Feed Me: Nutritional Building Blocks

Science, Health and Language Arts

Brief Description:

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 to obtain nutrients as animals do. 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.

Objectives: By the end of this unit the students will be able to:

1. List the three macronutrients that plants need and describe their sources;
2. Explain the difference between human nutrition and plant nutrients;
3. Describe the difference between soluble and insoluble;
4. Identify producers and consumers;
5. Obtain nutritional information by reading nutritional labels and from other scientific sources; and
6. Compare the fertilizer needs of different crops metaphorically.

Materials:

Materials Needed 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

Materials Needed for Class Demonstration:

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

Life Skills:

1. Understands Nutrition
2. Understands Systems

Preparation:

- Prior to conducting this lesson complete the "Gifts From the Sun" lesson from Project Food, Land & People or another lesson on photosynthesis. Also complete the soils lessons found in Project Food, Land & People (Perc Through the Pores, From Apple Cores to Healthy Soil, Soil's Not Trivial, In Harmony).
- Make copies of the student pages
  Favorite Foods
  Quiz
- Obtain the beads and string or make copies of the paper bead bracelets.
- Read the background information and decide how much of it to share with the students.

Time:

<u>Introduction:</u>

20 Minutes

<u>Activity One:</u>

80 Minutes

<u>Activity Two:</u>

45 minutes plus time for observation

<u>Activity Three:</u>

45 Minutes

Vocabulary:

- Insoluble
- Nitrogen
- pH
- Phosphorus
- Potassium
- Soluble

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 d 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. The three macronutrients that are required for plant growth and reproduction are nitrogen, phosphorus 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% of the protein in our bodies. 78% 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 (NH_4^+) or nitrate (NO_3^-). Crops like soybeans, peas, green beans, or alfalfa are legumes that can take atmospheric nitrogen and convert it into a usable form for other plants. Legumes have a symbiotic relationship with nitrogen-fixing bacteria that are found in nodules on the plant's roots. These bacteria take the nitrogen and oxygen from the air and fix it into a form that plants can use (nitrate) NO_3. When animals consume plant or animal proteins, part of their digestive and cell building process is to excrete ammonium in their urine and feces. Plants in return use the ammonium for their own growth and development. After the plants, animals and people make use of the nitrogen it is cycled back into the atmosphere, it completes the nitrogen cycle. Fertilizer companies take nitrogen from the air and using natural gas, make nitrogen fertilizer.

If nitrogen is deficient, plants will be yellow in color and stunted in their growth. Too much nitrogen will cause overabundant foliage with delayed flowering. The plant will then become subject to disease and the plant's fruit will be of poor quality.

7	14.0067
N	
Nitrogen	

15 30.974
P
PHOSPHORUS

Phosphorus (phosphate) is a mineral that plants need to utilize energy. Phosphorus is mined from deposits of fossilized sea creatures. [*Use image of clam shell]*. Could you eat this? Luckily, plants or animals can make this feasible for us. Phosphorous as a shell, is in an insoluble form. Fertilizer companies create a chemical reaction between the sulfuric acid and these fossilized sea creatures to make it soluble so that plants can make use of it. (Organic production used 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 it down into a more soluble form, but the process takes place slowly.) What happens to the sulfuric acid? It completely reacts with the phosphate and disappears with no toxic emissions. Phosphorus is a major component of plant genetics so it is important for flower, seed and fruit development. A phosphorus deficiency can result in stunted plant growth and seed sterility.

Phosphorus aids in plant maturity, increases seed yield, improves fruit development, and increases the vitamin content of fruit. The correct amount of phosphorus aids the plant's resistance to disease and prevents winter kill.

Potassium (Potash) is also an important mineral. It helps the plant prevent injury and fight stress and disease. Humans eat bananas to get potassium. Potassium chloride is another mineral mined from former sea deposits. This deposit is a salt (KCL) that you may have seen it as a salt substitute. One example is Nu-Salt. KCL is both Nu-Salt and potassium fertilizer. The FDA 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."

19
K
39.10

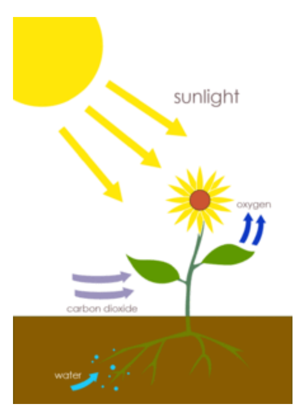
Potassium is needed for plant strength. Plants require it to form carbohydrates and conduct protein synthesis. A correct amount of potassium improves the color and flavor of fruit. Potassium is important for stem strength and cold hardiness. A deficiency results in stunted plants and poor root growth. Plants with a potash deficiency have low yields; spotted, curled leaves with dried out leaf edges. Potassium is important for early develop-

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. This balance of nutrients, needed in very small amounts, is called micronutrients. Micronutrients that plants very often require are the same micronutrients you will 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. 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 of money and under fertilizing would reduce yields. It is a fine balancing act.

<u>Introduction:</u>

1. Review the content of the photosynthesis lesson 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 grow.

Activity One – Human Nutrition

1. Ask the students, "How do you obtain the nutrients you need?" ***(By eating foods and drinking liquids.)***
2. Have the students complete the column on first student handout, ***Favorite Foods***, that identifies their favorite foods in each category.
3. As a homework assignment, have the students complete the first three ingredients and nutritional components for as many of their favorite foods by reading the nutrition label on the food's packaging. They may document either the weight of the ingredient or nutrient or the percent of the Daily Value. (Both are preferable and you could offer extra credit for documenting both.) Have them complete the activity by using the nutrient content handouts or researching the information on the Internet. An easy to use site is www.nutritiondata.com or for older students the USDA's nutrient database is very complete.
4. Use the Florida Ag in the Classroom newspaper "Growing up Healthy with Food from Florida" and complete the activities concurrently as appropriate.

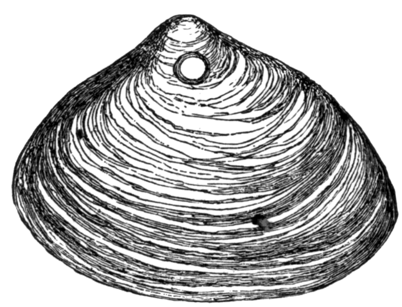
Activity Two - Plant Nutrients: Nitrogen

1. Where do the 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, phosphorus and potassium and produce your own food?" ***(No.)*** Explain that plants produce food and you consume food. Plants are producers and animals are consumers.

5. 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% 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% 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 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. 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 later be used to fertilize crops. People have discovered another way to obtain the nitrogen that plants need by using methane and the nitrogen in air to 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.

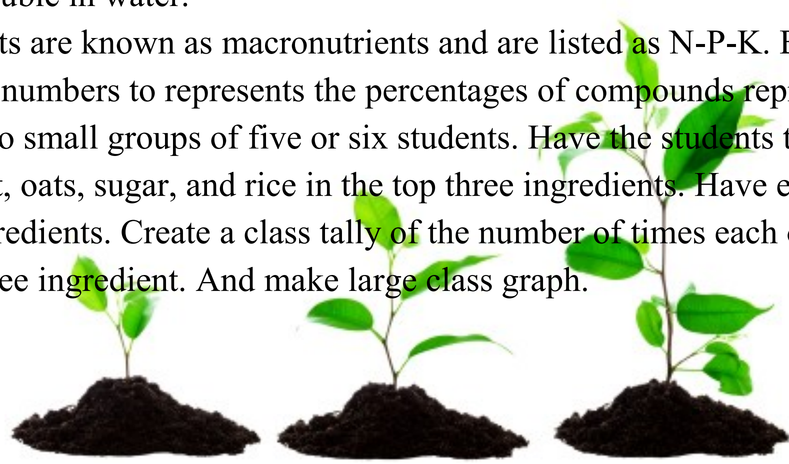
<u>Activity Three - Plant Nutrients: Phosphorus and Potassium</u>

1. Instruct the students to look again at wheat on their charts. Ask, "Does wheat also contain phosphorus and potassium? Where do these nutrients come from?" ***(Yes although many wheat foods may not list phosphorus as an ingredient. If that is the case have the student identify another food that contains phosphorus.)***
2. Explain that both phosphorus and potassium are mined and originally come from ancient seas. Phosphorus is mined as phosphate from deposits of fossilized sea creatures. Phosphorus is mined in Florida. Both phosphorus and potassium are non-renewable resources as currently used but can be recycled by composting.



3. Hold up the image of 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 phosphorus.
   a. In one glasses 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 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.

4. Explain that there are two ways to make the phosphorus available to plants. Fertilizer companies apply sulfuric acid to these fossils. That causes a chemical reaction that makes the phosphorus 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.
5. 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 phosphorus 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.
6. Explain that phosphorus is a mineral that plants need to utilize energy. Phosphorus is a major component of plant genetics so it is important for flower, seed and fruit development. A phosphorus deficiency can result in stunted plant growth and seed sterility.
7. 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.
8. 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 represents the percentages of compounds representing N-P-K.
9. Divide the class into small groups of five or six students. Have the students tally the foods that contain corn, wheat, oats, sugar, and rice in the top three ingredients. Have each group create graphs of these ingredients. Create a class tally of the number of times each of these ingredients appears as a top three ingredient. And make large class graph.



Activity Four– Grain Crops

1. 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 phosphorus to represent flowers and seeds, and white for potassium to represent salt. Write the color and nutrient in an obvious place.
2. Ask the class to choose one of the ingredients to produce cereal (corn, oats, wheat, or rice). Share that you are going to build a bracelet of the nutrients this crop requires to grow the grain needed to produce your cereal.
3. Share that you have tested your soil and found that the soil is completely depleted of N-P-K.

Crop	Nitrogen (N)	Phosphorus (P)	Potassium (K)
Corn	10	4	5
Oats	8	5	6
Wheat	6	5	8
Rice	6	8	5

4. Paper Bracelet:
    a. Write the letters of the crop on 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.
5. Have the students select another crop and complete a second bracelet – either paper or bead.

Activity Five – Fruits and Vegetables

1. Have the student tally the favorite vegetables and fruits and make a large classroom graph for each category.
2. Share that you have tested new fields and that this soil is only low on these three nutrients N-P-K.
3. Repeat the bracelet making process with fruits and vegetables using these ratios. If the fruit or vegetable's name is long it may be necessary to write it below the circles or use two bracelet templates. Begin with the class favorite and then have the students create their own favorite.

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

Review and Evaluation

1. Quiz the students as to the ratio in the amount of N-P-K in each crop.
2. Use the student quiz provided.

Extensions and Variations

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 available in the soil. 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 that you or the students being from home. Soil pH can also be tested.