html?number=C787&title=Gardening%20in%20Containers

USDA ARS (U.S. Department of Agriculture, Agricultural Research Service). 2016. National Nutrient Database for Standard Reference, Release 24. Nutrition Facts for Chickpeas (Garbanzo Beans, Bengal Gram), Mature Seeds, Cooked, Boiled, without Salt. Nutrient Data Laboratory Home Page.
http://ndb.nal.usda.gov/ndb/foods/show/4796?fgcd

WSU Vegetable Research and Extension School Garden Education.
http://mtvernon.wsu.edu/vegetables/schoolgarden/

Washington Dairy Council. 2018. Food Models.
https://nutrition.eatsmart.org/products/food-models

Washington State Office of Superintendent of Instruction, Child Nutrition. Vegetable Subgroup listing (2018).
http://www.k12.wa.us/ChildNutrition/Programs/NSLBP/pubdocs/VegetableSubgroupPosters.pdf

Zeratsky, K. 2016. What Are Probiotics and Prebiotics? Mayo Clinic.
http://www.mayoclinic.org/healthy-lifestyle/consumer-health/expert-answers/probiotics/faq-20058065

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