Lesson C4–5

Determining the Importance of Photosynthesis and Respiration

Unit C. Basic Principles of Agricultural/Horticultural Science

Problem Area 4. Identifying Basic Principles of Plant Science

Lesson 5. Determining the Importance of Photosynthesis and Respiration

New Mexico Content Standard:

Pathway Strand: Plant Systems

Standard: **II:** Address taxonomic or other classifications to explain basic plant anatomy and physiology.

Benchmark: **II-A:** Examine unique plant properties to identify/describe functional difference in plant structures including roots, stems, flowers, leave and fruit.

Performance Standard: **4.** Explain the processes of photosynthesis and respiration.

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

1. Explain photosynthesis and its importance.
2. Write the chemical equation for photosynthesis and explain it.
3. Explain how light and dark reactions differ.
4. Define respiration and explain why it is important.
5. List four factors that affect the rate of respiration.
6. Explain the importance of transpiration to plants.

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:

Lee, Jasper S. and Diana L. Turner. *AgriScience,* Third Edition. Danville, Illinois: Interstate Publishers, Inc., 2003. (Textbook and Activity Manual, Chapter 9).

Runner, Jay, Doug Anderson, and Michael G. White. Instructional Resource Guide — *Introduction to Horticulture*. Danville, Illinois: Interstate Publishers, Inc., 2002. (Instructor's Binder, Chapter 8).

Schroeder, Charles B., et al. *Introduction to Horticulture*, Third Edition. Danville, Illinois: Interstate Publishers, Inc., 2002. (Textbook and Activity Manual, Chapter 8)

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

Parker, Rick. *Introduction to Plant Science*. Delmar Publishers, 2000. (Textbook, Chapters 11 and 12).

Taiz, Lincoln & Eduardo Zeiger. Plant Physiology. The Benjamin/Cummings Publishing Company, Inc., 1991. (Textbook)

List of Equipment, Tools, Supplies, and Facilities

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

Terms.

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

Calvin cycle
Chlorophyll
Dark reactions
Glucose
Light reactions
Mitochondria
Photosynthesis
Respiration
Stomata
Transpiration

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. A possible approach is included here.

Start the lesson by shutting off the lights in the classroom. Ask the students if they could survive and continue to make energy if they were kept in the dark. Ask students what effect complete darkness would have on other mammals. Now ask the students what effect complete darkness would have on plants.

Summary of Content and Teaching Strategies

Objective 1: Explain photosynthesis and its importance

Anticipated Problem: What is photosynthesis?

I. ***Photosynthesis*** is the manufacture of food by plant cells.

   A. Sugar is the major product of photosynthesis and provides energy for the plant.

   B. There are two phases to the photosynthesis process.

      1. Energy gathering—Plant leaves soak up sunlight.

      2. Sugar making—Plants convert energy from sunlight into stored chemical energy.

         a. Chemical energy rearranges carbon dioxide in the plant in the presence of chlorophyll to form sugar.

         b. ***Glucose***, a simple sugar, is formed.

   C. Photosynthesis is the most important reaction on earth. All life forms are dependent on the reaction.

      1. Occurs in the chloroplasts

      2. $CO2 + light + chlorophyll + H2O \rightarrow C6H12O6 (glucose) + H2O + O2$

   D. In order for photosynthesis to occur, several things must be present.

      1. ***Chlorophyll***—green colored substance in plants.

      2. Light—Leaves absorb necessary energy from the sun's rays or artificial light.

      3. Carbon Dioxide—Enters the plant through structure called stomata in the leaves. Carbon dioxide is split during photosynthesis.

      4. Water—Water is also split during photosynthesis.

A variety of techniques may be used in helping students understand this objective. Display TM:C4–5A and use it to illustrate the concept of photosynthesis and its importance. Follow it up with LS:C4–5A to help demonstrate the role of pigmentation in photosynthesis. The recommended text materials should also be helpful to students. Have them read the suggested chapters listed in the recommended resources. Use classroom discussion to identify any concepts that require further emphasis.

Objective 2: Write the chemical equation for photosynthesis and explain it.

Anticipated Problem: What does the chemical equation for photosynthesis mean?

II. Photosynthesis is a series of chemical reactions that yields sugars, water, and oxygen.

A. The chemical equation of photosynthesis can be written in words:

Six molecules of carbon dioxide plus twelve molecules of water in combination with a healthy plant and some form of light energy, to make one molecule of sugar plus six molecules of water and six molecules of oxygen.

B. The products of photosynthesis include carbohydrates in the form of sugars and starches as well as water and oxygen.

A number of tools may be used in helping students gain mastery of this objective. Display TM:C4–5B to illustrate the chemical equation for photosynthesis. The recommended text materials will also prove useful. Have the class read the suggested chapters in the recommended textbooks. Use class discussion to summarize the objective. Identify any items that need further emphasis through student responses.

Objective 3: Explain how light and dark reactions differ.

Anticipated Problem: What makes the light reactions of photosynthesis different than the dark reactions?

III. Photosynthesis is a series of complex reactions that have been divided into two major phases. These two major phases have been named the light and dark reactions.

A. ***Light Reactions***

1. The light reactions are also known as light dependent reactions. Light allows energy to be released in the form of ATP which can be used by the plant in the splitting of water and the release of oxygen.
2. The pigments in chloroplasts absorb light energy to form NADPH and ATP to be used in the breakdown of CO2 in the dark reactions.

B. ***Dark Reaction***—

1. Also known as light independent reactions.

2. A chemical known as RuBP (rubilose biphosphate) absorbs carbon. Carbon dioxide and RuBP join together and go through a process called the Calvin cycle. The ***Calvin cycle*** reduces carbon dioxide to manufacture carbohydrates. The NADPH and ATP synthesis from the light reactions provide the energy needed to power the Calvin cycle.

3. As a result of the Calvin cycle, one molecule of glucose is formed.

The teacher can use a variety of techniques to assist students in understanding this objective. Display TM:C4–5C to reinforce the differences between the two major phases of photosynthesis. The recommended text materials should also be helpful. Have the class read the suggested chapters. Determine any concepts that need to be reemphasized through classroom discussion and student comments.

Objective 4: Define respiration and explain why it is important.

Anticipated Problem: What is respiration and why do we need to know about it in plants?

IV. ***Respiration*** is the process by which an organism provides its cells with oxygen so energy can be released from digested food. Respiration takes place in all living cells at all times.

A. ***Mitochondria*** are energy processing factories for plants. Respiration takes place in the mitochondria of all cells.

B. Respiration yields the opposite results as photosynthesis. The process of photosynthesis absorbs energy, consumes carbon dioxide and releases oxygen. Respiration uses energy, consumes oxygen and releases carbon dioxide.

Display TM:C4–5D to the class. Use it to illustrate the concept of plant respiration and the differences between respiration and photosynthesis. The recommended text materials will also be helpful to student understanding. Have the class read the suggested chapters. Use class discussion and student questions to determine any areas that need to be retaught.

Objective 5: List four factors that affect the rate of respiration.

Anticipated Problem: What controls the rate of respiration?

V. Temperature, oxygen, soil conditions, and light can affect the rate of respiration.

A. Temperature—There is a direct relationship between respiration and temperature, as the temperature increases so does the rate of respiration.

B. Oxygen—Oxygen is required for respiration to take place. As oxygen levels decrease so does the rate of respiration.

C. Soil conditions—Soil containing large quantities of water cause the rate of respiration to decrease because of the lack of oxygen.

D. Light—The amount of energy produced by photosynthesis in low light conditions is reduced. Therefore the amount of energy available to conduct respiration is lower.

TM:C4–5E will be helpful to students in understanding this objective. Use it to illustrate the factors that effect the rate of plant respiration. The recommended textbooks will also aid in student comprehension. Have the class read the suggested chapters. Discuss the objective as a class. Use students' comments to determine if any parts need further emphasis.

Objective 6: Explain the importance of transpiration to plants.

Anticipated Problem: Why is it necessary for plants to undergo transpiration?

VI. ***Transpiration*** in plants is the loss of water by evaporation through structures called stomata. ***Stomata*** are pores or openings in the plant that allow for the exchange of water and other substances. Transpiration in plants is similar to perspiration in humans.

A. Water molecules and transpiration together form a force that is essential for water movement through plants.
    1. As water evaporates through the stomata of plant, it creates a pull that aids in the absorption of water by the roots. (An analogy of using a straw to drink will help students to visualize this process.)
    2. Transpiration is a vital link in the hydrologic cycle. Ninety-nine percent of all water taken in by the plant is lost to transpiration. Therefore, transpiration contributes significantly to the generation of rainfall.

B. Factors affecting the rate of transpiration include:
    1. Wind speed—the relationship between wind speed and transpiration is a direct relationship.
    2. Temperature—as temperature increases so does the rate of transpiration because the plant uses transpiration as a mechanism to cool itself. Once again there is a direct relationship between temperature and transpiration.
    3. Humidity—Humidity influences the rate of transpiration because if the air is already saturated with water vapor, there will be a decrease in the rate of evaporation.
    4. Drought—If the plant is experiencing drought conditions it will close the stomata to prevent needed water from escaping. When the plant's stomata are closed transpiration does not take place.

A number of tools are available in helping students fully understand this objective. Use TM:C4–5F to help reinforce an understanding of transpiration. Follow it up with TM:C4–5G to demonstrate the factors that affect transpiration rate. Use LS:C4–5B to help reinforce a full understanding of transpiration. The recommended text materials will also be helpful. Have students read the suggested chapters. Follow the reading with classroom discussion. Use student questions to determine the need for further emphasis of particular concepts.

Review/Summary. Focus the review and summary of the lesson around the student learning objectives. Call on students to explain the content associated with each objective. Questions at the end of each chapter in the recommended textbooks may also be used in the review/summary.

Application. Application can involve the following student activity using the attached lab sheet.

Pigment Separation by Chromatography—LS: C4–5A

Transpiration of Tree Leaves—LS: C4–5B

Evaluation. Evaluation should focus on student achievement of the lesson objectives. Various techniques can be used, such as student performance on the application activities. The self-check section at the end of each chapter in the suggested references will be helpful. A sample written test is attached.

Answers to Sample Test:

Part One: Matching

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

Part Two: Completion

1. chloroplasts
2. chlorophyll
3. temperature, oxygen, soil conditions, and light
4. mitochondria
5. carbon dioxide, oxygen
6. oxygen, carbon dioxide

Part Three: Short Answer

1. Energy gathering, sugar making
2. The light reactions require the presence of light while the dark reactions do not. However, the dark reactions can take place in the presence of light. The light reactions make ATP and NADPH and the dark reactions consume it.
3. $6\ CO_2$ + light + chlorophyll $+12\ H_2O \rightarrow C_6H_{12}O_6$ (glucose) $+6\ H_2O + 6\ O_2$
   Six molecules of carbon dioxide combine with 12 molecules of water in the presence of light and green plant material to form one molecule of the simple sugar glucose and six molecules of both oxygen and water.

Sample Test Name _____

Test

Lesson C4–5: Determining the Importance of Photosynthesis and Respiration

Part One: Matching

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

a. glucose
b. light reaction
c. dark reaction
d. RuBP
e. stomata
f. humidity
g. drought
h. temperature

_____ 1. Affects both the rates of respiration and transpiration in plants.

_____ 2. During this process, ATP and NADPH are formed as a result of energy absorption by the chloroplasts.

_____ 3. The chemical that aids in photosynthesis by absorbing carbon dioxide.

_____ 4. The simple sugar that is formed as an end product of the Calvin cycle.

_____ 5. Factor that affects the rate of transpiration due to the amount of water vapor in the air.

_____ 6. The structure in plants that allows water to be exchanged.

_____ 7. Involves the Calvin cycle and is also known as the light independent reaction.

_____ 8. Causes the plant to close the stomata to decrease the rate of transpiration.

Part Two: Completion

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

1. Photosynthesis occurs in the _____ of plants.
2. The substance that gives plants their green color is _____.
3. Four factors affecting the rate of respiration include _____, _____, _____, and _____.
4. Respiration occurs in the _____ of all cells, which is known as the energy-processing factory for plants.
5. Photosynthesis absorbs energy, consumes _____ _____ and releases _____.

6. In contrast, respiration uses energy, consumes _____ and releases _____ _____.

Part Three: Short Answer

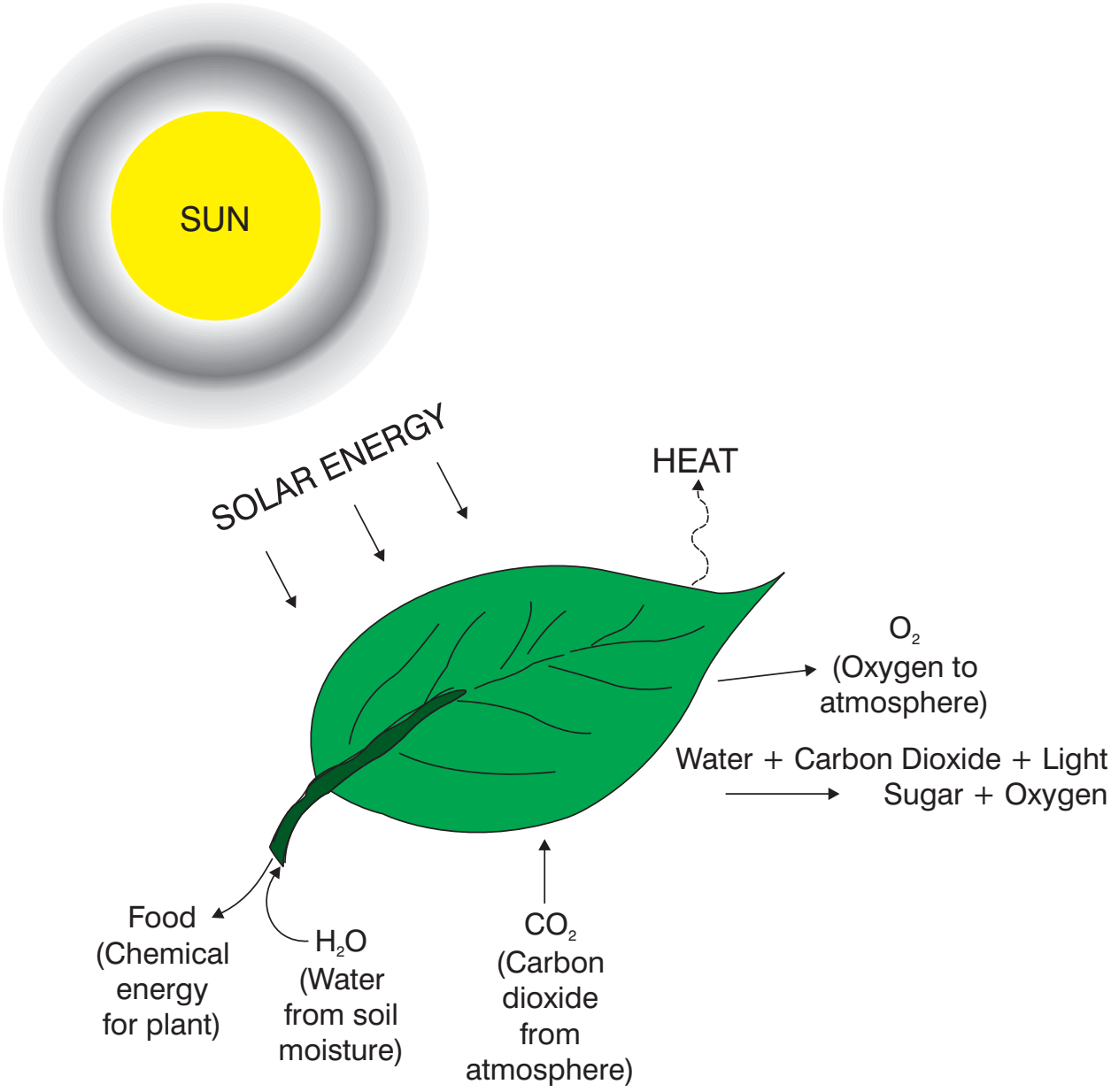
Instructions. Provide information to answer the following questions.

1. List the two major phases of photosynthesis.

2. Describe how the light and dark reactions are different.

3. Write the equation for photosynthesis in chemical notation and words.

Energy Flow


SUN
SOLAR ENERGY
HEAT
O_2
(Oxygen to atmosphere)
Water + Carbon Dioxide + Light
Sugar + Oxygen
Food
(Chemical energy for plant)
H_2O
(Water from soil moisture)
CO_2
(Carbon dioxide from atmosphere)

Photosynthesis Equation

$$\text{light} + 6CO_2 + 6H_2O \xrightarrow{\text{chlorophyll}} C_6H_{12}O_6 + 6O_2$$

Two Major Phases of Photosynthesis

A. Light Reaction

1. Light allows energy to be released as ATP which is used by the plant in splitting water and releasing oxygen.
2. Light energy absorbed and used in the breakdown of carbon dioxide.

B. Dark Reaction

1. Also known as light independent reaction.
2. Clavin cycle reduces carbon dioxide to manufacture carbohydrates.
3. Calvin cycle results in the formation of glucose.

TM: C4–5D

Comparison of Photosynthesis and Respiration

Photosynthesis

1. CO2 and H2O are used.
2. Food and O2 are produced.
3. Energy from light is trapped by chlorophyll and in food.
4. ATP is produced by use of light energy.
5. Only chlorophyll-containing cells carry out photosynthesis.
6. Occurs only in light.
7. Occurs in chloroplasts.
8. Total photosynthesis must exceed total respiration for growth to occur.

Respiration

1. O2 and food are used.
2. CO2 and H20 are produced.
3. Energy in food may be temporarily stored in ATP or lost as heat.
4. ATP is produced by oxidation of food.
5. Every living cell carries out respiration.
6. Occurs both in light and in darkness.
7. Glycolysis occurs in cytoplasm, while the final steps of aerobic respiration occur in mitochondria

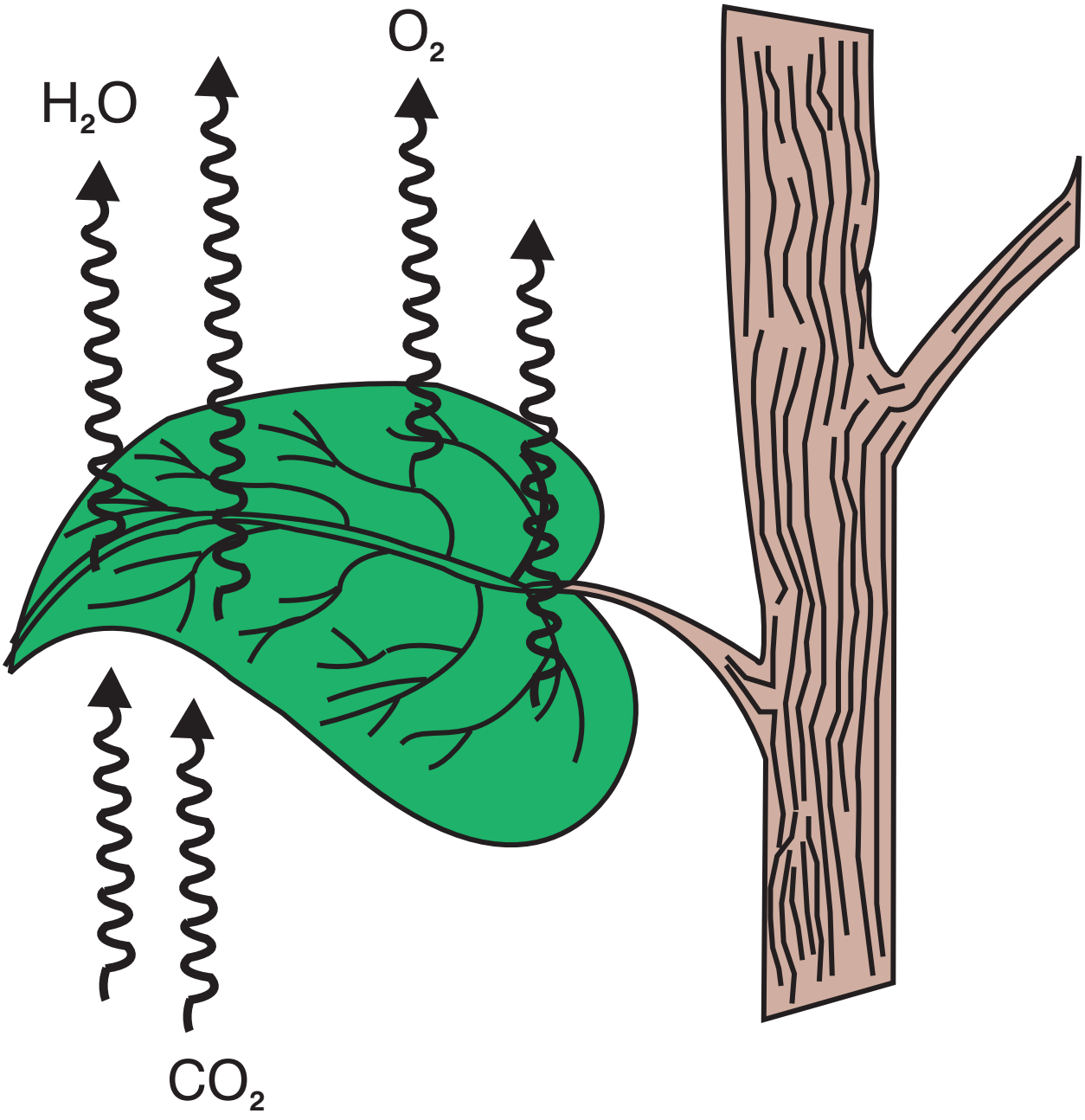
TM: C4–5E

Factors Affecting the Rate of Respiration

1. Temperature
2. Oxygen
3. Soil conditions
4. Light

TM: C4–5F

Transpiration and Gas Exchange in Leaves



Factors Affecting the Rate of Transpiration

1. Wind speed
2. Temperature
3. Humidity
4. Drought

 Name_____

Lab Sheet

Pigment Separation by Chromatography

This activity will allow you to determine the types of pigments present in leaves that allow the necessary process of photosynthesis.

Purpose:

1. Show that green leaves contain chlorophyll and other pigments that are necessary for photosynthesis to take place.
2. Compare green and non-green leaf pigments to determine their effect on photosynthesis.

Materials:

Chromatography paper
Pencil
Wide mouth jar or 200 ml beaker
Rubbing Alcohol
Plastic Wrap
Tape
Coin or other rounded object to smash plant leaves
Leaves from several plants (preferably with different colored leaves)
Examples include: Wandering Jew or a Variegated spider plant)
*Note—it might be an interesting modification to try this on leaves that have changed color in the fall.

Procedure:

1. Cut chromatography paper into strips about 6 inches long.
2. Place the green leaf at one end of the paper. Smash the leaf onto the paper to make a dark green mark about ½ inch from the end.
3. Wrap the other end around a pencil and tape it to the pencil.
4. Add 70 % isopropyl alcohol to the jar until there is about ½ inch of alcohol in the bottom of the jar.
5. Place the pencil with the paper attached into the jar so that only a about ¼ inch of paper is in the liquid. Be careful to keep the paper from touching the sides of the jar.
6. Cover the jar with plastic wrap to minimize evaporation.
7. Allow the paper to soak up the alcohol until it almost reaches the top.
8. Remove the paper and allow it to dry.
9. Observe the paper and note how the different colors separated.
10. Repeat this procedure for all the different plant samples available.

 Name_____

Lab Sheet

Transpiration of Tree Leaves

This activity is designed to enhance student learning about transpiration in plants.

Materials:

Clear plastic bags
Duct tape
Local tree
Balance scale

Procedure:

1. Hand out one plastic bag for each student or lab group.
2. Have students select a leaf or group of leaves on the tree to bag.
3. Instruct students to carefully wrap their bag around the leaf or leaves they have selected and tape it closed. Important: the tape must fit snugly and touch both the bag and the tree branch all the way around.
4. Allow the bags to stay on the tree for two or more days if possible. Results will be more dramatic and reliable for bags that are left on for longer periods.
5. Carefully remove the bag from the tree making sure no water is lost.
6. Weigh the bag, tape and tree parts together and then weigh each item separately.
7. By subtraction you can determine how much water was in the bag.
8. Figure the ratio of water to tree parts by dividing the water mass by the tree parts.

Questions

1. If the mass of your tree material was 2 ft^3, how much water would be expected to transpire from a tree that is 1500 ft^3 under the same conditions?

2. If there are 300 trees of the same size (1500 ft3), how much water would they give off in the length of time that your tree sample was bagged?

3. How much water would these trees put into the atmosphere in six months?

4. How do each of the following factors influence the rate of transpiration?
   a. temperature

   b. length of daylight hours

   c. time of year

   d. drought