# Science Ch. 5

Plants

NASA

Career

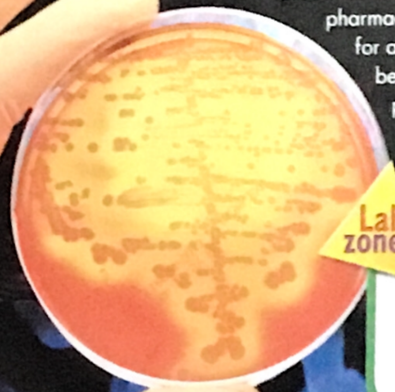
# Pharmacologist

**A pharmacologist is a scientist who studies and develops new drugs that help people and animals. These medical researchers are concerned with every part of the human body. They use scientific methods to try to find new ways to prevent and cure disease. They test new drugs to make sure they work and are safe. For example, some new drugs have helped treat cancer and heart disease.**

As a pharmacologist you might work in a medical school, a pharmaceutical (drug) company, a research laboratory, a government agency, or a university. In any of these places, you might spend the day working with other researchers and doing experiments. You might also spend a lot of time in the library looking for information about a particular disease or drug.

If you like studying about the human body and animals and how chemicals can affect them, then you might like being a pharmacologist. Becoming a pharmacologist takes a lot of work, though. Most pharmacologists go to college for at least six years. You can begin preparing to be a pharmacologist now by studying science and math.

Emily M. Holton, Ph.D., is a pharmacologist who works at NASA's Ames Research Center. She is studying the effect of gravity on human bone growth and development. Her study is important because in the weightlessness of space, astronauts might lose bone strength.



Lab zone

## Take-Home Activity

Suppose you are a pharmacologist developing a drug to cure a disease. What disease would you choose to find a cure for? Why?



Chapter 5

# Plants

Discovery Channel School Student DVD

online Student Edition
pearsonsuccessnet.com

## You Will Discover

- what the parts of a vascular plant are.
- how photosynthesis and respiration are related.
- how plants grow.

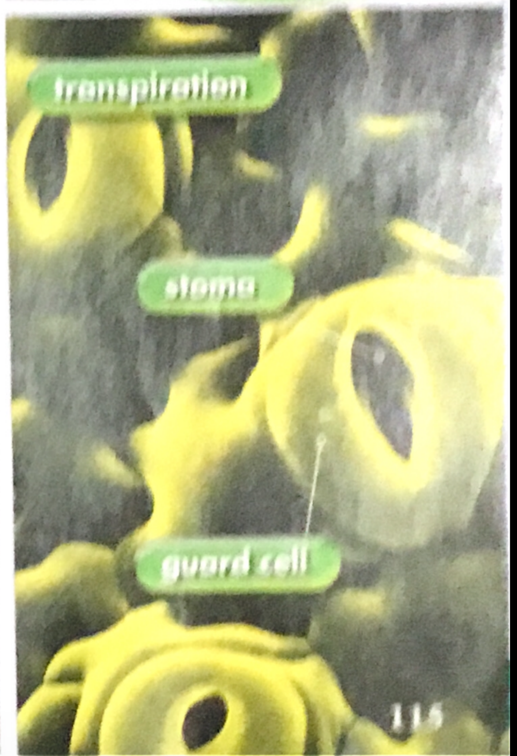
Build Background

# What processes take place in plants?


## Chapter 5 Vocabulary







## You Are There!

As you walk by the farmer's field, you can feel the warmth of the sunlight. The songs of birds fill the air. You glance down. What's that? You take a closer look. Small seedlings are beginning to break through the soil. How do these small plants grow into such large sunflowers? What will happen inside these plants as they grow?



AudioText

Lesson 1

# What are the parts of a vascular plant?

*Roots anchor a plant and absorb water and minerals from the soil. Leaves use the water to make food in the form of glucose for the plant. Stems provide support and transport water, minerals, and the glucose the plant makes.*

## Roots

Colorful flowers swaying back and forth in a garden on a windy day are beautiful. But why don't the plants blow away? The answer is found underground—the roots. A plant's roots spread throughout the soil and anchor the plant in the ground, even on a windy day. Some plants have one large root, called a taproot, with many smaller roots growing out from it. Carrots are taproots. Other plants, such as sunflowers, have a system of smaller roots that spread outward like the branches of a tree. A plant's root system may be as large as the part of the plant you see above ground.

Roots take in water and minerals from the soil. These materials enter the root through its **epidermis**, the thin outer layer of cells. The many tiny root hairs on the epidermis make it possible for the roots to take in more water from the soil than if the roots were smooth. From the epidermis, water and minerals move through a layer of cells to the xylem. **Xylem** moves water and minerals from the roots to other parts of a plant. It is part of the vascular system in all plants.

Another type of vascular tissue is phloem. **Phloem** carries sugars made in the leaves throughout the plant. Roots store some of these materials, usually in the form of starch. Carrots and sweet potatoes are roots that store food.


**The xylem of this plant root is made of long, narrow cells that are connected end to end. As the cells get older, only their cell walls remain, forming tubes throughout the plant. Phloem is made of living cells.**

1. **Checkpoint** Name three functions of roots.
2. **Compare and Contrast** How are the functions of xylem and phloem alike and different?

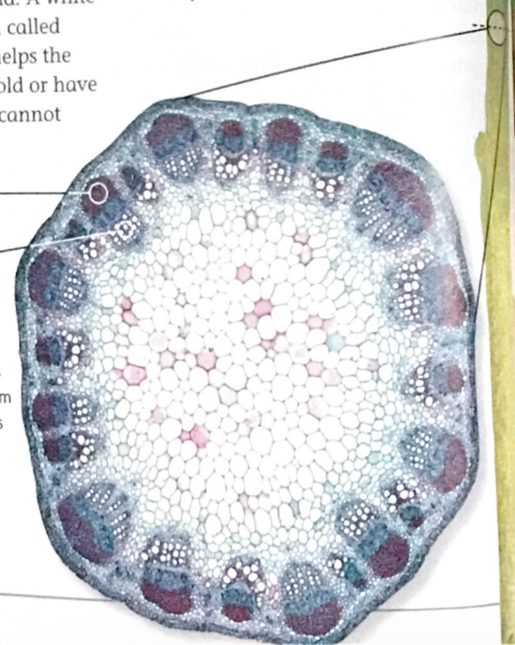
## Stems

Stems can be straight or curved, short or tall, smooth or rough. But no matter what they look like, all stems help give the plant support. Like roots, stems have xylem and phloem, which move water, minerals, and glucose between the roots and leaves of the plant.

Plants with stems that are green and easy to bend are called herbaceous plants. The stems of herbaceous plants often die in cold weather, but their roots continue to live. Herbaceous plants grow new stems each year. Clover, grasses, and poppies are just a few of the many kinds of herbaceous plants.

Some stems, such as a tree trunk, are rigid and strong. Plants with this kind of stem are called woody plants. Woody plants often grow tall and may last many years. Trees, shrubs, and most vines are woody plants. Some woody plants may lose their leaves for part of the year, but their stems do not die.

Some stems grow underground. A white potato is an underground stem called a tuber. Food stored in tubers helps the plants survive times that are cold or have little rain—times when plants cannot make the sugar they need.




### Cut Across a Stem

In many herbaceous plants, such as this sunflower, the xylem and phloem are found in bundles. These bundles form a ring. The xylem and phloem of other plants may be arranged differently, but xylem is always closer to the center of the stem.



## Leaves

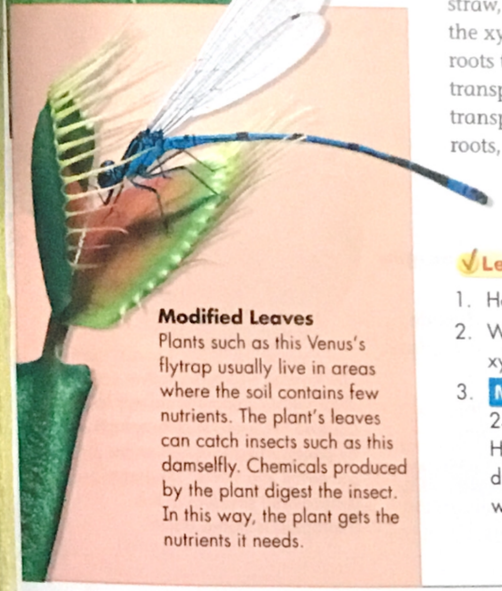
When you look at a plant, what is the first thing you notice? Often it is the leaves. Most leaves vary in shape and size, but all have one function in common—to make food in the form of glucose for a plant. During this process, water and gases pass in and out of the plant through small holes in the epidermis of the leaf. Each small hole is called a **stoma** (plural, stomata). Surrounding each stoma is a pair of guard cells. The two **guard cells** work together to open and close a leaf's stoma.

Sunlight can cause guard cells to take in water. The increased amount of water puts more pressure on the walls of the guard cells. This pressure forces the guard cells into a curved shape. When this happens, the stomata open. Most stomata are open in the daytime and closed at night.

When stomata open, gases from the air enter the leaf and water passes out of the leaf. This loss of water from the leaf is called **transpiration.** Air temperature, wind, and the amount of water in the air and the soil affect how much water is lost through transpiration.

As water moves out of a leaf, more water moves up through the xylem. Like drinking with a straw, transpiration pulls more water up through the xylem. Plants need most of the water their roots take in to replace the water lost during transpiration. When more water is being lost to transpiration than is being taken in by a plant's roots, the plant may wilt.


When the stomata are open, carbon dioxide from the air moves into the leaf. At the same time, water and the oxygen that is produced when plants make glucose pass out of the plant.



**Modified Leaves**
Plants such as this Venus's flytrap usually live in areas where the soil contains few nutrients. The plant's leaves can catch insects such as this damselfly. Chemicals produced by the plant digest the insect. In this way, the plant gets the nutrients it needs.

### Lesson Checkpoint

1. How do guard cells open and close stomata?
2. What causes water to move upward through xylem?
3. **Math in Science** A single corn plant can lose 245 liters of water in one growing season. How much water must be available in the soil during the growing season to replace that water in a field of 10,000 corn plants?

Lesson 2

# How do plants get and use energy?

*The leaves of a plant make glucose that contains energy, which the plant can use for life functions. Cells break down the glucose to release the energy stored in them.*

## Photosynthesis

If you walk through the forest in the spring, you might see many colors of flowers. But if you look at the leaves of many different plants, they are mostly green. What is so special about the color green?

Leaves and other parts of plants are green because of chlorophyll, which is a green substance in the chloroplasts of plant cells. Chlorophyll enables a plant to make its own food in the form of glucose. Animal cells don't contain chlorophyll, so animals cannot make their own food.

The process in which plants make glucose is called **photosynthesis.** During photosynthesis, plants use light energy from the Sun, carbon dioxide from the air, and water to make glucose and oxygen. In the process, energy is stored in the glucose. Plants and organisms that eat plants can use the glucose as a source of energy for life processes.

Photosynthesis can only take place in the presence of chlorophyll. The process of photosynthesis can be summarized in an equation.

$$\text{carbon dioxide} + \text{water} \xrightarrow[\text{chlorophyll}]{\text{light energy}} \text{glucose} + \text{oxygen}$$

Notice in the equation that plants use carbon dioxide and release oxygen during photosynthesis. Most organisms could not live without the oxygen plants produce.

The leaves of plants have many adaptations that enable the plant to carry on photosynthesis. Study the diagram to see how a leaf is adapted to carry on photosynthesis.

The layered structures in this chloroplast contain the chlorophyll. Glucose produced in chloroplasts by photosynthesis may then be converted into starch. The large light-colored structure in this chloroplast is stored starch.

## Leaf Structure

A waxy layer called the cuticle may cover a leaf and slow water loss.

The top and bottom of the leaf are covered with a layer of cells called the epidermis. This thin layer allows light to easily pass into the middle of the leaf.

Photosynthesis takes place in the middle of the leaf. These tall, thin cells absorb much of the sunlight that enters the leaf. In these cells are many chloroplasts that a plant needs to make sugar.

The veins of a leaf contain its xylem and phloem. Water and minerals enter the leaf through the xylem. Sugar made by the leaf moves to the rest of the plant through the phloem.

Cells in this part of the leaf are spread apart farther than other cells in the leaf. The air spaces surrounding cells allow the carbon dioxide that is needed for photosynthesis to move freely throughout the leaf.

Most leaves have more stomata on the lower epidermis. Less light reaches under the leaf, so the lower part is cooler and less water is lost through transpiration.

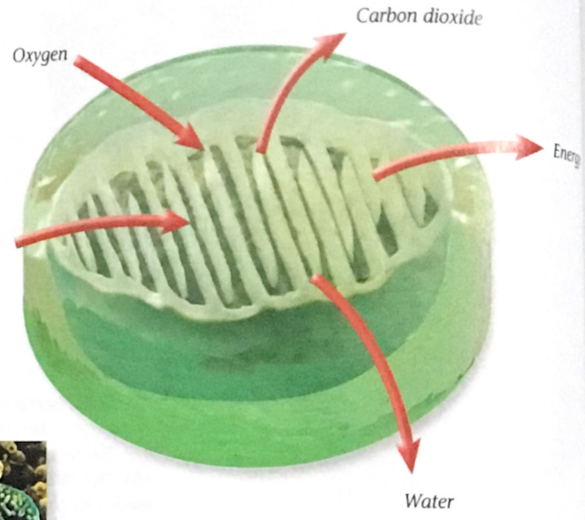
1. **Checkpoint** Describe three ways a plant's leaf is adapted for photosynthesis.
2. **Writing in Science** **Expository** Write a paragraph that explains the process of photosynthesis. Use the terms *roots, chloroplasts, xylem, phloem, stomata, glucose,* and *oxygen.*

## Energy from Food

On sunny days, plants can make more glucose than they need. What happens to this extra glucose? Plants change the extra glucose into other kinds of sugars and starches, which they can store. To use the stored food when they need it, plants must break it down to release the energy it contains. In fact, all organisms must break down food to release the stored energy. **Cellular respiration** is the process by which cells break down glucose with the release of energy.

Cellular respiration begins in the cytoplasm of cells. Here glucose is broken down into simpler substances. If the cell contains oxygen, these simpler substances move into the mitochondria of the cell. The mitochondria use oxygen to further break down the simpler substances. This process produces carbon dioxide and water, and energy is released. Because a mitochondrion releases energy, it sometimes is called the powerhouse of a cell. The process of cellular respiration can be summarized like this:

**glucose + oxygen ⟶ carbon dioxide + water + energy**




**Cellular Respiration in a Mitochondrion**

The blue structure in this electron microscope image is a mitochondrion. Chemical reactions take place on the many folds in the mitochondrion.




Both plants and animals give off carbon dioxide during cellular respiration.

## Carbon Dioxide–Oxygen Cycle

You may have noticed that the equations for photosynthesis and cellular respiration look a lot alike. In fact, look at these two equations again.

**carbon dioxide + water** $\xrightarrow[\text{chlorophyll}]{\text{light energy}}$ **glucose + oxygen**

**glucose + oxygen ⟶ carbon dioxide + water + energy**

The processes are almost the reverse of each other. The materials produced during one process are the same materials that are needed for the other process. In other words, they form a cycle. Together, photosynthesis and cellular respiration form the carbon dioxide–oxygen cycle.

The carbon dioxide–oxygen cycle can be summarized in this way: Day and night, animals breathe oxygen from the air. Plants take in oxygen and carbon dioxide through their leaves. During respiration, both plants and animals use oxygen to change energy in food to energy they can use. They give off carbon dioxide. Plants use some of the energy and carbon dioxide to produce more food and oxygen in the process of photosynthesis. The carbon dioxide–oxygen cycle assures that living things do not run out of the oxygen and carbon they need.

**Lesson Checkpoint**

1. What do plants need to carry on photosynthesis?
2. Why do most leaves have more stomata on the lower epidermis than on the upper epidermis?
3. **Compare and Contrast** How does the role of energy differ in photosynthesis and cellular respiration?

Lesson 3

# How do plants grow?

*Some plants produce seeds in flowers. Other plants produce seeds in cones. The conditions that plants need to grow vary among species. Plants have behaviors that are responses to the environment.*

## Angiosperms

A tiny seedling just starting to emerge from a seed is the first step in the growth of a plant that may later produce seeds. Some seed plants, called angiosperms, produce flowers. Angiosperms can be found in almost every land environment. In fact, scientists have identified between 200,000 and 300,000 species of angiosperms. Only insects have more species than angiosperms. Some examples of angiosperms include the peach tree in the picture, as well as tulips, grasses, daylilies, orchids, oak trees, grapes, tomatoes, and apples.

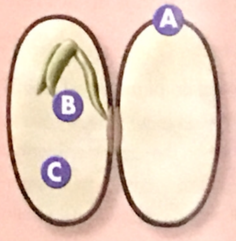
All angiosperms are vascular plants. They have specialized tissues for transporting materials throughout the plant. You read about these tissues—xylem and phloem—earlier in this chapter. The seeds of angiosperms form after pollination and fertilization. Most seeds develop in a fruit, which protects the seeds until they can begin to grow.

Humans depend on angiosperms in many ways. We use them as food crops and to make medicines. Lumber, cloth, rubber, perfumes, and cork are other products made from angiosperms.

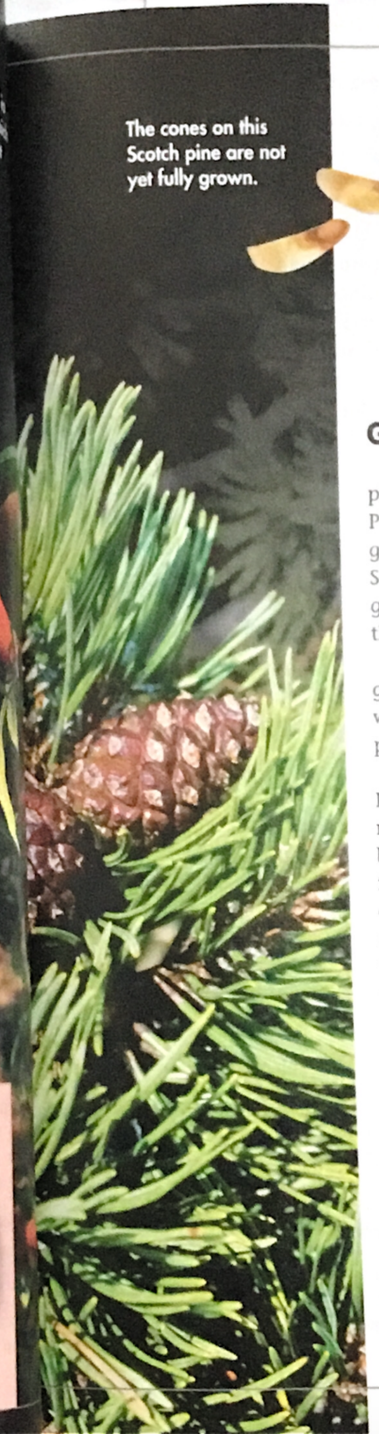
The fruit of this peach tree protects the seed. The seed is contained in a hard pit, which also protects it and keeps it from drying out.

### Parts of a Seed

- **A** The seed coat protects the embryo and cotyledon.
- **B** The embryo is the part of a seed that grows into a new plant. In some seeds, the first true leaf is visible at the tip of the embryo.
- **C** The cotyledon is sometimes called the seed leaf, but it isn't a true leaf. Cotyledons contain food that nourishes the plant until it can make its own food. This seed is called a dicot. It has two cotyledons. Some plants, called monocots, only have one cotyledon.





The cones on this Scotch pine are not yet fully grown.

Conifer cones, like this one, are covered with woody scales. The scales are modified leaves. The seeds are not protected by fruits.

## Gymnosperms

You probably have seen cones like the one in the picture. Did you know that seeds develop in the cones? Plants that produce their seeds in cones are called gymnosperms. These plants do not produce flowers. Some of the oldest living organisms on Earth are gymnosperms. One type, the redwood, can live for thousands of years.

You probably are most familiar with one type of gymnosperm—the conifers. Conifers are woody plants with needles or scalelike leaves. The Scotch pine in the picture is a conifer.

Conifers have two types of cones—male and female. Female cones contain ovules with egg cells. Male cones make pollen that contains sperm. Pollen is carried, often by wind, from male cones to female cones. Sperm then fertilize the egg cells. After fertilization, the female cone closes up, and seeds grow within it. The cone remains closed until its seeds are mature. This process may take up to two years. When the seeds are mature, they are released and fall to the ground. Unlike angiosperms, the seeds of gymnosperms are not contained in fruits.

Gymnosperms are important as sources of wood and materials for paper products. Paints often are made with gymnosperm materials. Oils from gymnosperms are used as air fresheners, disinfectants, and scents in soaps and cosmetics. Gymnosperm seeds are a source of food.

1. **Checkpoint** Name the three main parts of a seed and tell the function of each.
2. **Compare and Contrast** Draw a graphic organizer that shows how angiosperms and gymnosperms are alike and different.

## Germination and Growth

An embryo can only grow so large within the seed. Then the seed must wait until conditions in its environment are right for it to germinate. A plant germinates when it starts to grow from a seed. Each plant species needs certain conditions for germination and growth.

All seeds need a certain temperature to germinate. In cold climates seeds germinate in spring or early summer when the soil and air warm. Seeds also need water—to break open the seed coat. A plant that germinates in a tropical rain forest probably needs a higher temperature and more moisture than a plant that grows in a colder, drier climate.

Seeds need oxygen. When a seed coat opens, more oxygen can reach the cells of the embryo, and the cells get larger. Then they divide to make new cells. If the seeds get too much moisture, they may not get enough oxygen, and growth will not take place. Instead the seed will rot.

If conditions are not right, some seeds may become inactive, sometimes for long periods. This helps protect the embryo inside the seed. Some inactive seeds can survive conditions that would kill a growing plant. For example, some seeds can survive severe droughts, freezing temperatures, and forest fires.

Wheat seeds

Spores

## The Growing Plant

When a seed germinates, a root begins to grow downward, and the stem begins to grow upward. A plant gets larger by producing new cells at the tips of its roots and stems. Branches on the plant's stem may grow from side buds. Some plants have growth that increases the plant's width. Cells also divide to repair damaged tissue in the plant.

Not all plants grow from seeds. Mosses and ferns produce spores from which plants grow. You can see in the table how spores and seeds differ. But spores, too, can only develop into plants if conditions are right. For most spore-producing plants that means plenty of water is available.

| Spore | Seed |
|---|---|
| Contains a single cell that grows into a new plant | Contains a multicellular embryo that develops into a new plant |
| Does not contain stored food | Contains stored food |
| Is usually very small | Can vary in size |



**Phototropism is a response to light. Growth chemicals cause stems to bend toward light. Roots, however, bend away from light.**

**The response of a plant to gravity is geotropism. Even though germination took place in darkness, the roots of this corn seedling grew downward and the stem grew upward.**

## Responding to the Environment

Have you ever wondered why roots grow down and stems grow up? The reason is that plants, like all living organisms, respond to their environments. You may not think that plants have behaviors because plant behavior is not easy to see. But plants bend, droop, twist, and turn.

Unlike animals, plants do not have nerves to control behaviors. Instead behaviors can result from chemicals the plants make. Chemicals cause the cells in different parts of the plant to grow at different rates. Cells on one side of a stem may grow faster than the cells on the opposite side. As you can see in the diagram, this uneven growth causes the stem to bend.

All the plants on this page are showing some kind of behavior. They are growing either toward or away from something in their environment. Plant behavior caused by growth toward or away from something in the environment is called a **tropism**. For example, the roots of many plants grow toward water. This response of plants to water is called hydrotropism.

**Lesson Checkpoint**

1. At what three places does growth take place on a plant?
2. Why are tropisms important to a plant?
3. **Compare and Contrast** How are seeds and spores alike and different?

**Thigmotropism is a response to touch. A plant that has positive thigmotropism grows toward a surface that it touches. Plants with negative thigmotropism grow away from a surface.**

**During thigmotrophism cells on the side where the plant touches a surface grow more slowly.**

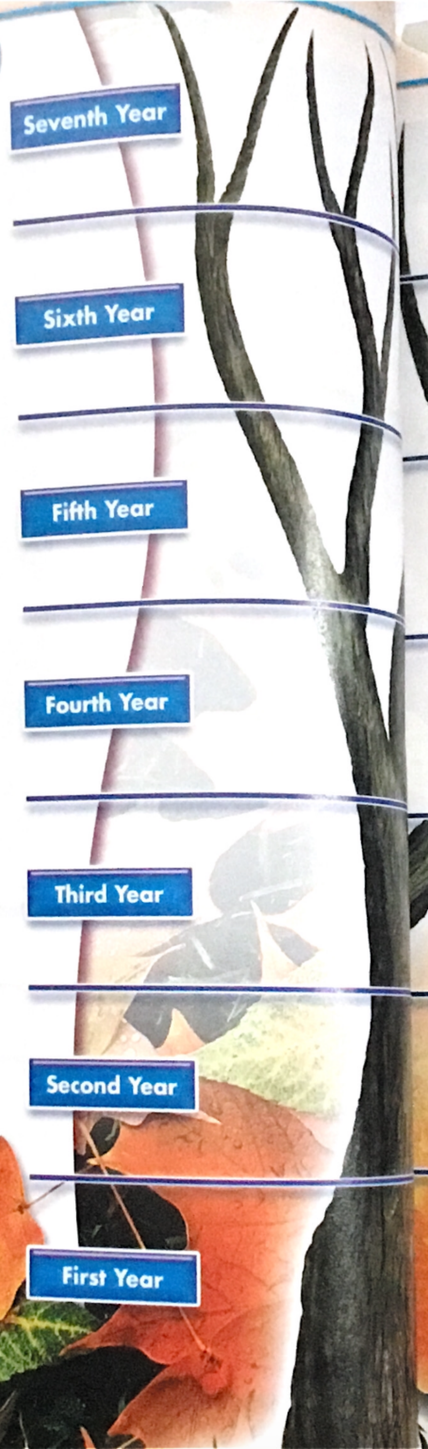
Math in Science

# Number Patterns in Plants

**Many different number patterns can be seen in plants. One number pattern is seen in the growth patterns of trees, the number of petals on a flower, the arrangement of leaves on a stem, and the pattern of seeds on the seed head of a flower.**

One pattern is the Fibonacci sequence, discovered in the 13th century by an Italian mathematician, Leonardo Fibonacci. The diagram at the right shows how the Fibonacci sequence appears in the growth pattern of a tree.

In a sequence of numbers, each number in the pattern is called a term. Each term in the Fibonacci sequence is the sum of the previous two terms. If you start with 1, the first five terms of the sequence are 1, 1, 2, 3, 5.




| Year | Number of Branches |
|---|---|
| First year | 1 branch |
| Second year | 1 branch |
| Third year | 2 branches |
| Fourth year | |
| Fifth year | |
| Sixth year | |
| Seventh year | |

Use the diagram to answer the questions.

1. Copy and complete the chart above.
2. If the tree shown in the diagram continued this growth pattern, what would be the number of branches for the eighth year?
3. Suppose a large tree grows for 15 years according to the pattern of the Fibonacci sequence. Make a table showing the number of branches in each year of growth. How many branches would there be in the 15th year?

## Lab zone Take-Home Activity

Use library resources to find examples of the Fibonacci sequence in flowers, shells, or elsewhere in nature. Write a report including diagrams.

# Chapter 5 Review and Test Prep

## Use Vocabulary

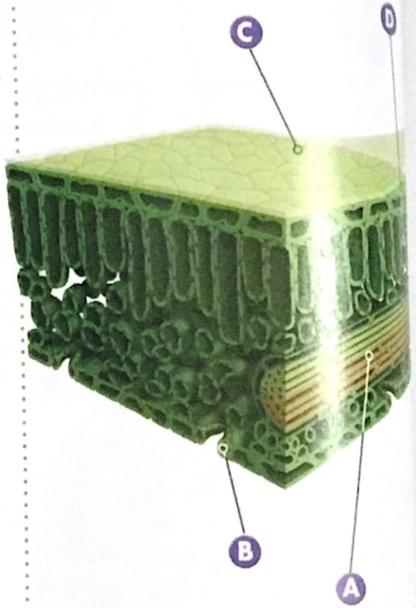
| | |
|---|---|
| **cellular respiration** (p. 124) | **photosynthesis** (p. 122) |
| **epidermis** (p. 119) | **stoma** (p. 121) |
| **guard cell** (p. 121) | **transpiration** (p. 121) |
| **phloem** (p. 119) | **tropism** (p. 129) |
| | **xylem** (p. 119) |

Choose the vocabulary term from the list above that matches each description.

1. This leaf part opens to allow water and gases to enter and leave a leaf.
2. Sugar made by the plant flows through this plant tissue.
3. This part of a leaf opens and closes a stoma.
4. During this process, cells of organisms release energy from food.
5. An example of this behavior is a plant growing toward sunlight.
6. During this process, water is lost from the leaf of a plant.
7. This plant structure carries water and minerals throughout a plant.
8. During this process, green plants make glucose.

## Explain Concepts

9. Name and describe two plant tropisms.
10. Why is chlorophyll important to plants?
11. The picture below shows the inside of a leaf. Identify each part that is labeled with a letter. Also tell how each part is an adaptation that helps the plant carry on photosynthesis.





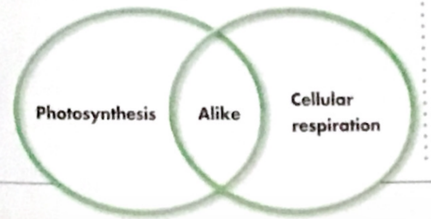

## Process Skills

| | Species A | Species B | Species C |
|---|---|---|---|
| Stem | rigid and strong | green, easy to bend | rigid and strong |
| Flowers | yes | yes | no |

12. **Classify** The table describes three species of plants. Classify each species as an angiosperm or a gymnosperm and as woody or herbaceous.
13. **Model** Make diagrams to show where xylem and phloem are found in roots and stems. Label the diagrams to show the function of each kind of tissue.

## Compare and Contrast

14. Make a graphic organizer like the one shown below. Write the letters of the descriptions in the correct parts of the diagram to compare and contrast photosynthesis and cellular respiration.
    - A releases oxygen
    - B produces carbon dioxide
    - C occurs in mitochondria
    - D occurs in chloroplasts
    - E performed by plants
    - F performed by animals




## Test Prep

Choose the letter that best completes the statement or answers the question.

15. Which of the following describes cellular respiration?
    - Ⓐ breaks down glucose, produces oxygen
    - Ⓑ breaks down glucose, produces carbon dioxide
    - Ⓒ breaks down carbon dioxide, produces oxygen
    - Ⓓ breaks down carbon dioxide, produces glucose
16. What is inside pollen?
    - Ⓕ eggs
    - Ⓖ ovules
    - Ⓗ seeds
    - Ⓘ sperm
17. A plant with green stems that lives only one season is a
    - Ⓐ woody plant
    - Ⓑ conifer
    - Ⓒ tuber
    - Ⓓ herbaceous plant
18. Which of the following plants produces spores that grow into new plants?
    - Ⓕ fern
    - Ⓖ Scotch pine
    - Ⓗ peach tree
    - Ⓘ grass
19. Explain why the answer you chose for Question 18 is best. For each of the answers you did not choose, give a reason why it is not the best choice.
20. Writing in Science **Descriptive** Suppose you are going to plant some seeds in your garden. Write a paragraph that describes the conditions you must consider in order for your seeds to germinate.