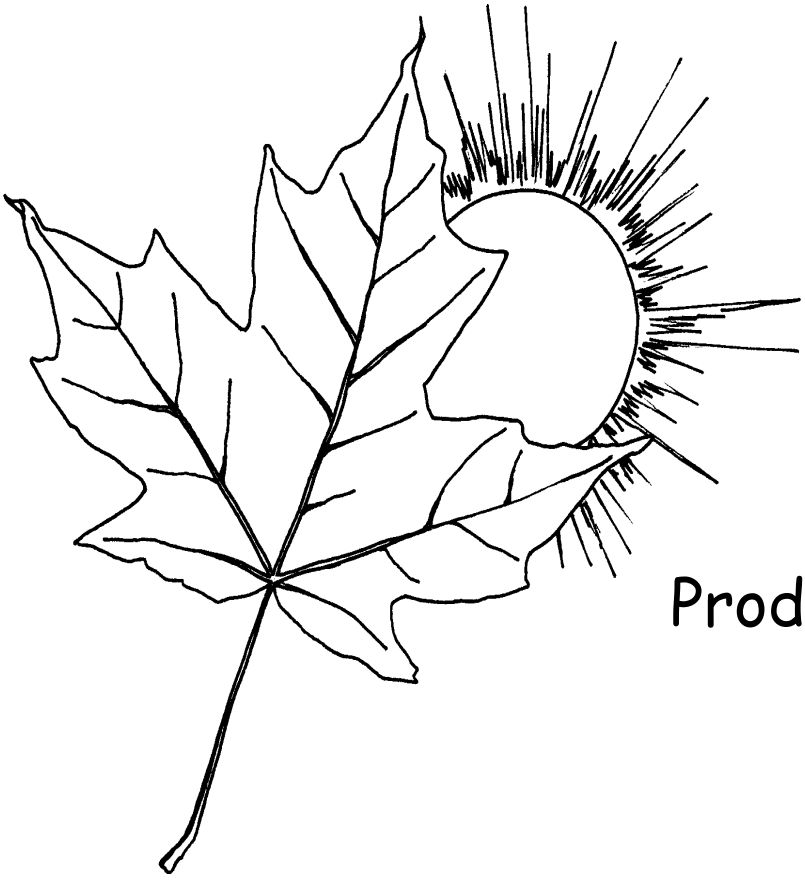
Photosynthesis and Plant Responses

Teacher's Guide
Grades 5-9

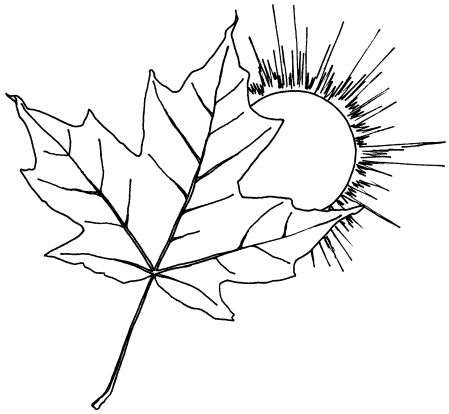


Produced by:
Brian A. Jerome, Ph.D.
Stephanie Zak Jerome

Narrated by:
Nina Keck

Production Assistants:
Matt Wimmer
Heidi Berry
Jessica Kassis
Fred Thodal

Visual Learning Company
Brandon, Vermont
1-800-453-8481
www.visuallearningco.com



Contributors and Reviewers:

Producers:
Brian A. Jerome, Ph.D.
Stephanie Zak Jerome, MPA

Narrator:
Nina Keck

Production Assistants:
Matt Wimmer
Heidi Berry
Jessica Kassis
Fred Thodal

Reviewers:
Kevin Omland, Ph.D.
Smithsonian Institution
Washington, DC

Mary Cahill, M.A.
Potomac School
McLean, Virginia

Susan Hurstecalderone, M.S.
Blessed Sacrament School
Washington, DC

Use and Copyright:

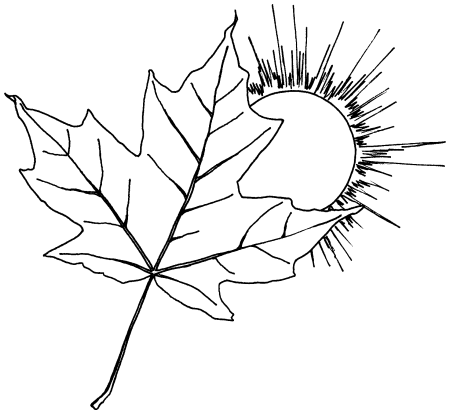
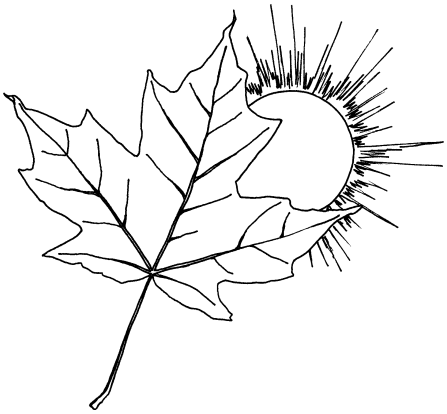


Table of Contents



Viewing Clearances

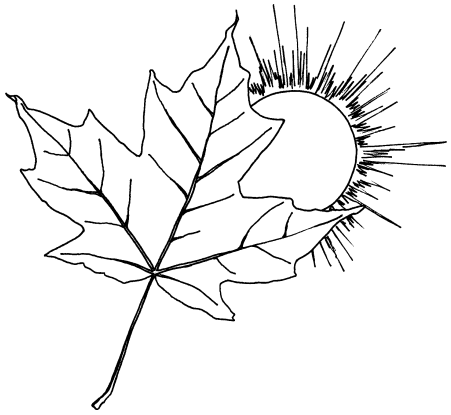
The video and accompanying teacher's guide is for instructional use only. In showing these programs, no admission charges are to be incurred. The programs are to be utilized in face-to-face classroom instructional settings, library settings, or similar instructional settings.

Duplication rights are available, but must be negotiated with the *Visual Learning Company*.

Television, cable, or satellite rights are also available, but must be negotiated with the *Visual Learning Company*.

Closed circuit rights are available, and are defined as the use of the program beyond a single classroom but within a single campus. Institutions wishing to utilize the program in multiple campuses must purchase the multiple campus version of the program, available at a slightly higher fee.

Discounts may be granted to institutions interested in purchasing programs in large quantities. These discounts may be negotiated with the *Visual Learning Company*.



A Message from our Company . . .

Dear Educator:

Thank you for your interest in the educational videos produced by the *Visual Learning Company*. We are a Vermont-based, family owned and operated business specializing in the production of quality educational science videos and materials.

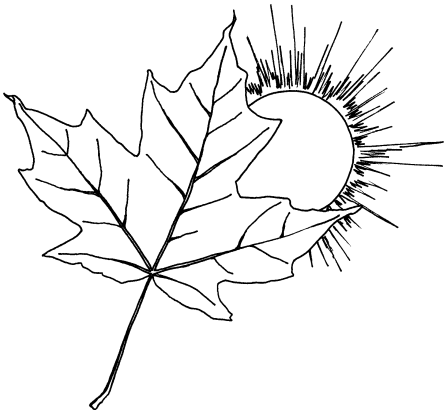
We have a long family tradition of education. Our grandmothers graduated from normal school in the 1920's to become teachers. Brian's mother was an elementary school teacher and guidance counselor, and his father was a high school teacher and superintendent. This family tradition inspired Brian to become a science teacher, and to earn a Ph.D. in education, and lead Stephanie to work on science education programs at NASA.

In developing this video, accompanying teacher's guide, and student activities, our goal is to provide educators with the highest quality materials, enabling students to be successful. In this era of more demanding standards and assessment requirements, supplementary materials need to be curricular and standards based - this is what we do!

Our videos and accompanying materials focus on the key concepts and vocabulary required by national and state standards and goals. It is our mission to help students meet these goals and standards, while experiencing the joy and thrill of science.

Sincerely,

Brian and Stephanie Jerome



National Standards Correlations

National Science Education Standards

(Content Standards: 5-8, National Academy of Sciences, c. 1996)

Science as Inquiry - Content Standard A:

As a result of activities in grades 5-8, all students should develop:

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

Life Science - Content Standard C:

As a result of their activities in grades 5-8, all students should develop an understanding of:

- Structure and function in living systems
- Regulation and behavior
- Diversity and adaptations of organisms

Benchmarks for Science Literacy

(Project 2061 - AAAS, c. 1993)

The Living Environment

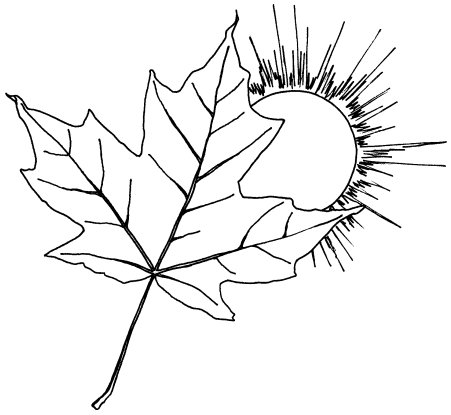
By the end of the eighth grade, students should know that:

• One of the most general distinctions among organisms is between plants, which use sunlight to make their own food, and animals, which consume energy-rich foods.

• Animals and plants have a great variety of body plans and structures that contribute to their being able to make or find food and reproduce.

• All living things are composed of cells, from just one to many millions, whose details usually are visible only through a microscope.

• Food provides the fuel and building material for all organisms. Plants use the energy from light to make sugars from carbon dioxide and water.

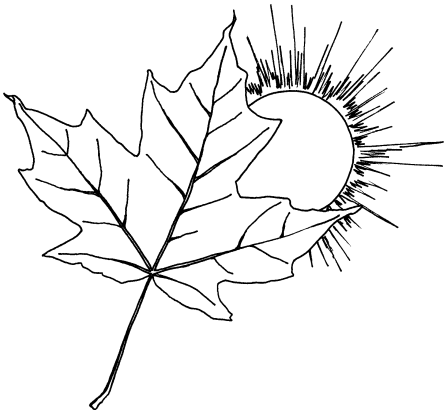


Student Learning Objectives

Video and Student Activities

Upon viewing the video and completing the enclosed student activities, students should be able to do the following:

- Understand plant pigments and how they affect plant color;
- Explain the role of chloroplasts in plant cell structure and photosynthesis;
- Describe the chemical process of photosynthesis;
- Identify the products of photosynthesis and how they are vital to everyday life;
- Understand the structure of leaves and how it relates to photosynthesis;
- Understand the concept of a stimulus;
- Explain phototropism, thigmotropism and gravitropism;
- Differentiate between positive and negative tropisms;
- Understand seed structure; and
- Describe the five stages in the process of germination.



Assessment

Preliminary Test:

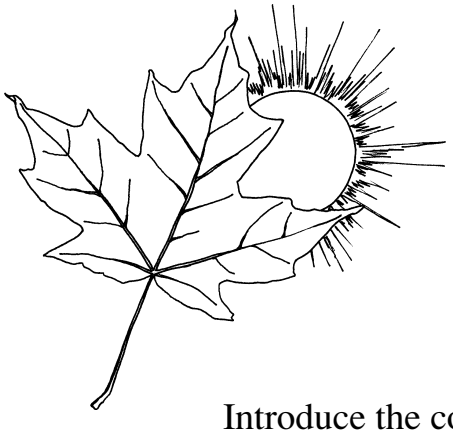
The Preliminary Test, provided in the Student Masters section, is an assessment tool designed to gain an understanding of student preexisting knowledge. It can also be used as a benchmark upon which to assess student progress on the objectives stated on the previous pages.

Video Review:

The Video Review, provided in the Student Masters section, can be used as an assessment tool or as a student activity. There are two main parts. The first part contains questions titled "You Decide" that can be answered during the video. The second series of ten questions consists of video review questions to be answered at the conclusion of the video.

Post-Test:

The Post-Test, provided in the Student Masters section, can be utilized as an assessment tool following student completion of the video and student activities. The results of the Post-Test can be compared against the results of the Preliminary Test to assess student progress.



Introducing the Video

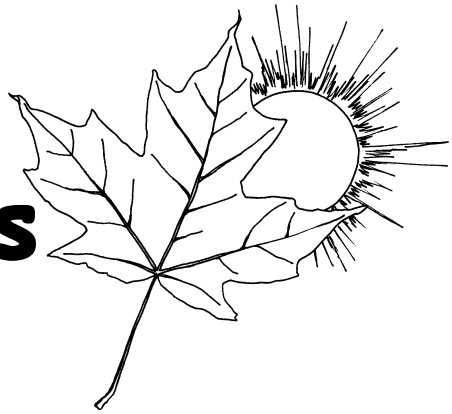
Introduce the concept of photosynthesis by allowing students a few minutes to formulate and then share a general definition of photosynthesis with the class. Divide the class into small groups. Ask each group to make a list of the ways in which the process of photosynthesis affects our everyday lives. Remind students to consider both the ingredients and the products of photosynthesis. Allow the students five to ten minutes to discuss the topic. Have a representative from each group write their list on the chalkboard. Discuss the examples as a class. Now have the groups formulate a list of ways in which plants respond to their environment. Add this list to that already on the chalkboard. Leave the lists on the board during the video. Upon completion of the program, ask the students for additional examples they may have learned from the video.

Video Viewing Suggestions

You may want to photocopy and distribute to students the video review provided in the Student Master. You may choose to have your students complete this Master while viewing the program or to do so upon its conclusion.

The program is approximately 20 minutes in length and includes a ten-question video quiz. Answers are not provided to the Video Quiz on the video, but can be found in the teacher's guide. You may want to grade student quizzes as an assessment tool, or review the answers in class.

The video is content-rich with numerous vocabulary words. For this reason you may want to periodically stop the video to review and discuss new terminology and concepts.



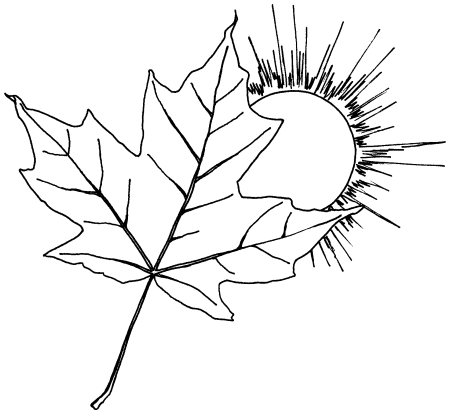
Student Assessments and Activities

Assessment Masters:

- Preliminary Test
- Video Review
- Post-Test

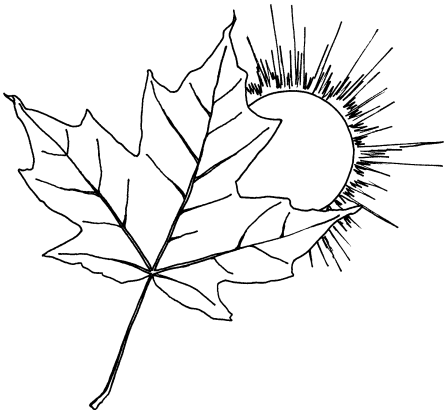
Student Activity Masters:

- Phototropism Lab
- Seeing Stomata
- Leaf Pigment Lab : Introduction to Chromatography
- Plant Vocabulary
- Seed Structure
- Stages of Sprouting: Germination



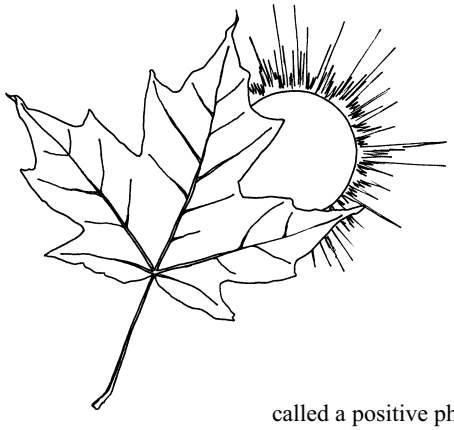
Video Script- *Photosynthesis and Plant Responses*

1. The sun is the star in our solar system around which the planets, including Earth, revolve.
2. Without the sun we would not have light or life.
3. The sun is the furnace that fuels all life on our planet.
4. All life depends on the energy provided by the sun.
5. Plants have developed the remarkable ability to directly use energy from the sun to produce food.
6. Photosynthesis is the process of plants utilizing the sun's light energy along with carbon dioxide and water to produce chemical energy and oxygen.
7. Photosynthesis is derived from the Greek words photo, meaning light, and the word synthesis, meaning to put together. Photosynthesis involves creating or putting together food using energy derived from light. Photosynthetic organisms are autotrophic, meaning they produce their own food or energy.
8. Photosynthesis is certainly one of the most important processes that occurs on our planet.
9. Without photosynthesis, most life as we know it, including human life, would cease to exist.
10. During the next few minutes we are going to take an in depth look at photosynthesis, as well as plant growth and responses.
11. **Graphic Transition- Light and Photosynthesis**
12. This is a rainbow. As you can see, it is made up of the colors red, orange, yellow, green, blue, indigo, and violet.
13. **You Decide!** Where do the colors in the rainbow come from?
14. The colors in the rainbow come from sunlight, also called white light.
15. When white light passes through raindrops...
16. ...or through a glass prism, as seen here, it gets separated into different component colors.
17. Most green leaves absorb all these colors except green and yellow.
18. Green is reflected back and is the color we usually see when looking at a plant.
19. Plants contain pigments that help them capture the energy in light. Chlorophyll is one of the most important pigments in a plant since it converts the energy in light to make food.
20. The pigment chlorophyll is dominant in trees in temperate areas during the summer, giving trees and grasses their green appearance.
21. As the growing season draws to a close, the chlorophyll pigment often becomes less dominant...
22. ...and other pigments are revealed, as seen in these colorful leaves.
23. These colors come from the other pigments called accessory pigments, such as the orangish carotenoids dominant in carrots.
24. **Graphic Transition - Chloroplasts**
25. As we just discussed, chlorophyll and other pigments are responsible for trapping energy from the sun and converting it to chemical energy that the plants can use to make food.
26. **You Decide!**
27. Where is the pigment chlorophyll found in a plant?
28. The pigment chlorophyll is found in the parts of plant cells called chloroplasts.
29. The small, round, green structures seen here in leaf cells under the microscope are called chloroplasts.
30. While chloroplasts are common to all green plant cells,...
31. ...they are not found in animal cells.
32. **Graphic Transition- Chemical Reactions in Photosynthesis.**
34. Without photosynthesis, life that depends on oxygen, including humans and other animals, would cease to exist.
35. It is estimated that plants provide 90% of the oxygen that we and other animals, such as this bee, breathe.
36. Photosynthesis is undoubtedly one of the most prevalent chemical reactions on Earth.
37. It is also one of the most complex. In the process of photosynthesis, plants take in a gas called carbon dioxide.
38. Carbon dioxide is a common gas in the atmosphere.
39. When we and other animals breathe out, or exhale, we exhale carbon dioxide.
40. Plants also utilize water during the process of photosynthesis.



Script

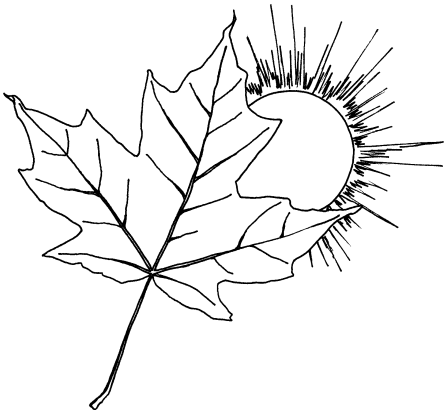
41. Water may be in the form of water vapor from the air or may be precipitation, such as rain.
42. The driving force in photosynthesis is light. As we already have discussed, plants trap light energy from the sun and convert it to chemical energy.
43. Chlorophyll and other accessory pigments play the major role, capturing light energy.
44. Via a series of complex chemical reactions, plants use carbon dioxide, water, and light to produce energy, which we and other animals depend on everyday.
45. **Graphic Transition-Products of Photosynthesis**
46. When resting, you breathe about 15 to 20 times per minute.
47. But when you exercise heavily, you breathe in as many as 50 to 75 times per minute.
48. **You Decide!**
49. What product of photosynthesis do we breath in?
50. Oxygen is an extremely important product, or result, of photosynthesis.
51. This woman and her team of oxen need oxygen to carry out normal body functions.
52. This oxygen exists in the air. Most of the oxygen we breath is produced by organisms that carry out photosynthesis.
53. Plants also produce another important product as a result of photosynthesis- a simple sugar called glucose.
54. Glucose is commonly used as food for the plant. Plants need glucose to live, grow, and reproduce.
55. Plants also use glucose to produce other chemicals they need to survive.
56. Glucose is also very important to animals that eat plants, serving as a vital source of energy.
57. **Graphic Transition- Chemical Equations for Photosynthesis**
58. As with most chemical reactions, a chemical equation can help interpret the reaction.
59. The chemical reaction for photosynthesis can be illustrated by a chemical equation that begins with carbon dioxide and water.
60. Light energy drives this process resulting in a carbohydrate, or simple sugar, and oxygen.
61. It is this simple sugar, glucose, that the plant uses for its energy.
62. **Graphic Transition- Leaves and Photosynthesis**
63. The view of the landscape from this hillside reveals a sea of green. The green color comes from leaves.
64. Leaves are the dominant photosynthetic structures of plants.
65. How are leaves designed to carry out photosynthesis? Let's take a closer look at a typical leaf.
66. The outer layer of the leaf is called the epidermis. It is commonly covered with a waxy coating called the cuticle. This waxy coating helps prevent water loss.
67. Underneath the upper epidermis layer is a layer of cells referred to as the Palisade layer. It is in this layer where most of the photosynthesis occurs.
68. Beneath the palisade layer is a layer of cells called the spongy mesophyll.
69. This layer has many air spaces between the cells, allowing oxygen, carbon dioxide, and water vapor to fully exchange between cells and the atmosphere.
70. Gases enter and exit leaves through tiny holes called stomata.
71. The amount of water vapor leaving the leaf is controlled by stomata.
72. Transpiration is the process of water leaving a plant's leaves.
73. Plants have the potential to lose large amounts of water. If they lose too much, they wilt, as has this plant.
74. **Graphic Transition-Plant Responses**
75. Have you ever wondered why a house plant leans toward an open window,...
76. ...or noticed how roots automatically grow downward into the soil?
77. In both of these cases, the plant is responding to a stimulus.
78. A stimulus is anything in the environment that causes an organism to change its behavior.
79. When a plant responds to a stimulus, it is exhibiting a tropism.
80. There are three main types of tropisms, all of which you probably see everyday.
81. In the case of the leaning house plant, the plant is responding to light. This is called phototropism.
82. These sunflowers also respond to light, following the path of the sun throughout the day. This response can be



Script

called a positive phototropism.

83. We see examples of positive phototropisms all around us everyday. For example, trees grow tall, toward the sun, spreading out their leaves to maximize their exposure to the sun.
84. **You Decide!**
85. What part of a plant exhibits a negative phototropism?
86. The roots of a plant exhibit a negative phototropism. They grow downward, away from the sun. But roots experience another kind of tropism as well.
87. This second type of plant response is called gravitropism, also referred to as geotropism. Gravitropism is a plant's response to gravity.
88. Roots are positively gravitropic because they grow in the same direction as the pull of gravity - down.
89. A third type of tropism is called thigmotropism. Thigmotropism is a plant's response to touch.
90. Watch what happens to this mimosa leaf when it is touched.
91. The blades of the leaves fold inward, away from the finger that touched it. Since the mimosa plant responded by moving away from the stimulus, this is called a negative thigmotropism.
92. We now understand plant responses, as well as how plants use photosynthesis to produce food for growth.
93. Now let's explore how plant growth begins.
94. **Graphic Transition: Seed Structure**
95. The beginning stages, or the "sprouting up", of a seedling is called germination.
96. Before we can fully understand germination, we must first be familiar with seed structure.
97. We see seeds around us all the time.
98. We eat them when we eat sunflower seeds...
99. ...or when we eat peanuts.
100. You probably have encountered seeds while eating fruit, but have you ever thought about the importance of seeds?
101. Seeds are the structures from which a new plant grows.
102. The seed is surrounded by a seed coat. This coat protects the inner tissues of the seed.
103. Inside the seed is the young plant, called the embryo. This is the part of the seed that will give rise to a mature plant.
104. Embryos contain 1 or 2 seed leaves called cotyledons. This is where the seed stores food necessary to grow.
105. Some embryos have one seed leaf. These seeds are called monocots. A corn seed is a monocot seed.
106. Other embryos have two cotyledons, such as the bean seed. These seeds are called dicots and are able to store all of their food in these two seed leaves.
107. **Graphic transition: Germination**
108. As we have already learned, the beginning stages of growth in a plant are called germination.
109. Once a seed has made its home in the soil, its next step is to begin germination. But germination does not always occur right away.
110. Seeds may remain dormant in the soil anywhere from a few weeks to many years, waiting for the best conditions to begin germinating.
111. **You Decide!**
112. What conditions are necessary for a seed to begin germination?
113. Most seeds require moist, warm environments to begin germinating.
114. The process begins when the seed absorbs water from the soil.
115. In the second stage of growth, the seed coat splits open and a primary root emerges.
116. Next, the primary root continues growing from the root tip down into the soil.
117. In the next step, a primary shoot grows upward, out of the soil and toward the sun.
118. Finally, the root system and the shoot enlarge to form a fully mature plant.
119. **Graphic Transition - Summing Up**
120. During the past few minutes we have explored the process of photosynthesis in plants.
121. We have learned that the products of photosynthesis, glucose and oxygen, are not only important for plant growth,...



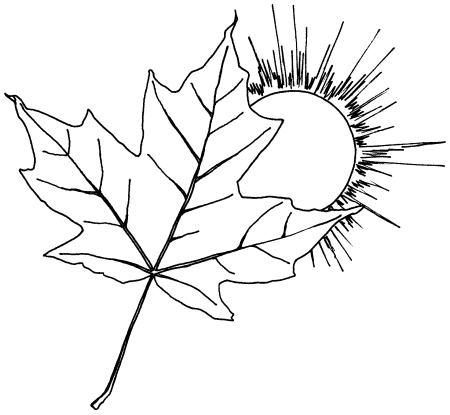
Script

122. ...but are vital to the survival of plants and animals as well.
123. We explored the structure of leaves, as well as their role in the process of photosynthesis.
124. In addition to photosynthesis, we investigated different plant tropisms, including phototropism gravitropism, and thigmotropism.
125. Finally, we took a look at seed structure...
126. ...and the process of germination.
127. So next time you see a plant, remember how important the process of photosynthesis is to our lives. You might just gain a new respect for the plants around you.

Video Quiz

Fill in the correct word when you hear the tone. Good luck and let's get started.

1. The green color of plants is caused by _____.
2. _____ are small, round, green structures containing pigments in the plant cell.
3. One product of photosynthesis that is commonly used as food is _____.
4. The dominant photosynthetic structures of plants are the _____.
5. _____ is the process of water escaping from plant leaves.
6. A _____ is anything in an environment that causes an organism to change its behavior.
7. When a plant responds to light it is exhibiting _____.
8. The inner tissues of a seed are protected by the ____ _____.
9. _____ is a plant's response to gravity.
10. The beginning stage of growth of a plant is called _____.



Answers to Student Assessment

Preliminary Test

1. photosynthesis
2. green
3. chlorophyll
4. chloroplasts
5. leaves
6. light
7. tropism
8. cotyledons
9. gravitropism
10. moist
11. True
12. False
13. True
14. False
15. False
16. False
17. True
18. True
19. False
20. False

Video Review

You Decide:

A. The colors in the rainbow come from sunlight.

B. The pigment chlorophyll is found in structures of plants cells called chloroplasts.

C. oxygen

D. the roots

E. Moist and warm conditions are necessary to initiate germination.

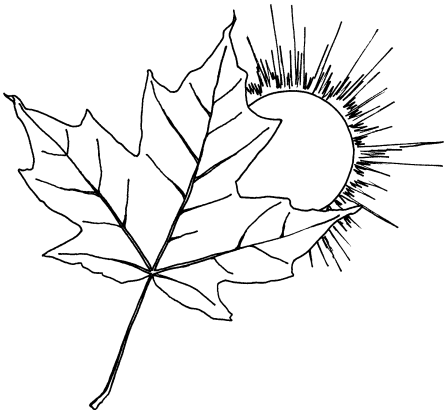
Video Quiz:

1. chlorophyll
2. chloroplasts
3. glucose
4. leaves
5. transpiration
6. stimulus
7. phototropism
8. seed coat
9. gravitropism
10. germination

Post Test

1. True
2. False
3. True
4. False
5. False
6. True
7. False
8. False
9. True
10. False
11. moist
12. green
13. chloroplasts
14. tropism
15. gravitropism
16. photosynthesis
17. cotyledons
18. leaves
19. light
20. chlorophyll

Answers to Student Activities



Phototropism lab

Conclusions: The seedlings exposed to the light through the hole in the milk carton should be growing toward the light. The other seedlings should not be growing toward the light source. The cells on the side opposite the light source elongate and grow, causing the plant to bend in the direction of the light. The tropism is positive because the plant is growing toward the stimulus.

Leaf Pigment Lab

Observations:

1. Colors will vary
2. Colors will vary
3. You should extract pigments not originally visible on the leaf.

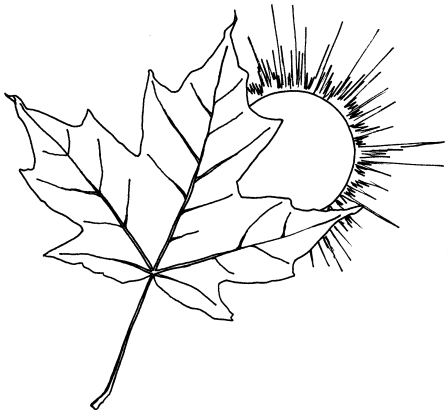
Conclusions: When sunlight is abundant, chlorophyll is continually produced, masking the carotenoids and the anthocyanins. Therefore, although other pigments may be present, the leaf would appear green.

Seeing Stomata

Conclusions: Sketches of stomata will vary.

More stomata should be open than closed.

Stomata allow water, carbon dioxide and oxygen to enter and exit the leaf. This gas exchange allows the raw materials for photosynthesis to enter leaves and the products to exit.



Answers to Student Activities

Vocabulary Lesson

1. photosynthesis
2. cotyledons
3. radicle
4. chloroplasts
5. stimulus
6. chlorophyll
7. endosperm
8. gravitropism
9. transpiration
10. phototropism
11. thigmotropism
12. hypocotyl
13. tropism
14. germination
15. carbon dioxide

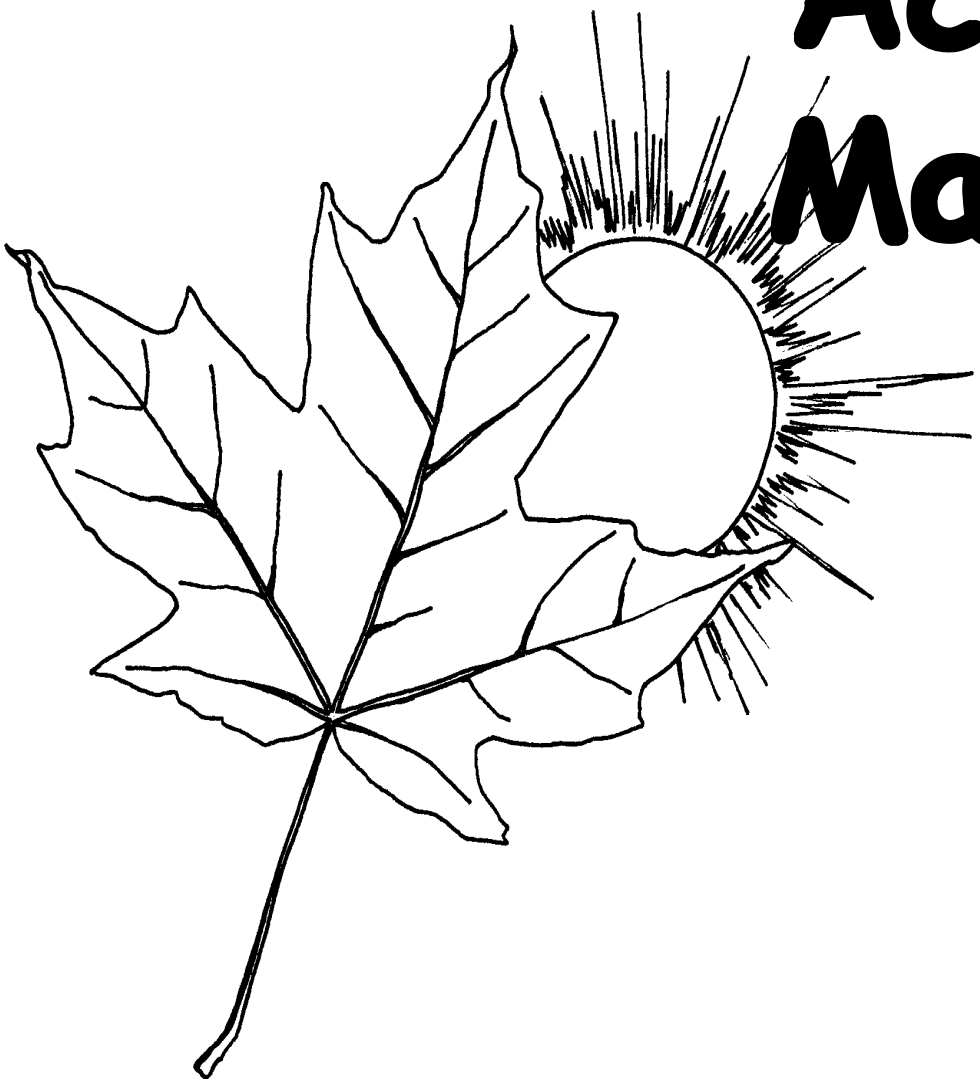
Seed Structure

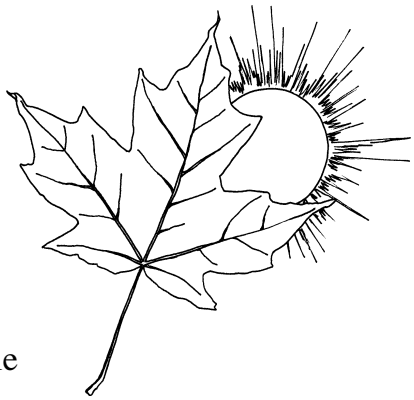
1. epicotyl
2. hypocotyl
3. radicle
4. seed coat
5. cotyledon
6. endosperm
7. cotyledon
8. epicotyl
9. hypocotyl
10. radicle

The Stages of Sprouting : Germination

* order = E, A, B, D, C

Assessment and Student Activity Masters



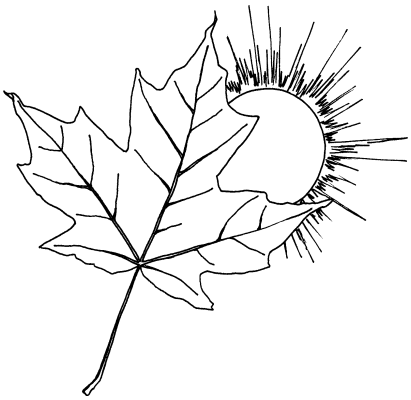


Preliminary Test

Directions: Fill in the blank with the correct word. A list of possible answers is provided at the bottom of the page.

1. The ability of plants to use energy from the sun to produce food is called _____.
2. The color _____ is reflected by most plants we see around us.
3. _____ is responsible for trapping light for plants to use in making food.
4. Chlorophyll is found in the _____ of plants.
5. The majority of photosynthesis carried out by a plant occurs in the _____.
6. Water, carbon dioxide, and _____ are the raw materials used in photosynthesis.
7. A plant's response to a stimulus is called a _____.
8. All seed embryos contain seed leaves also known as _____.
9. _____ is a plant's response to gravity.
10. Warm, _____ conditions are necessary to initiate germination.

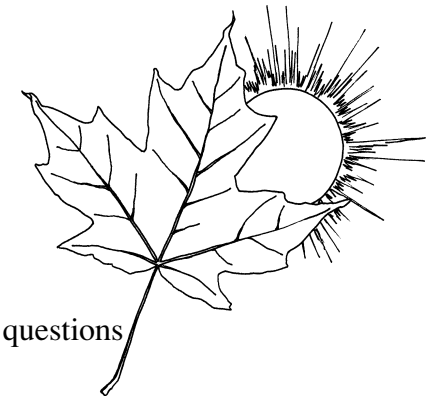
gravitropism
endosperm
light
embryo
photosynthesis
chlorophyll
leaves
chloroplasts
moist
cotyledons
tropism
green



Preliminary Test

Directions: Decide if the answer is True (T) or False (F).

11. Plants contain pigments that help them absorb sunlight.	T	F
12. During photosynthesis, a plant takes in glucose and oxygen to produce carbon dioxide and water.	T	F
13. Light energy drives the process of photosynthesis.	T	F
14. The palisade layer in leaves is below the spongy mesophyll.	T	F
15. Transpiration is the process of water entering plant leaves.	T	F
16. Thigmotropism is a plant's response to heat.	T	F
17. When a plant grows toward a stimulus, it is exhibiting a positive tropism.	T	F
18. Dicot seeds have two cotyledons, or seed leaves.	T	F
19. The primary root emerges from the seed in the last stage of germination.	T	F
20. Seeds germinate as soon as they are in soil.	T	F



Video Review

Directions: During the course of the program answer the "You Decide" questions as they are presented in the video.

You Decide!

A. Where do the colors in the rainbow come from? Answer:_____

B. Where is the pigment chlorophyll found in a plant? Answer:_____

C. What product of photosynthesis do we breathe in? Answer:_____

D. What part of a plant exhibits a negative phototropism? Answer._____

E. What conditions are necessary for a seed to begin germination? Answer._____

Video Quiz

1. The green color of plants is caused by _____.

2. _____ are small, round, green structures containing pigments in the plant cell.

3. One product of photosynthesis that is commonly used as food is _____.

4. The dominant photosynthetic structures of plants are the _____.

5. _____ is the process of water escaping from plant leaves.

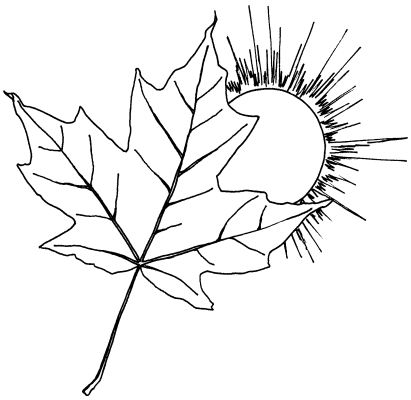
6. A _____ is anything in an environment that causes an organism to change its behavior.

7. When a plant responds to light, it is exhibiting _____.

8. The inner tissues of a seed are protected by the _____ _____.

9. _____ is a plant's response to gravity.

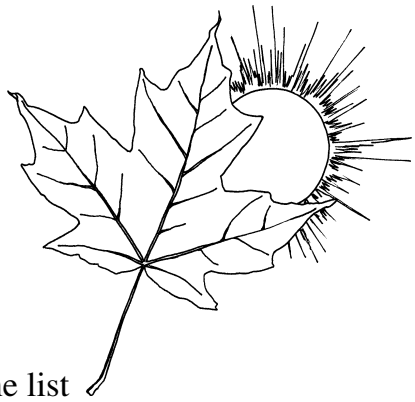
10. The beginning stage of growth of a plant is called _____.



Post Test

Directions : Decide if the answer is True (T) or False (F).

1. Dicot seeds have two cotyledons.	T	F
2. Transpiration is the process of water entering plant leaves.	T	F
3. Light energy drives the process of photosynthesis.	T	F
4. Seeds germinate as soon as they are in soil.	T	F
5. The primary root emerges from the seed in the last stage of germination.	T	F
6. Plants contain pigments that help them absorb light.	T	F
7. Thigmotropism is a plant's response to heat.	T	F
8. The palisade layer in leaves is below the spongy mesophyll.	T	F
9. When a plant grows toward a stimulus, it is exhibiting a positive tropism.	T	F
10. During photosynthesis, a plant takes in glucose and oxygen to produce carbon dioxide and water.	T	F



Post Test

Directions: Fill in the blank with the correct word. Choose from the list of possible answers at the bottom of the page.

11. Warm, _____ conditions are necessary to initiate germination.

12. The color _____ is reflected by most plants we see around us.

13. Chlorophyll is found in the _____ of plants.

14. A plant's response to a stimulus is called a _____.

15. _____ is a plant's response to gravity.

16. The ability of plants to use energy from the sun to produce food is called _____.

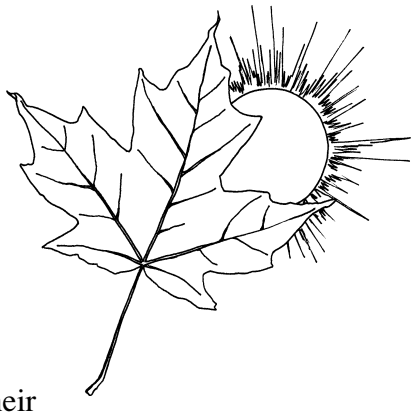
17. All seed embryos contain seed leaves also known as _____.

18. The majority of photosynthesis carried out by a plant occurs in the _____.

19. Water, carbon dioxide, and _____ are the raw materials used in photosynthesis.

20. _____ is responsible for trapping light for plants to use in making food.

green	light
gravitropism	chloroplasts
photosynthesis	leaves
tropism	chlorophyll
moist	cotyledons
endosperm	embryo



Phototropism Lab

Objective:
In this lab activity you will observe one way in which plants respond to their environment. Plants will be manipulated in order to demonstrate phototropism, a plant's response to light.

Background:
All living things change their behavior in response to what is going on in their environment. As we have already learned, anything in an environment that causes an organism to change its behavior is called a stimulus. A tropism is defined as the plant's responses to a stimulus. A tropism may be positive, meaning that the plant grows toward the stimulus, or it may be negative, meaning that the plant grows away from the stimulus. One of the most common tropisms that plants exhibit is called phototropism. Phototropism is a plant's response to light. When a plant is exposed to light, the cells on the side of the leaf opposite the light source grow and become longer. This causes the plant to bend in the direction of the light source.

Materials:
Two half-gallon milk cartons
Black paint
Paintbrush
Ten pea seeds
Soil
Scissors
Two plastic cups

Procedure:
1. Cut off the tops of the two milk cartons and paint the inside of the cartons black.
2. Fill each of the plastic cups 3/4 full with damp soil.
3. Plant five seeds in each cup. Make sure the kernels are just beneath the top of the soil.
4. Cut a hole, 1 cm in diameter, in the side of one milk carton.
5. Place the cups in a well-lit area. Place a milk carton over each cup. Make sure that the carton with the hole in it is situated so that light can shine through the hole.
6. Examine the seedlings after a few days. Record your observations.

Conclusions:
Describe any differences between the two groups of seedlings. Form a hypothesis to explain these differences. Is the observed tropism positive or negative?

Seeing Stomata

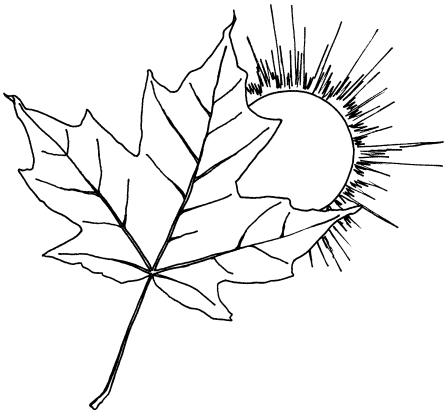
Objective:
In this lab activity you will use a microscope to observe the structure and function of stomata in the leaves of green plants.

Background:
We have already learned that on the leaves of all green plants are small openings called stomata. The stomata are located in the epidermis of the leaf and allow for gas exchange between the plant and the air. The opening and closing of the stomata is controlled by guard cells. Guard cells surround each stomate and control its activity according to the weather conditions that the plant is experiencing. Since water vapor commonly escapes from the stomata, the guard cells will close the opening when the plant's environment is very dry. When the environment has received a lot of rain and water loss is not a problem, the stomata remain open. Let's take a firsthand look at the structure and function of stomata!

Materials:
Microscope
Microscope slide
Spinach leaves in a dish of water
Salt solution
Coverslip
Tweezers

Procedure:
1. Remove a leaf of spinach. It should be spongy from having absorbed the water from the dish.
2. Using the tweezers, remove the epidermis covering the leaf. The epidermis is the outermost, transparent layer.
3. Place a small piece of this tissue onto a microscope slide and cover it with a cover slip.
4. Examine the tissue under low and high power. Try to identify the stomata and guard cells.

Conclusions:
Make a sketch of the stomata and the surrounding guard cells. Were the majority of the stomata open or closed? Form a hypothesis to explain why. Judging from your observations, what is the role of the stomata and how does this role relate to photosynthesis?

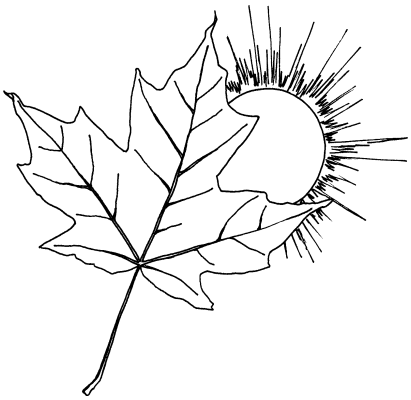


Leaf Pigment Lab: Introduction to Chromatography

Objective:
In this lab activity you will use a process called **paper chromatography** to separate the different pigments found in leaves.

Background:
Every fall the leaves on trees change from green to brilliant oranges, yellows, and reds. The appearance of these colors would not be possible without a number of pigments found in leaves. **Chlorophyll** gives leaves their green color in the spring and summer seasons. It also plays an important role in photosynthesis by trapping light energy from the sun, which is later used to turn carbon dioxide and water into food. A second group of pigments, called the **carotenoids**, produce yellow, orange and brown colors. The deep reds and purples we see in the autumn are a result of the third group of pigments called the **anthocyanins**. Together, these three pigments provide us with beautiful foliage every fall. During the spring and summer seasons, leaves produce chlorophyll continuously and therefore remain green. As autumn approaches and the night grows longer, less sunlight is available for plants. As a result, plants are unable to carry out photosynthesis at the same rate as they did during the growing season. When a plant is not undergoing photosynthesis, there is no need for chlorophyll. When chlorophyll production ceases, the beautiful colors produced by carotenoids and anthocyanins are revealed.

Materials:
Leaves
Small glass jar (beakers)
Aluminum foil
Rubbing alcohol
Paper coffee filters
Large, shallow pan
Tape
Glass stirring rod



Leaf Pigment Lab

Procedure:

1. Collect 4-5 small leaves from a few different tree species.
2. Tear these leaves into small pieces and place each species in its own jar.
3. Add enough rubbing alcohol to each jar so that the leaves are covered.
4. Cover each jar loosely with aluminum foil. Fill the shallow pan with approximately one inch of hot tap water and place the jars in the pan.
5. Allow the jars to sit in the water for a half-hour or until the alcohol has become darkly colored. Be sure to twirl the jar every five to ten minutes.
6. Remove the jars from the water and uncover them.
7. Place a thin strip of coffee filter paper in each jar so that its tip is submerged in the alcohol. Tape the other end of the paper to the top of the jar.
8. Allow the jar to sit for about an hour (maybe longer). The pigments from the leaf should travel up the filter paper.
9. Let the filter paper dry and observe the different shades of color extracted from the leaf.

Observations:

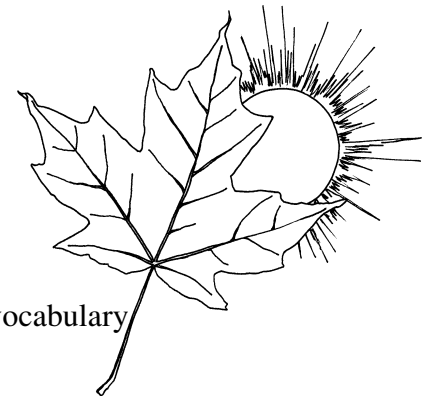
1. What color were the leaves before running the paper chromatography?

2. What colors were found on the filter paper?

3. Were all of the colors found on the filter paper evident on the leaves you collected?

Conclusions

Classify the colors found on the filter paper as a product of either chlorophyll, carotenoids, or anthocyanins. Explain how it is possible that pigments extracted from the leaf were not noticeable before the experiment.



Plant Vocabulary

Directions: Fill in the blanks with the letters necessary to complete the vocabulary word that corresponds with the given definition.

1. **_ _ o t _ s y _ t _ _ s i _** : the process plants use to make food and oxygen from water and carbon dioxide.

2. **c _ _ y l _ d _ _ s** : seed leaves found in plant embryos.

3. **_ a d _ c l _** : part of the plant embryo that gives rise to the root system.

4. **_ _ l o r _ p l _ s t _** : plant cell structures that contain pigments for trapping light.

5. **s _ _ m u l _ s** : anything in an environment that causes an organism to change its behavior.

6. **c _ _ o r _ p h _ l _** : pigment found in all green plants that is responsible for trapping light energy from the sun for photosynthesis.

7. **_ _ d o _ p _ r m** : tissue surrounding the plant embryo that stores food for the seed.

8. **g r _ _ i t _ o p _ _ _** : a plant's response to gravity.

9. **_ r a n _ _ i _ a t _ o _** : the loss of water vapor via the stomata in the leaves.

10. **_ h o _ o _ r o _ i _ _** : a plant's response to light.

11. **_ h i g _ _ _ r _ p i _ _** : a plant's response to touch.

12. **_ _ p o c _ t y _** : part of the plant embryo that becomes the lower stem of the plant.

13. **_ _ o p _ s m** : a plant's response to a stimulus in its environment.

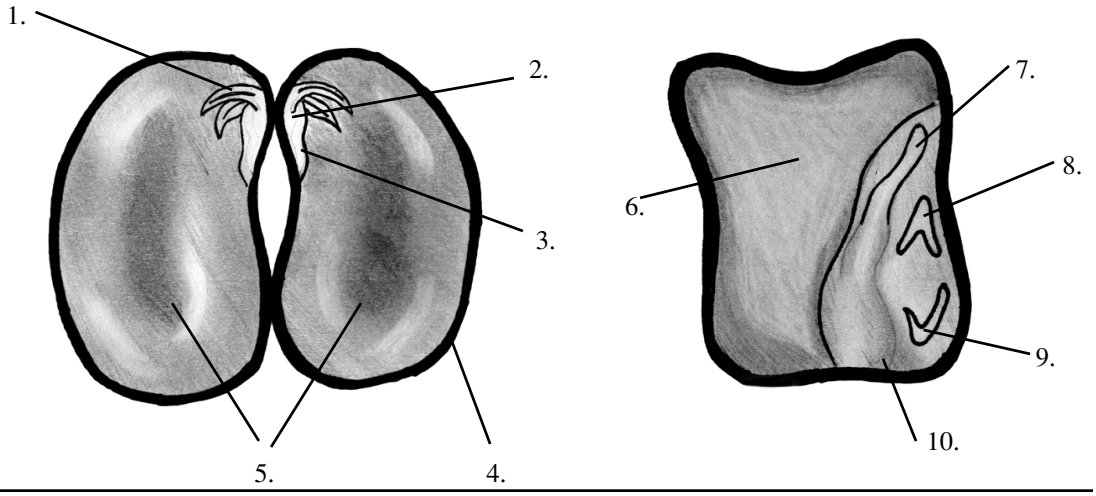
14. **_ e r _ i n _ _ i o _** : the beginning stages of the growth of a plant.

15. **c_ _ rb_ _ _io_ _ d _** : a common gas in the atmosphere that humans exhale and plants take in.

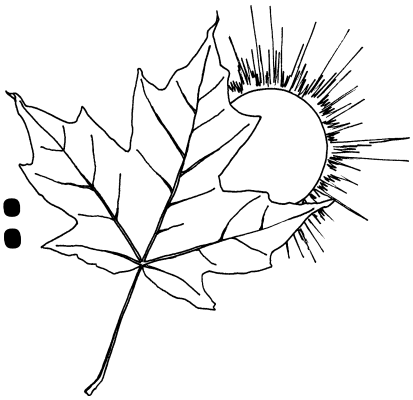
Seed Structure

Background:
We all know that a seed grows into a mature plant. But how does this happen? In order to fully understand plant growth, we must first explore the structure of seeds. A seed consists of three main parts. The **seed coat** is the outermost layer of the seed and acts as a tough, protective covering. It develops from the ovule wall. Within the seed is the young plant, also known as the **embryo**. The embryo in all seeds consists of at least one cotyledon. A **cotyledon** is a seed leaf. Seeds which have one cotyledon are called **monocots,** while seeds with two cotyledons are called **dicots**. The embryo consists of three parts in addition to the cotyledons. The **epicotyl** is the part of the embryo found above the point where the embryo is attached to the cotyledon. This part of the embryo will develop into the leaves and upper stem of a plant. The **hypocotyl** can be found just below the point where the embryo attaches to the cotyledon. It usually gives rise to the lower part of the plant's stem. The lowermost part of the embryo is called the **radicle**. The radicle is located below the hypocotyl and develops into the roots of the plant. When a seed has matured, it will remain dormant until it encounters the best conditions to begin growth. While the seed awaits these conditions, it survives on stored food. In monocots, the stored food is found in the area surrounding the embryo, called the **endosperm**. There is no endosperm in dicots since two large cotyledons make up most of the embryo. Therefore, food is stored in the cotyledons of dicots. When conditions are right, both these types of seeds will use their stored food to begin germination!

Directions: Label the parts of both types of seeds using the following terms: *endosperm, radicle, seed coat, cotyledon, epicotyl,* and *hypocotyl.*



Stages of Sprouting: Germination



Background:
Once a seed finds its way to a new home in the soil, its next step is to begin growing. The beginning stages of the growth of a seed are called germination. However, germination does not always occur right away. Germination will only occur when conditions are favorable. Some seeds will remain dormant for anywhere from a few weeks to many years! Most seeds require a moist, warm environment to begin the process of germination. Germination will begin when the seed absorbs water. The water activates the seed's ability to use the food it has stored. In the second stage of germination, the embryo's growth causes the seed coat to split open and the primary root, or radicle, forces its way into the soil. Next, the primary root responds to gravity and continues to grow from the root tip down into the soil. In the fourth stage, the primary shoot grows upward toward the sun, shedding the seed coat. The primary shoot includes the hypocotyl and epicotyl of the seed. Finally, the roots and shoot enlarge to become a fully mature plant.

Directions: Cut out the following five stages of germination and place them in the correct order on the back of this worksheet.