Lesson C3–6

Determining Nutrient Functions and Utilization

Unit C. Plant and Soil Science

Problem Area 3. Seed Germination, Growth, and Development

Lesson 6. Determining Nutrient Functions and Utilization

New Mexico Content Standard:

Pathway Strand: Plant Systems

Standard: **I:** Apply principles of anatomy and physiology to produce and manage plants in both a domesticated and natural environment.

Benchmark: **I-A.** Analyze and evaluate nutritional requirements and environmental conditions to develop and implement a fertilization plan.

Performance Standard: **2.** Determine plant nutrient requirements for optimum growth. **3.** Identify function of plant nutrients in plants.

Student Learning Objectives. Instruction in this lesson should result in students achieving the following objectives:

1. Discuss the 16 essential nutrients, their functions, and deficiency symptoms.
2. Identify the nonfertilizer nutrients and their functions.
3. Identify the primary macronutrients and their functions, and deficiency symptoms.
4. Identify the secondary micronutrients and their functions, and deficiency symptoms.
5. Identify the micronutrients and their functions, and deficiency symptoms.

List of Resources.

The following resources may be useful in teaching this lesson:

Recommended Resources. One of the following resources should be selected to accompany the lesson:

Biondo, Ronald J. and Jasper S. Lee. *Introduction to Plant and Soil Science and Technology*, 2nd Edition. Danville IL: Interstate Publishers, Inc. 2003

Parker, Rich. *Introduction to Plant Science*. Albany, New York: Delmar. 2000

Other Resources. The following resources will be useful to students and teachers:

Herron, Ray V., *The Science of Agriculture: A Biological Approach*. Albany, New York: Delmar. 2002

List of Equipment, Tools, Supplies, and Facilities

Writing surface
Overhead projector
Transparencies from attached masters
Copies of student lab sheet

Terms.

The following terms are presented in this lesson (shown in bold italics):

Denitrification
Leach
Macronutrient
Micronutrient
Nitrification
Nitrogen cycle
Nitrogen fixation
Nutrient deficiency
Nutrient excess
Nutrients
Soluble salts

Interest Approach.

Use an interest approach that will prepare the students for the lesson. Teachers often develop approaches for their unique class and student situations. Two possible approaches are included here.

Bring a variety of plants to class that show nutrient deficiencies. Ask the students what they notice about the plants. After they comment that the plants look sick, ask what might be the cause of the illness. Guide the discussion toward nutrient deficiencies and the objectives of this lesson.

Poll the students as to who takes vitamins everyday. Follow up by asking why they take vitamins. What is the value of vitamins? Have a multivitamin bottle on hand and instruct a student to read off the minerals listed. Ask whether plants would benefit from vitamins and minerals? Steer the discussion into the lesson and state the learning objectives.

Summary of Content and Teaching Strategies

Objective 1: Discuss the 16 essential nutrients, their functions, and deficiency symptoms.

Anticipated Problem: What are the 16 essential nutrients, their functions, and deficiency symptoms.

I. Certain chemical elements, called ***nutrients***, are essential for plant growth and development. Sixteen nutrients have been identified as being essential for plant growth.

   A. A little phrase can be used to help memorize the 16 essential elements for plant growth. It is "C. B. Hopkins Café Mighty Good Closed Monday Morning See You Zen." It represents the following: Carbon (C), Boron (B), Hydrogen (Hopkins), Oxygen (HOpkins), Phosphorus (HoPkins), Potassium (HopKins), Nitrogen (HopkiNs), Sulfur (HopkinS), Calcium (Café), Iron (cafÉ), Magnesium (Mighty good), Chlorine (Closed), Manganese (Monday), Molybdenum (Morning), Copper (See you = Cu), Zinc (Zen).

   B. Plant growth, fueled by cellular respiration, takes place primarily at night when photosynthesis is shut down. With signals from hormones, enzymes are produced. Each enzyme has a specific job. The enzymes break down sugars and recombine them with nitrogen and other nutrients. Many complex products result including, starches, pectin, lignin, cellulose, lipids or fats, proteins, pigments, hormones, vitamins, and alkaloids and tannins that protect plants from pests and diseases.

   C. If a plant fails to receive the needed amount of nutrients, it will show signs of ***nutrient deficiency***. Nutrient deficiencies most often result in an unhealthy plant appearance. Symptoms vary with the nutrient that is in short supply. Common symptoms of deficiencies include discoloration of the leaves, death of leaf tissue, and stunted growth. Because of the complex interactions of nutrients in plant processes, deficiency symptoms for different nutrients are often very similar.

   D. High levels of nutrients or ***nutrient excess*** can cause damage to plants. Chemical fertilizers dissolved in water are referred to as ***soluble salts***. Nutrient excess involves the build up of soluble salts that have a burning effect on plant roots.

Begin the lesson with an interest approach to capture the attention of the students. Clearly state the objectives of this lesson. Obtain a PowerPoint presentation or build a PowerPoint presentation to be used as a guide for classroom instruction. Utilize the text and transparency masters in this lesson in the PowerPoint presentation. Have students take notes during lecture-discussion. Ask questions during instruction to gauge student understanding of the concepts.

Objective 2: Identify the nonfertilizer nutrients and their functions.

Anticipated Problem: What are the nonfertilizer nutrients and their functions?

I. Three nutrients make up 89 percent of a plant's tissues. They are carbon, hydrogen, and oxygen.

   A. These are considered to be nonfertilizer nutrients because they are not given to plants as a fertilizer. Plants obtain these nutrients from air and water. Carbon comes from carbon dioxide; hydrogen from air and water; and oxygen from the air, water, and carbon dioxide. These nutrients are the building blocks for carbohydrates, proteins, fats, nucleic acids, and the many other compounds in plants.

Continue with the PowerPoint presentation. Or use TM: C3–6A—Nonfertilizers, TM: C3–6B—The Oxygen Cycle, and TM: C3–6C—The Carbon Cycle with an overhead projector to show students key points they should place in their notes. Engage the students in discussion on nonfertilizer nutrients.

Objective 3: Identify the primary macronutrients and their functions, and deficiency symptoms.

Anticipated Problem: What are primary macronutrients and their functions, and deficiency symptoms?

II. ***Macronutrients*** are those elements used in great quantities by plants. There are six macronutrients. Those used in the largest amounts are called primary macronutrients. They are nitrogen (N), phosphorus (P), and potassium (K).

   A. Nitrogen is one of the most abundant and mobile elements on Earth. It is found in the air and the soil. Nitrogen is a part of chlorophyll. Plants lacking in nitrogen take on a yellowish color and appear stunted. Organic matter in the soil is the source of most nitrogen obtained by plants. Nitrogen is absorbed in the form of nitrate (NO_3–) regardless of whether nitrogen is applied as a fertilizer or is from organic matter. ***Nitrification*** is the process carried out by soil bacteria in which ammonium (NH_4+) from organic matter or chemical fertilizers is converted to nitrate. The nitrate becomes part of the soil solution and is absorbed by crops. Nitrates ***leach*** or pass through soils readily and may erode primarily through water runoff. Nitrate also converts to gaseous N_2 under wet soil conditions in a process known as ***denitrification.*** Nitrogen is therefore a nutrient that needs to be added to soils for optimal plant growth. Before plants can use nitrogen it must be removed from the atmosphere through nitrogen fixation or through the manufacture of chemical fertilizers. ***Nitrogen fixation*** is a natural process in which rhizobia bacteria in root nodules of legumes (alfalfa, clover, peas, beans, and vetch) convert nitrogen to a nitrate form. Legumes typically do not need nitrogen fertilizers because they make their own nitrogen supply. Nitrogen continually changes from usable nitrogen to atmospheric nitrogen. This flow of nitrogen is called the ***nitrogen cycle***.

2. Phosphorus plays a crucial role in the reproduction of seed plants. It is an important element for DNA. It promotes rapid root growth. Unlike nitrogen, phosphorus is very immobile in soil. However, since a large portion of a plant's phosphorus is found in seeds and fruit, the soil must be replenished annually. Deficiency symptoms include a purple tinge to the leaves.
3. Potassium is necessary for the manufacture of starches and sugars. It assists in the plant disease and pest fighting mechanisms. It plays a role in the opening and closing of stomates. Symptoms of deficiency include a leaf tip burn and yellow or white streaks in the veins of the leaves.

Lead a lecture-discussion on primary macronutrients. Call upon students to participate in the discussion. Use visual aids, such as a chalkboard or overhead projector. Transparency masters TM: C3–6D—Primary Macronutrients and TM: C3–6E—The Nitrogen Cycle should be used to illustrate main points.

Objective 4: Identify the secondary macronutrients and their functions, and deficiency symptoms.

Anticipated Problem: What are the secondary macronutrients and their functions, and deficiency symptoms?

III. Three macronutrients used to a lesser degree than nitrogen, phosphorus, and potassium are calcium (Ca), magnesium (Mg), and sulfur (S). Calcium, magnesium, and sulfur are said to be secondary macronutrients because moderate amounts are needed.

A. Calcium is needed for the formation of strong cell walls. It is instrumental in young, growing cells, especially in the root system. It also aids plants in using other nutrients. Calcium deficiencies appear as deformed, curled leaves.
B. Magnesium is used in chlorophyll and is important to photosynthesis. It activates many plant enzymes. It is involved in the production of starches and fats and the movement of other nutrients throughout the plant. Deficiency symptoms include a yellowing of lower leaves and thin stems.
C. Sulfur is needed for protein formation. It also stimulates root growth. Young leaves that have a light green color is a symptom of deficiency.

Have the students read related sections of text materials identified in the resources list. Require students to take notes on the major points presented in the chapter. Follow the reading session with a discussion on secondary macronutrients. Use transparency master TM: C3–6F—Secondary Macronutrients as a guide for discussion. Have the students expand their notes based on the discussion. The discussion can also serve as a way to monitor students' mastery of the material.

Objective 5: Identify the micronutrients and their functions, and deficiency symptoms.

Anticipated Problem: What are the micronutrients and their functions, and deficiency symptoms?

IV. Those nutrients that are needed in smaller amounts by the plants, but are still essential to plant growth are called ***micronutrient***s. The micronutrients are boron (B), copper (Cu), chlorine (Cl), iron (Fe), manganese (Mn), molybdenum (Mo), and zinc (Zn).

A. The exact role of boron is unclear, but it appears to be essential for pollination and reproduction, cell division, and the transport of sugars. Young leaves look yellow and thick when the nutrient is lacking.

B. Copper regulates several chemical processes including chlorophyll synthesis and respiration. A shortage results in the yellowing of leaves with the younger leaves affected first.

C. Chlorine is involved in light reactions of photosynthesis. It aids root and shoot growth. Deficiency symptoms have not been recognized.

D. Iron is important in chlorophyll formation and is a component of enzymes involved in photosynthesis, respiration, and nitrogen fixation. Young leaves yellow first. The veins remain green.

E. Manganese is important in chlorophyll formation. It is part of enzymes involved in respiration and nitrogen metabolism. The symptom of deficiency is young leaves yellow first with the veins remaining green.

F. Molybdenum is part of enzymes involved in nitrogen metabolism. It aids nitrogen fixation and protein synthesis. Deficiency symptoms appear as yellow older leaves and growth is stunted.

G. Zinc is important in chlorophyll, auxin, and starch formation, and it is part of the enzymes that are involved in respiration. Older leaves that yellow and stunted growth are deficiency symptoms.

Students can be given the task of completing LS: C3–6A—Essential Nutrient Functions and Deficiency Symptoms in class or as homework. Take students on a field trip to fertilizer service company or have an agronomist appear as a guest speaker. Have the speaker discuss nutrient interactions with plants and deficiency symptoms. Prepare the students in advance to ask questions. Tour the land lab or nearby fields to see plants exhibiting nutrient deficiencies. Use TM: C3–6G—Micronutrients to highlight concepts. At the conclusion of the discussion, review and summarize the information presented in the lesson. Follow up with an evaluation. Use the sample test provided to assess student mastery of the material.

Review/Summary. Restate the student learning objectives at the conclusion of the lesson. Review the material that has been covered in class discussions, laboratory activity, and other learning experiences. Call on students to explain the content associated with each objective. Use their responses as the basis for determining any areas that need re-teaching. Questions at the end of the chapters in the textbooks may also be used in the review/summary.

Application. Application can involve one or more of the following student activities using the attached lab sheets:

LS: C3–6A—Essential Nutrient Functions and Deficiency Symptoms

TM: C3–6A—Nonfertilizers

TM: C3–6B—The Oxygen Cycle

TM: C3–6C—The Carbon Cycle

TM: C3–6D—Primary Macronutrients

TM: C3–6E—The Nitrogen Cycle

TM: C3–6F—Secondary Macronutrients

TM: C3–6G—Micronutrients

Evaluation. Evaluation should focus on student achievement of the objectives for the lesson. Various techniques can be used, such as student performance on the application activities. A sample written test is attached.

Answers to Sample Test:

Part One: Matching

1 = e, 2 = g, 3 = h, 4 = c, 5 = a, 6 = j, 7 = i, 8 = b, 9 = f, 10 = d

Part Two: Completion

1. 89
2. nonfertilizer
3. Sixteen
4. burning
5. primary
6. calcium (Ca), magnesium (Mg), and sulfur (S)
7. nitrate (NO_3–)
8. Phosphorus
9. Potassium
10. photosynthesis

Part Three: Short Answer

1. Discoloration of the leaves, death of leaf tissue, and stunted growth.
2. "C. B. Hopkins Café Mighty Good Closed Monday See You Zen." It represents the following: Carbon (C), Boron (B), Hydrogen (Hopkins), Oxygen (HOpkins), Phosphorus (HoPkins), Potassium (HopKins), Nitrogen (HopkiNs), Sulfur (HopkinS), Calcium

(Café), Iron (cafÉ), Magnesium (Mighty good), Chlorine (Closed), Manganese (Monday), Molybdenum (Morning), Copper (See you = Cu), Zinc (Zen).

3. Carbon, Hydrogen, Oxygen; Nitrogen, Phosphorus, Potassium; Calcium, Magnesium, Sulfur; Boron, Iron, Chlorine, Manganese, Molybdenum, Copper.
4. Carbohydrates, proteins, fats, nucleic acids, and the many other compounds in plants.
5. Starches, pectin, lignin, cellulose, lipids or fats, proteins, pigments, hormones, vitamins, alkaloids, and tannins that protect plants from pests and diseases.

Sample Test Name _____

Test

Lesson C3–6: Determining Nutrient Functions and Utilization

Part One: Matching

Instructions. Match the term with the correct response. Write the letter of the term by the definition.

a. Denitrification
b. Nutrient excess
c. Nutrients
d. Macronutrient
e. Micronutrient
f. Nitrate
g. Nitrification
h. Nitrogen fixation
i. Nutrient deficiency
j. Soluble salts

_____ 1. Those nutrients that are needed in smaller amounts by the plants, but are still essential to plant growth.

_____ 2. The process carried out by soil bacteria in which ammonium (NH_4+) from organic matter or a chemical fertilizer is converted to nitrate.

_____ 3. A natural process in which rhizobia bacteria in root nodules of legumes convert nitrogen to a nitrate form.

_____ 4. Chemical elements essential for plant growth and development.

_____ 5. Process in which nitrate converts to gaseous N_2 under wet soil conditions.

_____ 6. Chemical fertilizers dissolved in water.

_____ 7. Signs that a plant fails to receive the needed amount of nutrients.

_____ 8. High levels of nutrients that can cause damage to plants.

_____ 9. Nitrogen is absorbed by plants in this form.

_____ 10. Those elements used in great quantities by plants.

Part Two: Completion

Instructions. Provide the word or words to complete the following statements.

1. Three nutrients make up ____ percent of a plant's tissues.
2. Carbon, hydrogen, and oxygen are considered to be _____ nutrients.
3. _____ nutrients have been identified as being essential for plant growth.

4. Nutrient excess involves the buildup of soluble salts that have a _____ effect on plant roots.
5. Those macronutrients used in the largest amounts are called _____ macronutrients.
6. Three macronutrients used to a lesser degree than nitrogen, phosphorus, and potassium are _____, _____, and _____.
7. Nitrogen is absorbed in the form of _____ regardless of whether nitrogen is applied as a fertilizer or is from organic matter.
8. _____ plays a crucial role in the reproduction of seed plants and promotes rapid root growth.
9. _____ assists in the plant's disease and pest-fighting mechanisms.
10. Magnesium is used in chlorophyll and is important to _____.

Part Three: Short Answer

Instructions. Provide information to answer the following questions.

1. What are the common symptoms of nutrient deficiencies?

2. What is a little phrase can be used to help memorize the 16 essential elements for plant growth?

3. List the three nonfertilizer, three primary macronutrients, three secondary macronutrients, and micronutrients.

4. Carbon, hydrogen, and oxygen are the building blocks for compounds?

5. Identify many complex products made when enzymes break down sugars and recombine them with nitrogen and other nutrients.

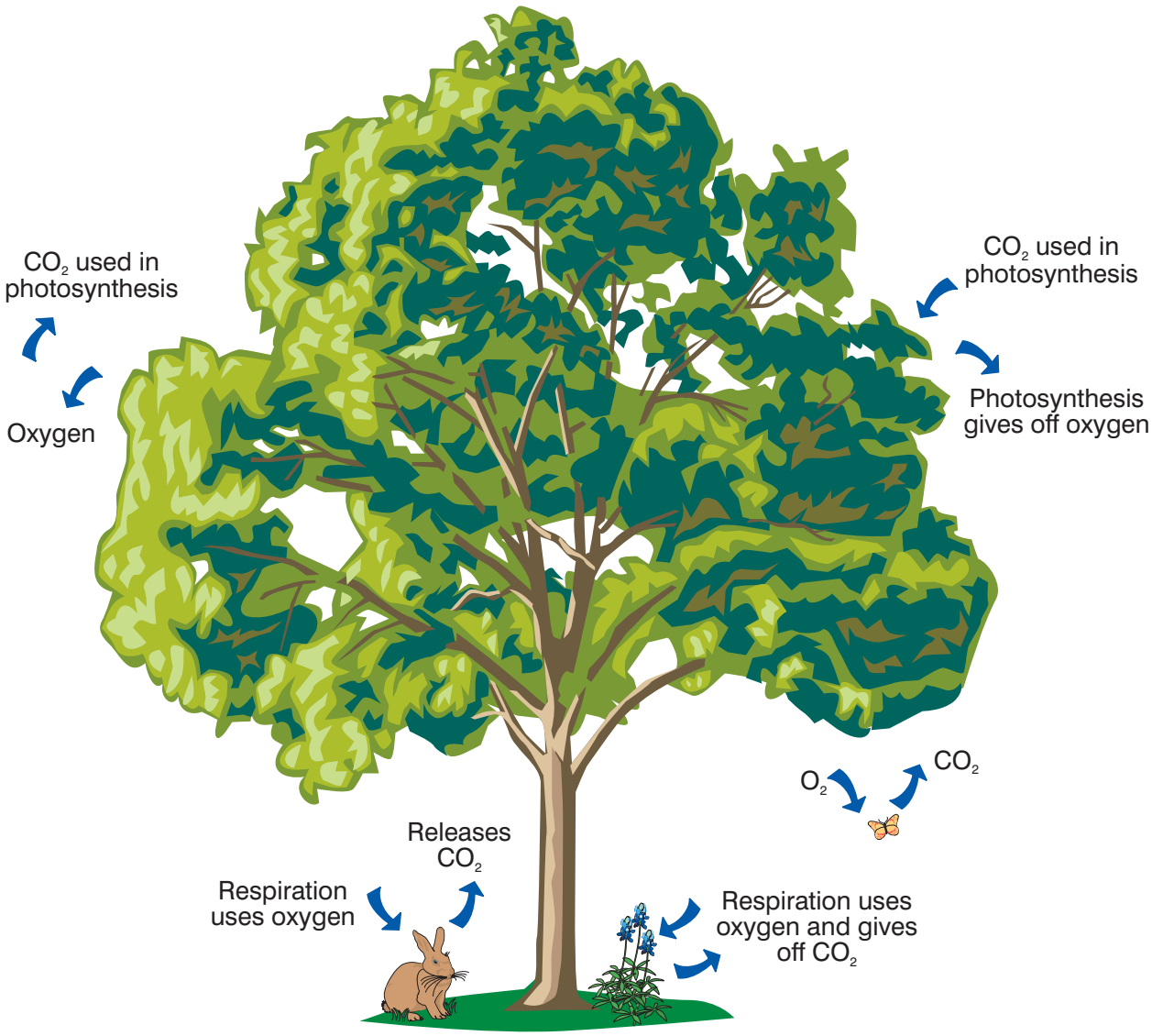
TM: C3–6A

NONFERTILIZERS

Nutrient	Influence/Function
Carbon	Building block for carbohydrates, proteins, fats, nucleic acids
Hydrogen	Building block for carbohydrates, proteins, fats, nucleic acids
Oxygen	Building block for carbohydrates, proteins, fats, nucleic acids

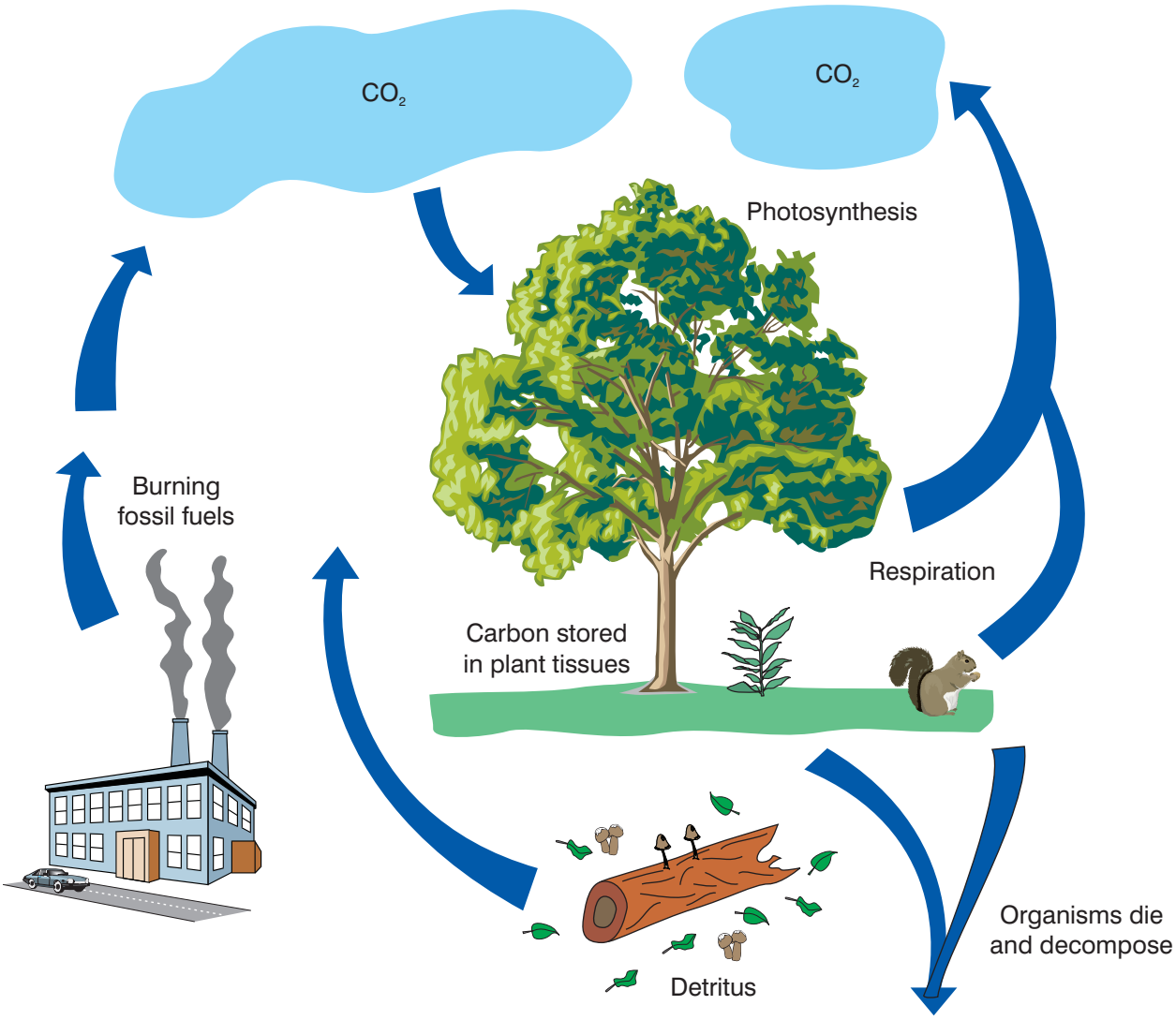
TM: C3–6B

THE OXYGEN CYCLE



TM: C3–6C

THE CARBON CYCLE



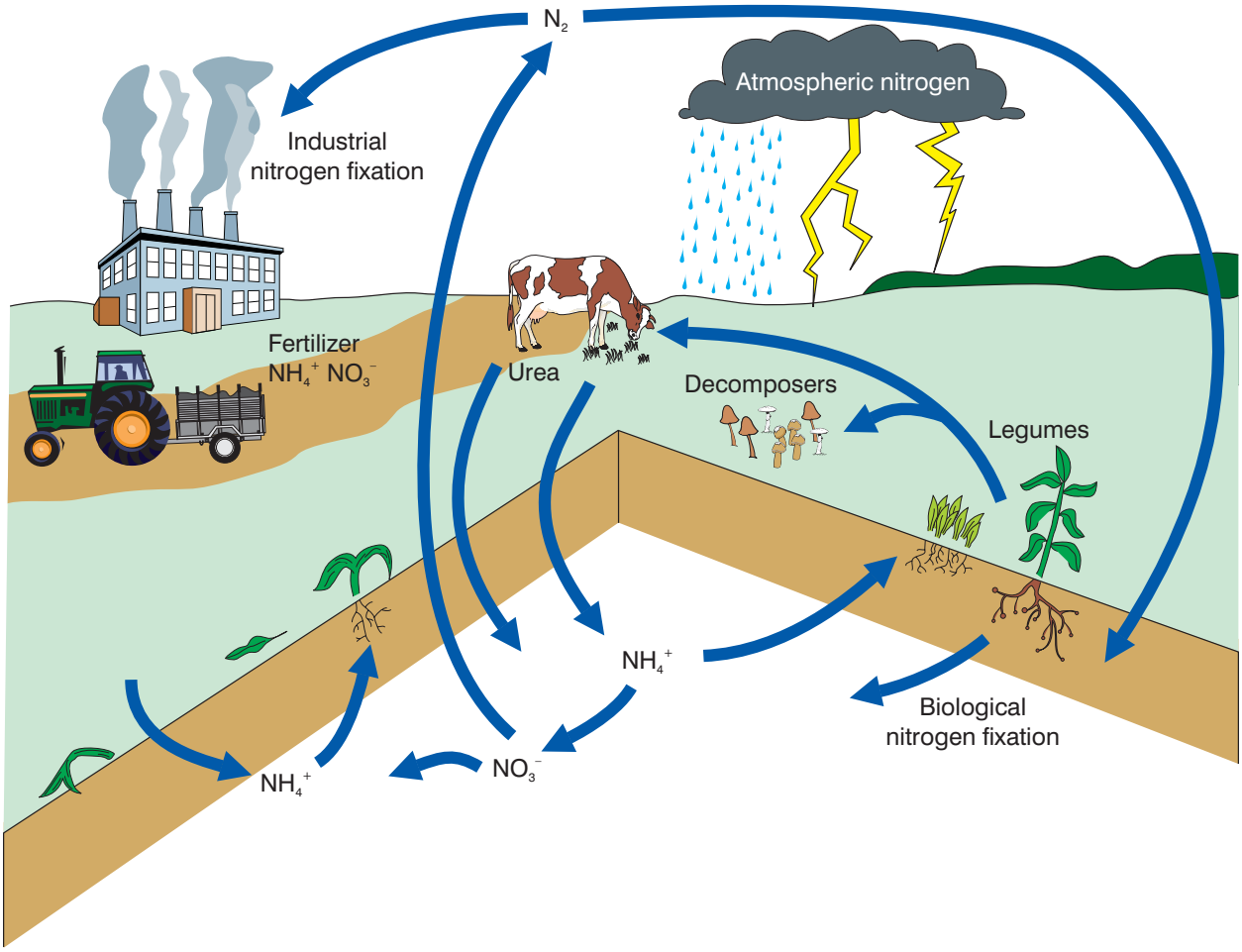
TM: C3–6D

PRIMARY MACRONUTRIENTS

Nutrient	Influence/Function	Deficiency Symptom
Nitrogen	Produces stem and leaf growth; gives plants dark green color; synthesis of amino acids and proteins	Entire plant lighter green, lower leaves yellowing; slow or dwarfed growth
Phosphorus	Stimulates root development and growth; aids in cell division; encourages flower bud formation; improves winter hardiness; helps plants to a vigorous and rapid start	Purplish coloration to leaves and stems; stunted growth
Potassium	Increases plant vigor and disease resistance; aids in the transport of foods through the phloem; has key role in opening and closing stomata; thickens cell walls	Yellowing or death of tissues at tips and outer edges of older leaves

TM: C3–6E

THE NITROGEN CYCLE



TM: C3–6F

SECONDARY MACRONUTRIENTS

Nutrient	Influence/Function	Deficiency Symptom
Calcium	Maintains strength of cell walls; promotes early root growth	Short, much branched roots; young leaves at growing points die back
Magnesium	Essential for chlorophyll and photosynthesis; activator for many plant enzymes; aids nutrient uptake	Loss of green leaf color starting with bottom leaves
Sulfur	Stimulates root growth; needed for protein formation; gives green color	Young leaves light green with veins being lighter

TM: C3–6G

MICRONUTRIENTS

Nutrient	Influence/Function	Deficiency Symptom
Boron	Essential for pollination and reproduction; cell division; transport of sugars	Young leaves yellow and thick
Copper	Regulates several chemical processes; chlorophyll synthesis and respiration	Yellowing of leaves,, younger leaves affected first
Chlorine	Involved in light reactions of photosynthesis; aids root and shoot growth	Symptoms have not been recognized
Iron	Important in chlorophyll formation; component of enzymes involved in photosynthesis, respiration and nitrogen fixation	Young leaves yellow first; veins remain green
Manganese	Important in chlorophyll formation; part of enzymes involved in respiration and nitrogen metabolism	Young leaves yellow first; veins remain green
Molybdenum	Part of enzymes involved in nitrogen metabolism; aids nitrogen fixation and protein synthesis	Older leaves yellow; stunted growth
Zinc	Important in chlorophyll, auxin, and starch formation; part of enzymes involved in respiration; needed for auxin and starch formation	Older leaves yellow; stunted growth

Name _____

Lab Sheet

Essential Nutrient Functions and Deficiency Symptoms

Instructions:

Complete the table.

Nutrient	Influence/Function	Deficiency Symptom
Carbon		
Hydrogen	Building block for carbohydrates, proteins, fats, nucleic acids	
Oxygen	Building block for carbohydrates, proteins, fats, nucleic acids	
Nitrogen		
Phosphorus		
Potassium	Increases plant vigor and disease resistance; aids in the transport of foods through the phloem; has key role in opening and closing stomata; thickens cell walls	

Calcium		
Magnesium		Loss of green leaf color starting with bottom leaves
Sulfur		Young leaves light green with veins being lighter
Boron		
Copper		Yellowing of leaves,, younger leaves affected first
Chlorine		Symptoms have not been recognized
Iron		
Manganese		
Molybdenum	Part of enzymes involved in nitrogen metabolism; aids nitrogen fixation and protein synthesis	
Zinc		