Activity: Feed Me – Nutritional Building Blocks

Grades 3-5

Time:

Groundwork: 20 minutes
Exploration: Three 30-to-45 minute periods
Making connections: Ongoing

Materials:

- **Copies of the Foods and Nutrition Handout**

For Each Student Group:

- **Large colored beads and string including alphabet beads or printed copies of bracelets and crayons or colored pencils**
- **Scissors**
- **Tape**
- **Student Activity Sheets**
- **Small bowls labeled as directed**

For class demonstration:

- **Glasses of water**
- **Chalk**
- **Seashells**
- **Eggshells**
- **Sugar cubes or sugar**
- **Salt**
- **Vinegar**
- **pH paper**
- **Sample of NuSalt**
- **Soil test kit (optional)**

Standards At-A-Glance

Next Generation Sunshine Standards Met:

LA.3.6.1.1, LA 4.6.1.1, SC.3.L.14.1, SC.3.N.1.3, SC.4.E.6.3, SC.4.E.6.6, SC.4.L.17.2, SC.5.P.8.2, HE.3.B.1.1, HE.4.B.1.2

Standard Reinforced or Skill Utilized:

SC.2.L.17.1, SC.3.L.17.2, SC.4.L.16.1, SC.4.L.16.2, SC.4.L.17.3, SC.4.N.1.1, SC.4.P.8.2

Overview

The difference between human nutrition and plant nutrients is often one of the concepts that students misunderstand. This is proven in documented errors found in standardized test questions. Students hear the term "plant food" and take that term literally, believing that plants eat (as animals do) to obtain nutrients. The intent of this lesson is to clear up that misconception as well as to teach students about the actual nutrients that plants require and the source of those nutrients.

Background

In learning about the process of photosynthesis, students are taught that plants take carbon dioxide and water in the presence of chlorophyll and sunlight and make plant sugars. Carbon dioxide is obtained from the atmosphere and the carbon and oxygen atoms are used. The hydrogen and oxygen atoms are obtained in the breakdown of water molecules that are absorbed by a plant's roots and transported to the leaves. The carbon, hydrogen and oxygen are used to build simple sugar and the excess oxygen is given off as atmospheric oxygen. But that is a very simplified explanation of plants producing food. In reality, the process is much more complex and many more nutrients are required to produce starches, protein, cellulose, lignins and oils.

There are many nutrients that plants need to make the foods that all animals require. The nutrients needed in greatest quantity are known as macronutrients. Those needed in very small amounts are micronutrients or even trace elements. (Macro – in large amounts; micro— in small amounts.) The three macronutrients that are required for plant growth and reproduction are nitrogen, phosphorous, and potassium. These are identified by the initials N-P-K on any fertilizer formulation. The quantity and source of these three nutrients varies by crop and method of agricultural production.

Nitrogen is the key element in protein. Nitrogen is needed for leaf growth and green leaves. It makes up 16 percent of the protein in our bodies. Seventy-eight percent of the earth's air is nitrogen, but it is not in a form that plants can use directly. In the atmosphere, nitrogen is N_2 and the plants need it to be either ammonium or nitrate. Crops like soybeans, peas, green beans, or alfalfa are legumes that can form a relationship with nitrogen–fixing bacteria that are found in nodules on the plant's roots. These bacteria take atmospheric nitrogen and convert it into a useable form for plants. Legumes take the nitrogen and oxygen in the air and fix it into a form that plants can use (nitrate) NO_3. Animals consume plant or animal proteins and as part of their digestive and cell building process, excrete ammonium in their urine and feces. Plants can make use of the ammonium in both urine and feces. Both of these plant sources take time and use land resources. Fertilizer companies take nitrogen from the air and, using natural gas, make nitrogen fertilizer.

After plants, animals and people use nitrogen, where does it end up? Nitrogen is cycled back into the atmosphere. It completes the nitrogen cycle. If nitrogen is deficient, plants will yellow and their growth will be stunted. Too much nitrogen will cause overabundant foliage with delayed flowering. The plant will become subject to disease, and the plant's fruit will be of poor quality.

Phosphorous (phosphate) is a mineral plants need to utilize energy. Phosphorous is mined from deposits of fossilized sea creatures. Ask: Could you eat this? (Use image of clam shell.) Well, neither can plants or animals make use of it in this form. It is in an insoluble form as a shell or a rock made of many shells. So fertilizer companies cause a reaction between sulfuric acid and these fossilized sea creatures to make it soluble so that plants can make use of it. (Organic production uses the same mined fossilized sea creatures, but grinds them up and applies them in their insoluble form. Microorganisms and the acidity of the soil will eventually break it down into a more soluble form, but the process takes place slowly.) What

Plants obtain carbon dioxide from the air through stomata on the plant's leaves.

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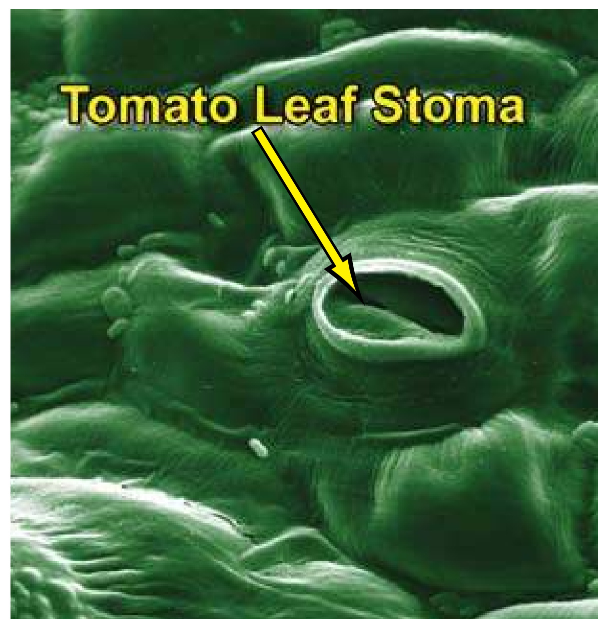
happens to the sulfuric acid? It reacts with the phosphate, and disappears with no toxic emissions. Phosphorous is a major component of plant genetics, so it is important for flower, seed, and fruit development. A phosphorous deficiency can result in stunted plant growth and seed sterility. Phosphorous aids in plant maturity, increases seed yield, improves fruit development, and increases the vitamin content of fruit. The correct amount of phosphorous builds the plant's resistance to disease.

Potassium (Potash) is also an important mineral. It helps the plant prevent injury and fight stress and disease. Humans eat bananas for potassium. Potassium chloride is also mined from former sea deposits. But this time the deposit is a salt (KCL) that you may have seen as a salt substitute. One example is Nu-Salt®. KCL is both Nu-Salt® and potassium fertilizer. The federal Food & Drug Administration-approved human version has been enhanced to improve the flavor and Nu-Salt® is used as a substitute for table salt (NaCl – sodium chloride). Potassium, a perfectly harmless ingredient, also comes from nature as an inert and edible salt. It has not been changed very much from the point of mining it from 3,000 feet below the surface of the earth. It is ground up, washed and resized into granules for farmers to spread on their fields. Potash (potassium carbonate) is not "manufactured."



In addition to carbon, hydrogen, oxygen, and the three macronutrients above, crops need 11 other elements to grow properly. Three of these nutrients are considered secondary nutrients: sulfur, calcium, and magnesium. Other nutrients, needed in very small amounts, are known as micronutrients. Micronutrients that plants very often require are the same micronutrients found listed on the label of a bottle of supplemental vitamins and minerals (in the mineral portion) intended for human consumption. Important micronutrients are iron, copper, nickel, manganese, selenium, calcium, zinc, chromium, chlorine, molybdenum, and boron. The amount of these micronutrients varies from crop to crop, as does the amount of any specific macronutrient.

As farmers raise crops and remove them from the field at harvest, these macro and micronutrients are removed, as well. In order to grow healthy crops (healthy foods) every year, the nutrients need to be replenished in the soil. Farmers and gardeners do this by fertilizing their crops with both macro- and micronutrients. Gardeners do this, as well. Whether conventional or organic production, these nutrients must be replenished. Both conventional and organic producers make use of animal manures for some of these nutrients. Conventional

producers use commercial fertilizers, while organic producers use compost and fertilizers approved as organic. Many of these products come from the same sources. How do gardeners and farmers know how much fertilizer is needed? They test the soil. Many large farms also use Global Positioning Systems (GPS) to make maps of their fields as they harvest the crop. Based on the yield at harvest, a computer calculates the specific amount and type of fertilizer needed for the next crop. Farmers work diligently to apply the correct amount of fertilizer to produce the healthiest crop. Over-fertilizing would waste money and under-fertilizing would reduce yields. It is a fine balancing-act.

There are many nutrients that plants need to make the foods that all animals require. The nutrients needed in greatest quantity are known as macronutrients. Those needed in very small amounts are micronutrients, or even trace elements.

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Groundwork

Objective: Review the process of photosynthesis, producers, and consumers. Describe the difference between human nutrition and plant nutrients.

1. Review the content of a photosynthesis lesson ("Gifts from the Sun" from *Project Food, Land & People* is recommended) and ask students where the carbon, hydrogen, and oxygen come from and how the plant obtains these elements. (Carbon dioxide and oxygen from the air — through stomata on the plant's leaves; Hydrogen from water molecules that the plant absorbs through its roots and transports to the leaves.)
2. Explain that this is a simple version of what happens inside a plant to produce food, and that the end result of that activity was that the plant produced a simple sugar. Ask, "Do plants only produce sugar?" (No.) "What else do plants produce?" (Plants make complex carbohydrates such as starch, cellulose and lignin — such as the starch found in vegetables and the strong cells that make up tree trunks. Plants also make proteins – such as the protein found in soybeans and peanuts. And plants make oils as well – such as the oil pressed out of corn kernels, safflower, sunflower seeds, and canola, as found in vegetable oils.)
3. Explain that these are the macronutrients of human nutrition. We need them in large quantities. Plants also make micronutrients that we need in very small quantities – vitamins and phytonutrients (beneficial compounds found in plants). Plants also absorb and use minerals that we need in small quantities, such as iron or boron.
4. In this lesson, we are going to explore the nutrients that plants need to produce common crops and how those nutrients are translated into foods that provide you with the nutrition you need to be healthy and to grow.
5. Provide students with copies of the Foods and Nutrition handout. Have them complete the portion of the page that indicates their favorite foods and research the major components of those foods. This may include reading package ingredient labels, nutrition labels, or searching for the information on the manufacturer's website.
6. Have students complete the nutrient components of that food, as well. That information may also be on the nutrient label, or the student can search the nutrient database at the United States Department of Agriculture at: *http://www.nal.usda.gov/fnic/foodcomp/search/*.

Exploration – Nutrients Versus Nutrition

Objectives: Identify producers and consumers. Obtain nutritional information by reading nutritional labels and from other scientific sources. Explain the difference between human nutrition and plant nutrients.

1. Ask the students, "How do you obtain the nutrients you need?" (By eating foods and drinking liquids.) "Where do plants get the nutrients they need?" (Answers will vary, but most students will probably not know beyond what they have learned in the photosynthesis lesson.)
2. Ask: "Have you heard the term 'plant food'? Do plants eat food (carbohydrates, protein, fats or vitamins)?" (Answers will vary. If the students insist that plants eat, continue with these questions; if not skip to #3.) "Do plants have mouths and teeth to eat? Stomachs and intestines to digest?" (No, plants do not eat. Carnivorous plants [the exception] kill and absorb insects because they live in an area where the soils are nitrogen poor. However, it would probably be confusing to discuss this unless students bring this up.) It is important for students to understand that plants do not eat in the manner that animals do.
3. Explain that the term "plant food" actually refers to fertilizer. Just as animals speak in cartoons, we know that they do not in real life. It is the same with the term plant food. Plants do need nutrients, but they make their own food, they don't eat it. Ask the students to define fertilizer. (Their answers may or may not be correct.)
4. Ask, "Can you absorb water, minerals, carbon dioxide, nitrogen, phosphorous, and potassium and produce your own food?" (No.) Explain that plants *produce* food, and you *consume* food. Plants are producers and animals are consumers.

Exploration – Plant Nutrients - Nitrogen, Phosphorous, Potassium

Objectives: Describe the difference between soluble and insoluble. List the three macronutrients that plants need and describe their sources.

1. On your student handout, find a food that has wheat as the first ingredient listed. Note that this food contains protein as a nutrient. Explain that a key component of protein is nitrogen. Nitrogen makes up 16 percent of the protein in our bodies. In order for wheat to make protein, the plant has to take in nitrogen.
   a. Ask, "Where does the nitrogen come from?"
   b. Explain that the air is 78 percent nitrogen but most plants such as wheat cannot use the nitrogen in air. It is in a form that the plant cannot use. It has to be converted into either nitrate or ammonium that the plant can take in and use to make protein. This is naturally done by bacteria in aquatic environments, plants that are called legumes (beans, peas, alfalfa, clover, trefoil, etc.) or by lightening. Legumes are special plants which have nodules on their roots that contain bacteria that fix the nitrogen in the air into a form that the plants need. These plants use that nitrogen for their own use. When these plants die and decompose, the nitrogen they contain slowly becomes available to other plants in the soil. Or, if animals such as cattle eat these plants, much of that protein is converted into meat or milk, but some is excreted in manure and urine. That manure can be used later to fertilize crops. People have discovered another way to obtain the nitrogen that plants need. Using methane and nitrogen in the air, humans produce a commercial fertilizer called nitrogen fertilizer. This discovery has allowed us to grow more productive crops and feed more people.
   c. Explain that nitrogen is a renewable resource.
2. Instruct students to look again at wheat on their charts. Ask, "Does wheat also contain phosphorous and potassium? (Yes, although many wheat foods may not list phosphorous as an ingredient. If that is the case, have the students identify another food that contains phosphorous.) Where do these nutrients come from?"
3. Explain that both phosphorous and potassium are mined and originally come from ancient seas. Phosphorous is mined as phosphate from deposits of fossilized sea creatures. Phosphorous is mined in Florida. (See "Phosphate: The Nutrient from Florida" lesson in *Keeping Florida Green.*) Both phosphorous and potassium are non-renewable resources as currently used but can be recycled by composting.

Every bag of fertilizer has a ratio listed in numbers to represent the percentages of compounds representing N-P-K (Nitrogen, Phosphorous and Potassium).

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4. Hold up the image of a clam shell, or real seashells and egg shells. Ask, "Could you eat this?" Explain that plants cannot use minerals in this form, either. It is in an insoluble form of calcium and phosphorous.
   a. In one glass of water, add sugar or sugar cubes, and in a second, add table salt, and stir both to demonstrate that sugar and salt are soluble in water.
   b. In a third, fourth, and fifth glass, add a seashell or seashells, egg shells and a piece of chalk, and stir to demonstrate that each is insoluble. The chalk may melt, but should not dissolve. It should form a layer on the bottom of the glass.
5. Explain that there are two ways to make the phosphorous available to plants. Fertilizer companies apply sulfuric acid to these fossils. That causes a chemical reaction that makes the phosphorous soluble for plants to use. What happens to the sulfuric acid? It completely reacts with the phosphate and disappears with no toxic emissions. Explain that sulfuric acid is a very strong acid and that for this demonstration you will be using a weak acid – vinegar or citrus juice.
   a. In the sixth and seventh glass, add chalk and eggshell to vinegar or citrus juice. Both can be used to demonstrate the different levels of solubility. Stir and wait. Explain that because this is a weak acid (test it with pH paper to demonstrate) it will take time, so return to the glass and stir occasionally over time. Also explain that vinegar is made largely of water.
   b. A seashell can also be used, but the demonstration will be very slow, and the weak acid will need to be replenished as it reacts with the shell.
6. Explain that organic production methods use the same mined fossilized sea creatures, but they grind them up and apply them in their insoluble form. Microorganisms and the acidity of the soil will eventually break the phosphorous down into a more soluble form, but it takes place slowly, even more slowly than the demonstration, because the acids in the soil are weaker. Also, most plants do not like an acid soil, and gardeners and farmers try to keep the soil pH at a neutral level, so this works against the mined material becoming soluble.
7. Explain that phosphorous is a mineral plants need to utilize energy. Phosphorous is a major component of plant genetics, so it is important for flower, seed, and fruit development. A phosphorous deficiency can result in stunted plant growth and seed sterility.
8. Potassium is also known as potash. Potassium chloride is salt also mined from former sea deposits. But this time the mineral deposit is salt (KCL), not fossils.
   a. You may have seen KCL as a salt substitute. One example is Nu-Salt®. KCL is both Nu-Salt® and potassium fertilizer, but the human version has been enhanced to improve the flavor. Nu-Salt® is FDA-approved as a salt substitute for table salt. This harmless ingredient also comes from nature as an inert and edible salt. It does not change very much from the point of mining it from 3,000 feet below the surface of the Earth.
   b. KCL is ground up, washed and resized into granules that farmers spread on their fields. Potash is not "manufactured."
   c. In the last glass, place NuSalt® in water and stir to demonstrate solubility. Explain that because it is a salt, it is soluble in water.
9. These three nutrients are known as macronutrients and are listed as N-P-K. Every bag of fertilizer has a ratio listed in numbers to represent the percentages of compounds representing N-P-K.

Enrichment – Plant Needs Vary

Objectives: Compare the fertilizer needs of different crops metaphorically.

1. Explain that this next activity is intended to make the point that each crop has different nutrient needs.

2. Distribute copies of the bracelet pages, or use beads and string with alphabet letters and three colors of beads. Label one color -N-, another -P-, and a third color -K-. To further link the concepts with the colors for students, the recommended colors are green to represent leaves, purple for phosphorous to represent flowers and seeds, and white for potassium to represent salt. Write the color and nutrients in an obvious place.
3. Ask the class to choose a fruit or vegetable from their favorites list. Share that you are going to build a bracelet of the nutrients this crop requires to grow the fruits and vegetables needed to produce your favorite fruit or vegetable dish.
4. Share that you have tested your soil and found that the soil is completely depleted of N-P-K. Reproduce this chart in a visible place, and share that the students will create bracelets that represent the needs of a crop used to produce their favorite food. Make sure that they understand that this is just a representation, and actual plant nutrient needs differ.

Crop	Nitrogen (N)	Phosphorous (P)	Potassium (K)
Fruits	6	3	9
Leafy Vegetables	12	3	3
Root Vegetables	9	6	4
Flower Vegetables	6	4	8

5. Decide if you will use either the paper bracelet or the bead and string bracelet. Use the appropriate directions.

Paper Bracelet

a. Write the letters of the crop in the first group of circles.
b. Share the fertilizer ratio from the chart above for the crop selected.
c. Have the students color in the appropriate circles in the order N-P-K to symbolize the crop.

Bead Bracelet

a. Select and string the letter beads to spell the crop name.
b. Share the fertilizer ratio from the chart above for the crop selected.
c. Have the students string the appropriate color beads in the order N-P-K.

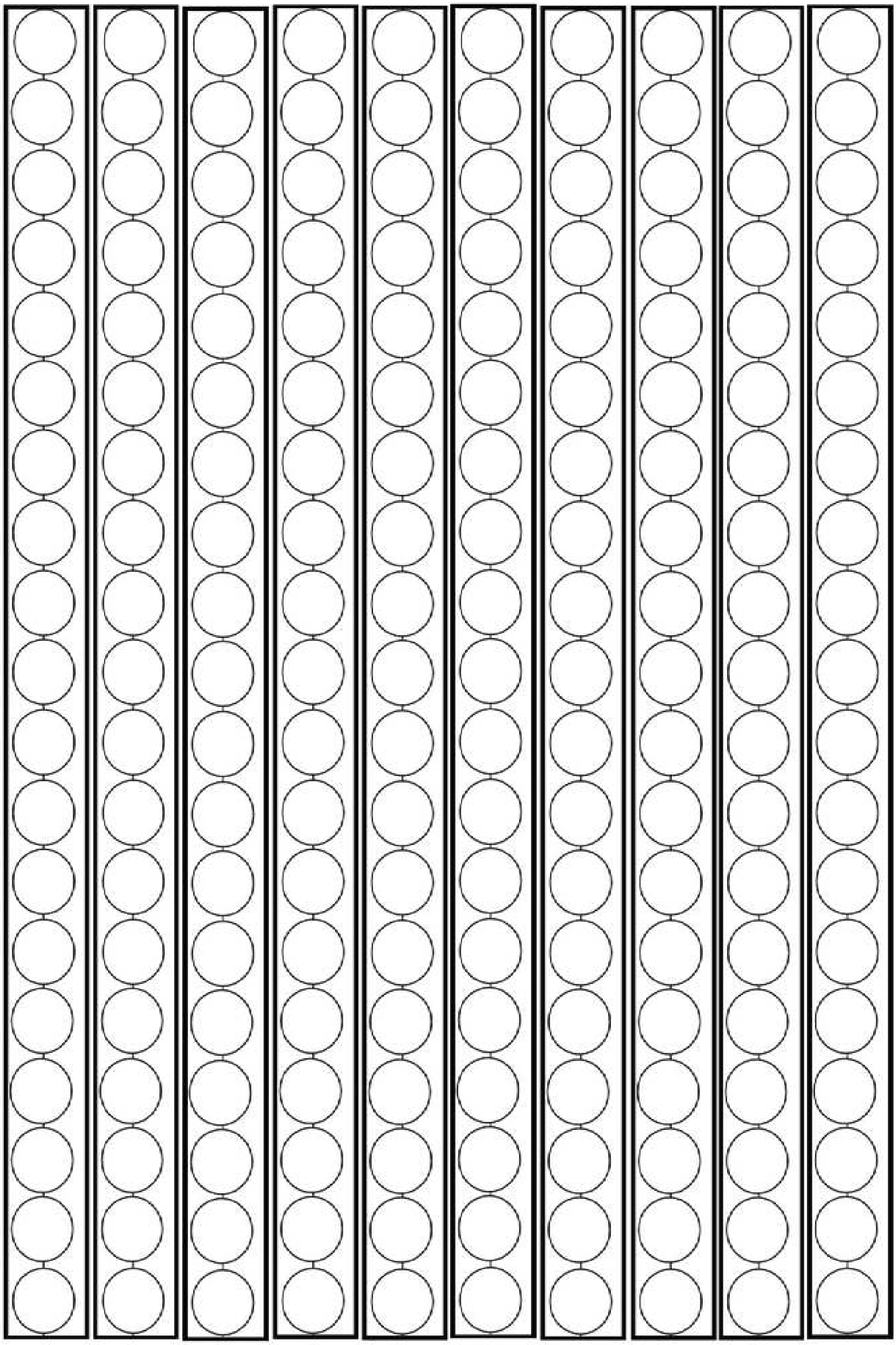
Extensions for Middle and High School

1. Obtain several fertilizers with different ratios of N-P-K and set up experiments demonstrating the impact of different fertilizers on plants. Have the students hypothesize the impact, based on information in this lesson.
2. Obtain a soil test kit (available in most garden shops or nurseries that tests N-P-K). Explain that farmers test their soil before they plant or fertilize so that they do not over-fertilize or under-fertilize. Test the soil around the school or soil that you or the students bring from home. Soil pH can also be tested.

Additional Materials:

1. The *Keeping Florida Green* curriculum developed by Florida Agriculture in the Classroom, has lessons about the classification of Florida's plants that can be used in concert with the garden. It can be obtained by attending a workshop. The lesson "Phosphate: The Nutrient from Florida" should be used in conjunction with this lesson.
2. *Project Food, Land & People's Resources for Learning* can be obtained by attending a workshop.

Nutrient Bracelet Template



Foods and Nutrition Handout

Name ________________________________

List your favorite food or foods in each of the categories below. Using the nutritional label on the package, identify the main ingredients of the processed foods and nutrients. Enter each into the chart. (Note: Ingredients are listed in order of greatest to least; nutrients are not.)

Food	Favorite	First Ingredient	Second Ingredient	Third Ingredient	Protein	Carbohydrate	Phosphorous	Potassium
Cereal								
Cereal								
Cracker								
Fruit		XXX	XXX	XXX				
Green Vegetable		XXX	XXX	XXX				
Starchy Vegetable		XXX	XXX	XXX				
Beverage								
Bread								
Meat								
Snack Food								

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Sample Pre-Post Assessment

1. As plants undergo photosynthesis, they need nutrients in addition to carbon, hydrogen, and oxygen. Why?

2. What does N – P – K stand for?
   a. Nurturing – Parenting – Knowing
   b. Nitrogen – Potassium – Kryptonite
   c. Nitrogen – Phosphorous – Potassium
   d. Nitrogen – Potassium – Phosphorous

3. N – P – K will be listed on a fertilizer bag as a group of numbers. What do these numbers represent?

4. Why do farmers and gardeners need to fertilize their soil?

5. All grains, fruits and vegetables have the same nutrient needs. True False