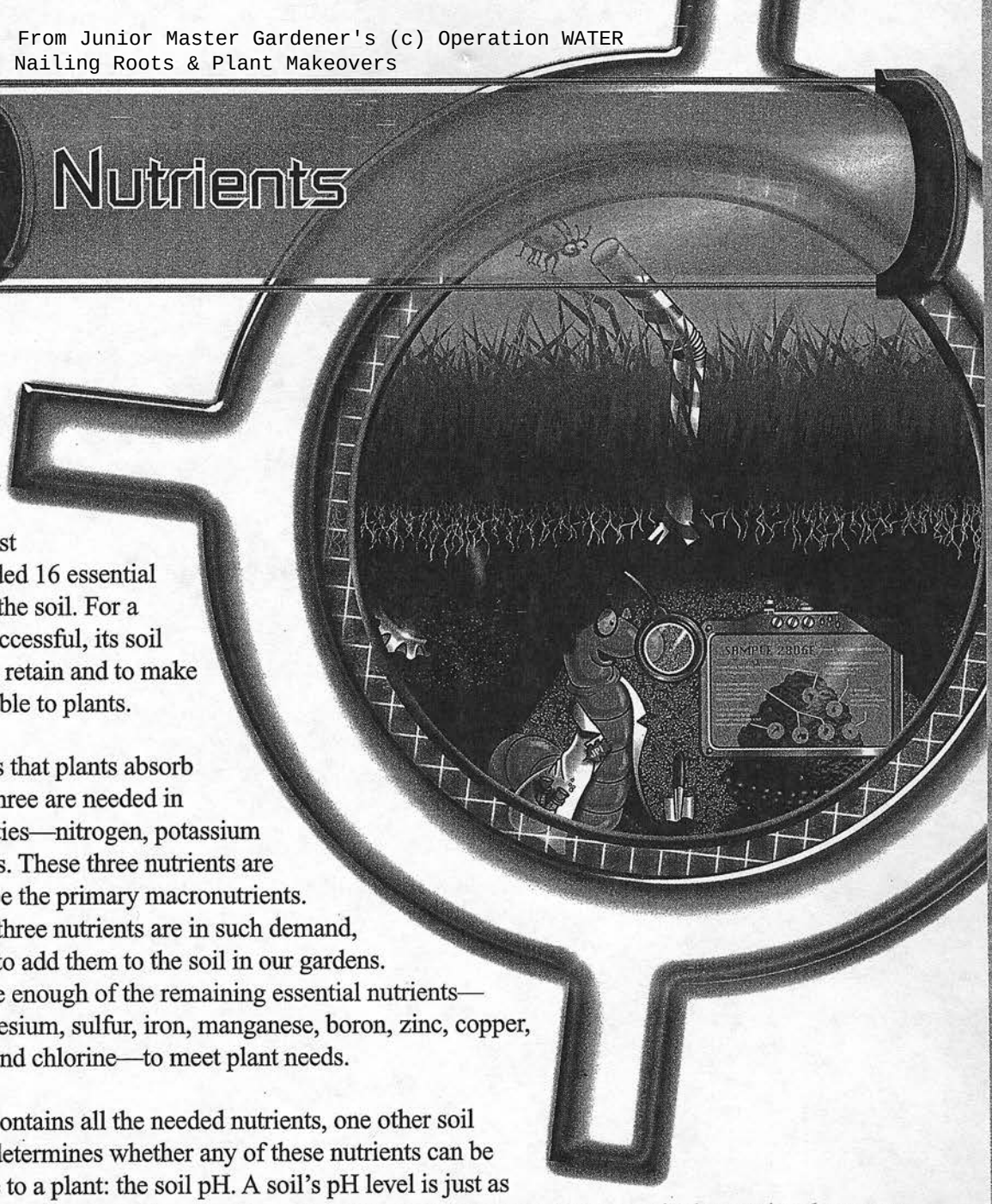
Nutrients



Except for oxygen, carbon and hydrogen, plants get almost all of their needed 16 essential elements from the soil. For a garden to be successful, its soil must be able to retain and to make nutrients available to plants.

Of the nutrients that plants absorb from the soil, three are needed in greatest quantities—nitrogen, potassium and phosphorus. These three nutrients are considered to be the primary macronutrients. Because these three nutrients are in such demand, we often need to add them to the soil in our gardens. Most soils have enough of the remaining essential nutrients—calcium, magnesium, sulfur, iron, manganese, boron, zinc, copper, molybdenum and chlorine—to meet plant needs.

Even if a soil contains all the needed nutrients, one other soil characteristic determines whether any of these nutrients can be made available to a plant: the soil pH. A soil's pH level is just as important as the nutrients in the soil. If a soil's pH is too high or too low, a particular nutrient becomes insoluble, preventing it from being dissolved in water and absorbed by a plant's roots.

All of these 16 essential elements are constantly being used through nutrient cycling. They have been used again and again since time began. Because of this, natural landscapes throughout the world have supported a diversity of plant life that has flourished without any help from people.

In this section, the students will learn about these nutrients and how plants absorb them. Three group activities will help illuminate these concepts: the students will collect and measure composite soil samples, take an expedition to observe the nutrient cycle in action, and work together to diagnose and "heal" sickly plants suffering from nutrient deficiencies.

In addition to the group work are activities the youths may complete independently. A student may complete an activity on the student page or one in the *Nutrients* option at www.jmgkids.us/thistle. As you distribute the student pages, read the narrative (page 32) to the group.

4. Nailing Roots

Objective: Understand that soil pH affects a plant's ability to absorb nutrients; measure soil pH and amend the soil as needed

Time: Session 1: 25 minutes; Session 2: 40 minutes; Session 3: variable

Materials: Hammer, nail, bottle of multivitamins, several shovels and trowels that can be shared among student groups, bucket, pH test kit; for each student: a copy of the pH Nutrient Availability Chart

Note: *Before the lesson, you will need to obtain a soil pH test kit. Garden centers sell basic, easy-to-use kits to test soil pH for $4 to $8 each. Instructions on collecting a soil sample for the test are detailed in this lesson.*

Although it may be a bit more expensive, you can have the soil analyzed by your state's soil-testing service. To obtain a soil sample bag and submittal form, contact your local county Extension office. The listing for the Extension office is in the white pages of the phone book under "county government."

The results from a soil-testing laboratory are generally more accurate than those from consumer test kits. The lab will send you a report that includes a measurement of soil pH and key nutrients. The cost for this service may range from $10 to $20 per sample.

Session 1

Escort the students to your garden area. Also take a hammer, nail and a bottle of multivitamins. Tell them that nutritionists and doctors say it is important for people to eat a variety of fruits and vegetables. Ask the students why variety is so important to nutrition.

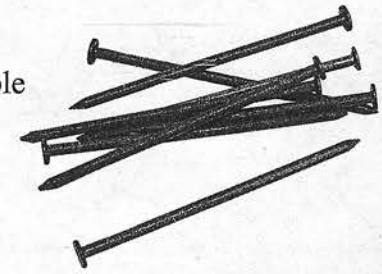
Help them understand that we need to consume different foods because in order to live and grow, our bodies require a variety of nutrients found in these foods. Different nutrients each serve specific functions in our bodies, such as maintaining a steady heart rhythm (manganese) or helping wounds heal (zinc). Without all of these nutrients, our bodies cannot function normally.

Show the bottle of vitamins to the group and read aloud the nutrients listed on the label. Point out one specific nutrient—calcium. Ask the students: **What is a food source for calcium?** Most of the group will likely recommend milk as an excellent source of calcium.

Ask: **Where do cows get the calcium for their milk?** *A cow's body does not produce calcium, but rather it converts the calcium found in its food source—plants.*

Explain that plants take in calcium when it is dissolved in water and absorbed through the roots. Plants use this *soluble* (dissolved in water) calcium to form cell walls. Once the calcium enters the tissues of the plant material, it can then be absorbed by animals and, in effect, be recycled to help the animals' bones grow strong and healthy.

Point to another vitamin on the label—iron. Explain that iron is a required nutrient for plants and animals. When iron occurs in its soluble form in the soil, plants absorb it and use it to make chlorophyll.



Thanks to plants, our bodies can absorb iron from the foods we eat. Our bodies need iron to transport oxygen between our cells.

Hold up the hammer and nail. Tell the group that the nail contains iron. Explain that you will place it into the roots to provide the nutrient for the tree. Begin driving the nail into the soil at the base of the tree just below the surface. Ask which students think the tree can get iron from that nail.

Ask the students if they have ever tried to grow any type of plant. Were they successful? Tell them that many people cannot grow plants but don't know why. These two facts can help explain:

1. **All living organisms need nutrients, but they must have them in a form that their systems can absorb.**

   Just as we couldn't absorb iron from holding a nail in our mouths, a plant cannot absorb the insoluble form of iron in the nail. Plants must have access to nutrients that are available in a soluble form.

2. **Whether a nutrient is in a soluble form in the soil depends on the soil's pH.**

   The pH level of the soil tells us how acidic or basic the soil is. Most soils have a pH between 5 and 9. Tell the students that the soil in their garden has a pH measurement in that range now.

   The reason pH is so important is that at certain pH levels, even soluble nutrients can quickly become insoluble, which makes them unavailable to plants. If the pH of a soil is too high or too low, plants can't get the nutrients they need.

Ask the students how to determine the soil pH. If the pH is too high or low, how they can fix it? These concepts will be covered in the next session.

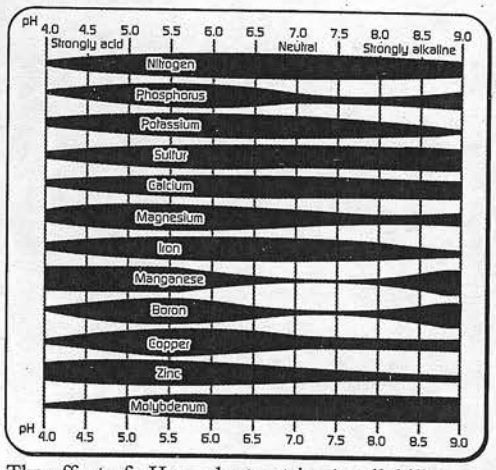
Session 2

Return to the classroom and ask a student to make a rough sketch of the garden area to be tested. The student should draw the outline of the garden from a bird's-eye perspective on a chalkboard or poster.

Give a copy of the pH Nutrient Availability Chart to each student. Ask the class to examine and then discuss the information in the chart. Explain that the nutrients listed are the essential elements for the plants. Along the top of the chart is a scale of possible pH readings of the students' garden soil.

Remind the students that the soil might contain nutrients that are soluble—and able to be absorbed by plants—only at certain pH levels. The bars along each nutrient listed show the pH levels at which the nutrient becomes soluble. The wider the bar, the greater the nutrient availability at that pH level.

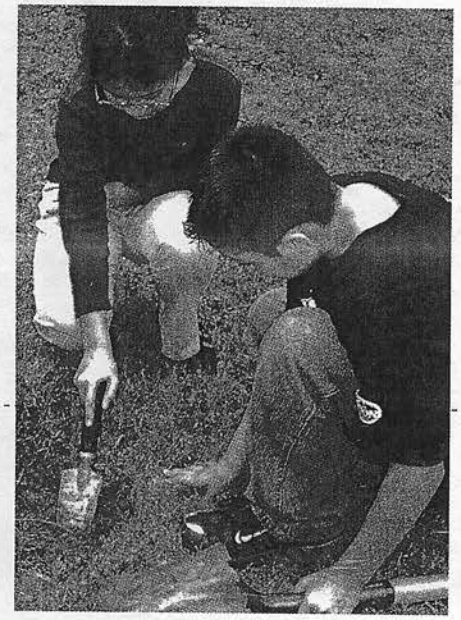
Ask the students to examine the chart. Point out that there is a wide range of soil pH levels at which elements are available for use by plants. Have the students draw a box on the chart to outline a range of 5.5 to 6.5. Explain that when the soil pH is within this optimum range, all of these essential elements can be readily absorbed by plants.



The effect of pH on plant nutrient availability. Although nutrients are available at lower pH levels as the chart indicates, when the soil pH falls below 5.5, other variables related to soil chemistry impede most plants' ability to absorb some nutrients.

Refer to the garden sketch created earlier. Explain that the way to accurately measure the soil pH of their garden is to take several soil samples, mix them to create a *composite sample,* and test the pH of that composite. Have the students help mark Xs on 10 to 12 spots on the garden map where your group could take samples.

Divide the students into groups corresponding with the number of Xs on the garden map and return outdoors, taking shovels, trowels and a bucket with you. Explain the steps of the correct method to collect a soil sample, and have the students help demonstrate the steps.



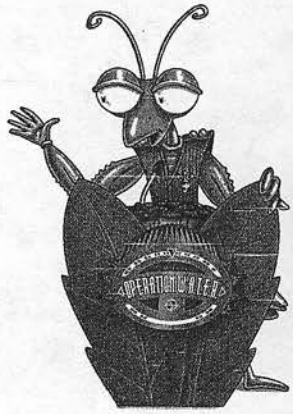
Taking a soil sample

1. Select 10 to 12 spots throughout the garden from which to collect small samples.
2. Using a shovel, scrape away the surface layer of grass or leaf litter.
3. Collect one trowel full of soil (about ½ cup) at each site from the 0 to 6 inches deep level.
4. Mix all the samples in a bucket to create a composite sample.

After taking the sample, allow the soil to dry completely before testing it.

Next assign each group a location in the garden from which to collect soil.

Session 3: Nails in the Garden?



Have the students guess what their soil pH will be. Follow the instructions on the label of your test kit to demonstrate how to test a soil sample. Soil test kits vary in how they measure pH.

With the pH measurement, ask the students to use a highlighter to mark the pH reading and nutrient availability in their garden. Use the following questions to guide them in planning to use the information:

Is the pH in a range that will allow needed nutrients to be available for their plants? *Different plants thrive at different pH levels. In typical garden areas, most vegetables, herbs, fruit and ornamental plants do well if the soil pH falls in a range of 5.5 to 6.5.*

Some plants require a lower (acidic) pH; others grow best at much higher (alkaline) pH levels. The ideal pH conditions for a wide range of plants are available at resource links through www.jmgkids.us/thistle.

Examples of specific crops that grow best in very acidic soils are listed below.

Plants needing lower pH/acidic soils

Vegetables	Fruit	Ornamentals
Radishes (4.5-5.5)	Blueberries (4.0-5.0)	Azaleas (4.5-5.5)
Sweet potatoes (4.5-5.5)	Cranberries (4.2-5.0)	
Potatoes (4.8-5.5)	Raspberries (4.5-5.5)	

What if the soil pH is too low? How can it be raised? *To help raise soil pH, add powdered limestone, or lime. Wood ash can also make the soil less acidic.*

The amount of material needed and how to apply it vary according the crops or plants to be grown and the garden's size, soil type and pH. For specific details for using these materials, consult a county Extension agent or nursery professional.

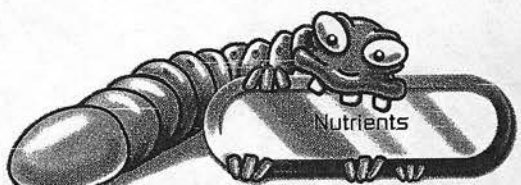
What if the pH of the soil is too high? How can it be made lower? *Sulfur can be added to the soil to lower pH. However, if the pH is very high, it may be difficult to lower it enough for many garden plants.*

Powdered and granular sulfur products are sold at local garden centers. A county Extension agent or nursery professional can provide specific instructions on using these materials.

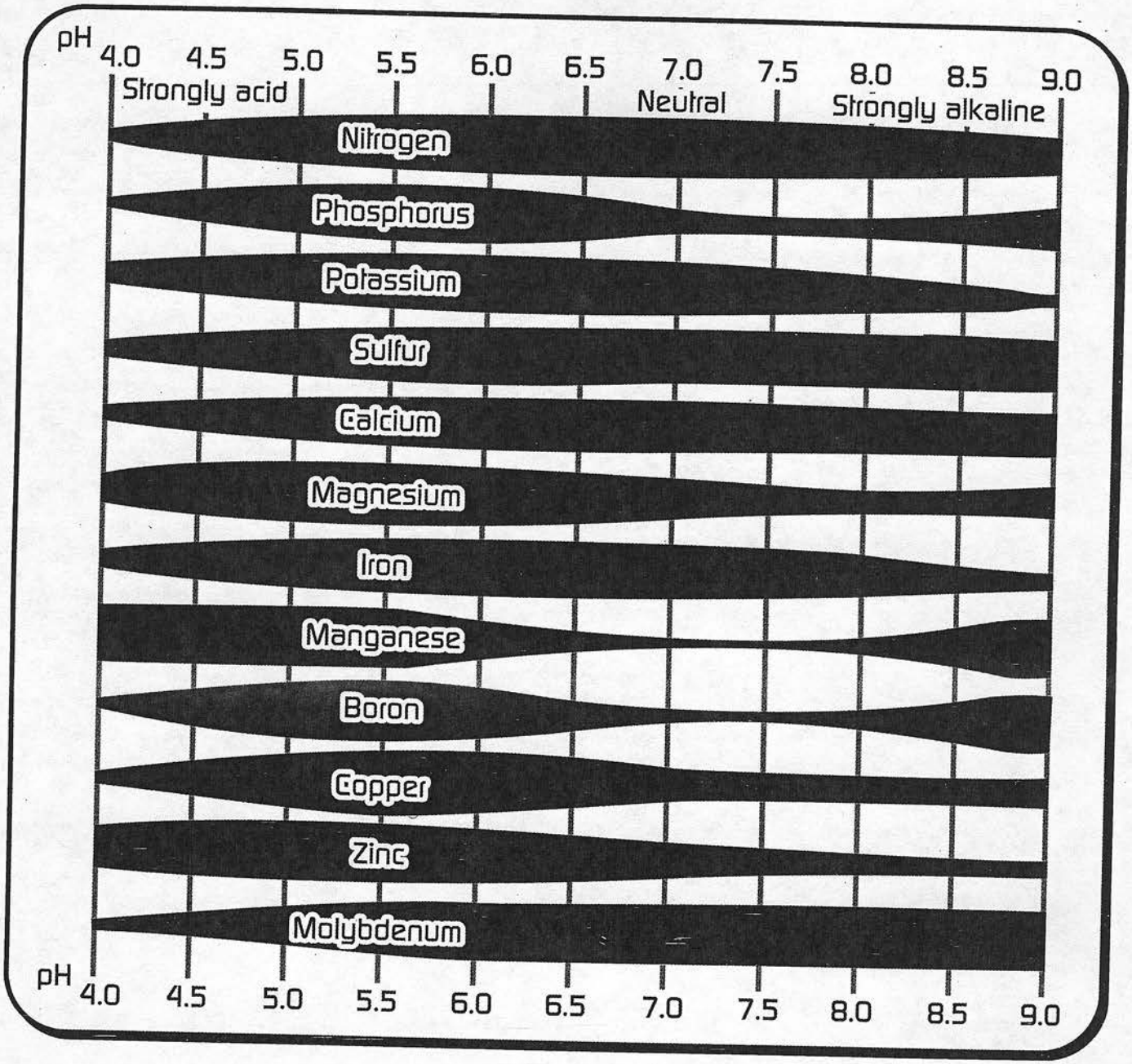
Close the discussion by reiterating that soil pH that is too high or too low can make soil nutrients insoluble, and roots cannot absorb insoluble nutrients. It helps to know the pH of the soil, especially if the plants are showing some type of nutrient deficiency. If the pH is too high or too low, adding more nutrients may be no more useful than sticking nails in the soil.

Extension

Science: Have the children experiment with soil pH by using hydrangea shrubs in containers. If the soil is acidic, the shrub will produce blue flowers; an alkaline soil will produce pink flowers. Adjust the soil pH by adding sulfur or lime to regular potting or garden soil.



pH Nutrient Availability Chart



6. Plant Makeovers

Objective: Demonstrate the symptoms of nutrient deficiencies in plants
Time: 45 minutes for construction of plants, 15 to 30 minutes for discussion
Materials: For each group of two to four students: Plant Makeover Card, construction paper, other miscellaneous craft supplies (tape, markers, scissors)

Ask the students if they have ever seen makeovers in magazines or on television in which a person is given a new haircut or new clothes, for example. Have them describe some of the dramatic changes shown in some of the "before" and "after" photos.

Tell the students that today they will be the ones doing the makeovers. The subject of the makeovers will be plants needing help. Explain that the class will "make over" sickly looking plants that have health problems, such as dead spots on the leaves and rotting of the ends of the fruit.

Clarify that a plant's health problems can be caused by many different factors, including insects, diseases and environmental conditions. But the plants in today's class are all lacking needed nutrients.

Divide the class into groups of two to four students each and give each group Plant Makeover Cards. Have the students read the cards to learn the symptoms that a plant would demonstrate if it lacked that specific soil nutrient. They could also use the resource links at www.jmgkids.us/thistle or other references to find examples of various symptoms.

The groups will use construction paper and other craft supplies to create two models of the plant displaying the symptoms on their cards. The models could be paper sculptures, or the group could dress up students as the healthy and unhealthy plants.

Stress that the students should illustrate the symptoms listed on their cards. The groups should first create a "before" model of an unhealthy plant, then create an "after" plant with no deficiency and its health restored.

As an option, the groups could also act as announcers in a fashion show, detailing what the plant lacked, explaining the functions that the needed element serves, and describing the physical symptoms of the deficiency.

Allow time for each group to present the "before" and "after" illustrations. Then guide the group in the following discussion:

What caused the health problems for the plants they worked with today? *The plants could not get the nutrients they needed.*

Why wouldn't a plant be able to get the nutrients it needs? *The nutrients may not be available in the soil. Or, the pH of the soil (how acidic or alkaline the soil is—see the* Nailing Roots *lesson) may be making the nutrients insoluble so they can't be absorbed by the roots.*

How can we find out what would be causing the problem? *The soil can be tested (see the* Nailing Roots *lesson) to determine the soil pH or the nutrients that are lacking.*

How can the problem be solved? *If the pH level is good, the missing nutrients may simply be added to the soil. If the pH is too high or too low, the soil can be amended to adjust the pH.*

The materials, the amount and the method of application will vary depending on the garden's size, location, soil type and the crops or plants to be grown. For specific details on using these materials, contact your county Extension office or nursery professional.

Explain that only 16 elements are essential for plant growth. Three of these—carbon, hydrogen and oxygen—are readily available in the air and water for plants to absorb. The remaining 13 elements are absorbed through the soil.

Ask the students who demonstrated deficiencies in nitrogen, phosphorus and potassium to stand. Point out that these nutrients are unique because they are required in the largest amounts by the plants. They are called the *primary macronutrients.*

Primary macronutrients can easily be added through fertilizer. Every container of fertilizer lists a ratio of numbers such as 25-10-15. These numbers provide the percentages of those macronutrients in the container.

Ask the students demonstrating primary macronutrients to sit down and the students representing plants lacking calcium, magnesium and sulfur to stand. These are the *secondary macronutrients.* Usually, soils have enough of these nutrients for plants to stay healthy.

The students demonstrating secondary macronutrients should sit down. Ask the rest of the class to call out the names of the remaining nutrients: boron, chlorine, copper, manganese, molybdenum, iron and zinc. These are *micronutrients* and are needed only in very small amounts.

Although plants require different amounts of these nutrients, these elements are all essential for the health of a plant.

Close the lesson by applauding the students' makeover efforts. Reiterate that a plant's health can be affected by a deficiency of a needed nutrient. Macronutrients and micronutrients play vital roles in the health of a plant. Gardeners will be more successful if they understand the soil from which the plants are absorbing those essential elements.

Extension

Science: Ask the students to find and discuss the macronutrients and micronutrients on the periodic table of the elements. What do these elements have in common? How are they different?

Plant Makeover Cards
Macronutrients / Micronutrients

Nitrogen (N)

Symptoms of deficiency:
- Reduced growth
- Yellowing of leaves
- Symptoms on oldest leaves first

N is important for foliage (leaf) growth in a plant.

Phosphorus (P)

Symptoms of deficiency:
- Reduced growth
- Thin stems
- Loss of lower leaves
- Reduced flowering

P is important for root growth, especially for young plants and seedlings.

Potassium (K)

Symptoms of deficiency:
- Reduced growth
- Burnt/brown leaf edges
- Dead spots on leaves
- Wilts easily

K is important for flower and fruit development and resistance to frost, drought and certain diseases in a plant.

Magnesium (Mg)

Symptoms of deficiency:
- Reduced growth
- Yellowing of leaf edges
- Reduced seed production
- Cupped leaves

Mg occurs in chlorophyll; therefore, it is important to photosynthesis.

Calcium (Ca)

Symptoms of deficiency:
- Lack of bud growth
- Dead root tips
- Cupping of older leaves
- Rot on ends of fruits
- Pits on root vegetables

Ca is required for plant growth, cell division and enlargement.

Sulfur (S)

Symptom of deficiency:
- General yellowing of leaves or entire plant

S is important in the formation of protein within a plant.

Iron (Fe)

Symptoms of deficiency:

- Yellowing of leaves in newest growth
- Leaves are yellow with dark green veins (called intervenal chlorosis).

Fe is used in the formation of chlorophyll.

Copper (Cu)

Symptoms of deficiency:

- Wilting even with sufficient moisture
- Small, misshapen, wilted new growth
- Leaves can become light green, with tips dying.

Cu contributes to photosynthesis, respiration and reproduction.

Zinc (Zn)

Symptoms of deficiency:

- Smaller leaves
- Puckered leaf edges
- Leaves are yellow with dark green veins (called intervenal chlorosis).
- Yellowing of newer, upper leaves and browning of lower, older leaves
- Some plants show white stripes along the center, or midrib, of leaves.

Zn is an essential component of many plant enzymes.

Manganese (Mn)

Symptoms of deficiency:

- Leaves are yellow with dark green veins (called intervenal chlorosis).
- This begins at edges of leaves and progresses inward.
- Yellowing between leaf veins is followed by brown spotting.

Mn is essential for chloroplast production.

Molybdenum (Mo)

Symptoms of deficiency:

- Whitish tan between leaf veins on older leaves (called intervenal chlorosis)
- Occurs first on older leaves
- Plant stunted

Mo aids in nitrogen absorption.

Boron (B)

Symptoms of deficiency:

- Cracked stems
- Newest buds of the plant die.
- Leaf tips are white and rolled.

B aids in sugar transport, cell division and production of amino acids.

Chlorine (Cl)

Symptoms of deficiency:

- Wilted leaves that turn bronze, then die
- Club roots (stunted)

Cl is essential for photosynthesis and disease prevention.