Photosynthesis

Guide for Reading
- How does the sun supply living things with the energy they need?
- What happens during the process of photosynthesis?

The sun is the source of energy for most living things. All cells need energy to carry out their functions. The process by which a cell captures the energy in sunlight and uses it to make food is called **photosynthesis**.

**Nearly all living things obtain energy either directly or indirectly from the energy of sunlight captured during photosynthesis.** Plants, such as grass, use energy from the sun to make their own food through the process of photosynthesis. An organism that makes its own food is called an **autotroph**. An organism that cannot make its own food is called a **heterotroph**. Many heterotrophs obtain food by eating other organisms.

Photosynthesis is a complex process. **During photosynthesis, plants and some other organisms use energy from the sun to convert carbon dioxide and water into oxygen and sugars.** Photosynthesis takes place in two stages: (1) capturing the sun’s energy and (2) producing sugars. In plants, this energy-capturing process occurs mostly in the leaves. The chloroplasts in plant cells give plants their green color. The green color comes from **pigments**, colored chemical compounds that absorb light. The main photosynthetic pigment in chloroplasts is **chlorophyll**. Chlorophyll captures light energy and uses it to power the second stage of photosynthesis to produce sugars. The cell needs two raw materials for this stage: water (H$_2$O) and carbon dioxide (CO$_2$). Plant roots absorb water from the soil, and the water then moves up to the leaves. Carbon dioxide enters the plant through small openings on the undersides of the leaves called **stomata**. Once in the leaves, the water and carbon dioxide move into the chloroplasts.

Inside the chloroplasts, the water and carbon dioxide undergo a complex series of chemical reactions and produce two important products of photosynthesis: sugar and oxygen. Plant cells use sugar for food and to make other compounds, such as cellulose. Plant cells also store sugar for later use. Oxygen exits the leaf through the stomata. Almost all of the oxygen in Earth’s atmosphere was produced by living things through photosynthesis. The events of photosynthesis can be summed up by the following chemical equation:

\[
\text{light energy} \\
6 \text{ CO}_2 + 6 \text{ H}_2\text{O} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6 \text{ O}_2
\]

**Cell Processes and Energy**

Section Summary
Photosynthesis

This section explains how plants make food by using the energy from sunlight.

Use Target Reading Skills

As you read, create a flowchart that shows the steps in photosynthesis. Put each step in a separate box in the flowchart in the order in which it occurs.

**Sources of Energy**

1. In the process of photosynthesis, plants use the energy in ______________________ to make food.
2. Complete the following table about how living things use the sun’s energy.

<table>
<thead>
<tr>
<th>How Living Things Use Energy From the Sun</th>
</tr>
</thead>
<tbody>
<tr>
<td>Living Thing</td>
</tr>
<tr>
<td>--------------</td>
</tr>
<tr>
<td>Grass</td>
</tr>
<tr>
<td>Zebra</td>
</tr>
<tr>
<td>Lion</td>
</tr>
</tbody>
</table>

**The Two Stages of Photosynthesis**

3. List the two stages in the process of photosynthesis.
   a. ____________________________
   b. ____________________________

4. The green pigment in chloroplasts, called ____________________, absorbs light energy from the sun.

5. Is the following sentence true or false? Besides the energy in sunlight, the cell needs water and carbon dioxide to make sugar. ________________________

6. What are stomata?
   ____________________________
   ____________________________
Cell Processes and Energy  •  Guided Reading and Study

7. Circle the letter of each product of photosynthesis.
   a. water
   b. carbon dioxide
   c. oxygen
   d. sugars

8. Is the following sentence true or false? Photosynthesis produces the carbon dioxide that most living things need to survive. ________________________

The Photosynthesis Equation

9. Write the chemical equation for the process of photosynthesis.

10. What word does the arrow in the chemical equation stand for?

11. Circle the letter of each raw material of photosynthesis.
   a. carbon dioxide
   b. glucose
   c. water
   d. oxygen

12. Circle the letter of each sentence that is true about the products of photosynthesis.
   a. Plant cells use the sugar for food.
   b. Some of the sugar is made into other compounds, such as cellulose.
   c. Some of the sugar is stored in the plant’s cells for later use.
   d. Extra sugar molecules pass out of the plant through the stomata.
Photosynthesis

Understanding Main Ideas
Fill in the blanks in the photosynthesis equation below with the names of the missing compounds. Then answer the questions that follow in the spaces provided.

\[
\text{sunlight} \quad 1. \quad + \quad 2. \quad \rightarrow \quad 3. \quad + \quad 4. \quad
\]

5. What are the raw materials of photosynthesis?

________________________________________________________________________

6. What are the products of photosynthesis?

________________________________________________________________________

7. Why is \textit{sunlight} written above the arrow in the equation, rather than on either side of it?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

8. Where does photosynthesis occur?

________________________________________________________________________
________________________________________________________________________

Building Vocabulary
Fill in the blank to complete each statement.

9. The process by which a cell captures the energy in sunlight and uses it to make food is called \______________.

10. \______________ are colored chemical compounds that absorb light.

11. The main pigment found in the chloroplasts of plants is \______________.

12. \______________ are small openings on the undersides of leaves through which carbon dioxide enters a plant.

13. An organism that makes its own food is a(n) \______________.

14. A(n) \______________ is an organism that cannot make its own food.
Chlorophyll and the Color of Light

A pigment is a colored chemical compound that absorbs light. You can think of a pigment as a kind of sponge that absorbs light of all colors except the ones that it transmits and reflects. The colors that you see are the colors of light that the pigment reflects. The bar graph below shows the percentages of light of different colors that are reflected by the plant pigment chlorophyll.

**Percent of Visible Light Reflected by Chlorophyll**

<table>
<thead>
<tr>
<th>Color of light</th>
<th>Percent of visible light reflected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Violet</td>
<td>10</td>
</tr>
<tr>
<td>Blue</td>
<td>10</td>
</tr>
<tr>
<td>Green</td>
<td>90</td>
</tr>
<tr>
<td>Yellow</td>
<td>70</td>
</tr>
<tr>
<td>Orange</td>
<td>50</td>
</tr>
<tr>
<td>Red</td>
<td>40</td>
</tr>
</tbody>
</table>

**Answer the following questions on a separate sheet of paper.**

Which color of light does chlorophyll reflect most? About what percent of light of this color does chlorophyll reflect?

Which color of light does chlorophyll absorb most? About what percent of light of this color does chlorophyll absorb?

At least 50 percent of light of a given color must be reflected to be visible. Which colors of light do you see when you look at a “green” leaf?

Which colors of light do you not see when you look at a “green” leaf?

Explain in your own words how chlorophyll makes a leaf look green.
Respiration

Guide for Reading

- What events occur during respiration?
- What is fermentation?

Cells store and use energy in a way that is similar to the way you deposit and withdraw money from a savings account. When you eat a meal, you add to your body’s energy savings account. When your cells need energy, they make a withdrawal by breaking down the carbohydrates in food to release energy.

The process by which cells obtain energy from glucose (a type of sugar) is called respiration. During respiration, cells break down simple food molecules such as sugar and release the energy they contain. Because living things need a continuous supply of energy, the cells of all living things carry out respiration continuously. The term respiration also is used to mean breathing, that is, moving air in and out of your lungs. To avoid confusion, the respiration process that takes place inside cells sometimes is called cellular respiration. The two kinds of respiration are related. Breathing brings oxygen into your lungs, and oxygen is necessary for cellular respiration to occur in most cells.

Like photosynthesis, respiration is a two-stage process. The first stage takes place in the cytoplasm of the organism’s cells. There, glucose molecules are broken down into smaller molecules. Oxygen is not involved in this stage of respiration, and only a small amount of energy is released. The second stage of respiration takes place in the mitochondria. There, the small molecules are broken down into even smaller molecules. These chemical reactions require oxygen, and a great deal of energy is released. Two other products of respiration are carbon dioxide and water.

Photosynthesis and respiration can be thought of as opposite processes. Together, these two processes form a cycle that keeps the levels of oxygen and carbon dioxide fairly constant in the atmosphere.

Some cells obtain their energy through fermentation, an energy-releasing process that does not require oxygen. Fermentation provides energy for cells without using oxygen. One type of fermentation occurs in yeast and some other single-celled organisms. This process is sometimes called alcoholic fermentation because alcohol is one of the products made when these organisms break down sugars. Another type of fermentation takes place at times in your body when your muscles run out of oxygen—for example, when you’ve run as fast as you could for as long as you could. One product of this type of fermentation is an acid known as lactic acid. When lactic acid builds up, your muscles feel weak and sore.
Respiration

In this section, you will learn how cells get energy from food.

Use Target Reading Skills

Before you read, write a definition of respiration in the graphic organizer. As you read, revise your definition based on what you learn.

What Is Respiration?

1. What happens during respiration?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

2. Cells store energy in the form of ________________.
3. How do cells “withdraw” energy?
________________________________________________________________________
________________________________________________________________________

4. Is the following sentence true or false? Respiration that takes place inside of cells is the same as breathing air in and out of the lungs.
________________________

5. Use the table below to list the raw materials and products of respiration.

<table>
<thead>
<tr>
<th>Raw Materials</th>
<th>Products</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Match the events in respiration with the stages in which they occur. The items in the second column may be used more than once.

<table>
<thead>
<tr>
<th>Event in Respiration</th>
<th>Stage of Process</th>
</tr>
</thead>
<tbody>
<tr>
<td>6. Takes place in the mitochondria</td>
<td>a. first stage</td>
</tr>
<tr>
<td>7. Takes place in the cytoplasm</td>
<td>b. second stage</td>
</tr>
<tr>
<td>8. Oxygen is involved.</td>
<td>c. both first and second stages</td>
</tr>
<tr>
<td>9. Energy is released.</td>
<td></td>
</tr>
<tr>
<td>10. Glucose molecules are broken down.</td>
<td></td>
</tr>
</tbody>
</table>
Respiration (continued)

11. Complete the cycle diagram below, which describes the relationship between photosynthesis and respiration.

Photosynthesis

Respiration

Plants produce _____________.

Organisms use _____________.

Plants use _____________.

Organisms produce _____________.

Fermentation

12. What is fermentation?

________________________________________________________________________

________________________________________________________________________

13. Is the following sentence true or false? Fermentation releases more energy than respiration. ________________

14. List the two types of fermentation and tell where each takes place.
   a. ______________________________________________________________________

   b. ______________________________________________________________________
Cell Processes and Energy

Respiration

Understanding Main Ideas
Fill in the blanks in the table below. Then answer the questions that follow in the spaces provided.

<table>
<thead>
<tr>
<th>Raw Materials</th>
<th>Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>3.</td>
</tr>
<tr>
<td>2.</td>
<td>4.</td>
</tr>
<tr>
<td>5.</td>
<td></td>
</tr>
</tbody>
</table>

6. Where in the cell does the first stage of respiration take place?

7. Where in the cell does the second stage of respiration take place?

8. How does fermentation differ from respiration?

9. Which type of fermentation occurs in yeast?

10. Which type of fermentation sometimes occurs in human muscle cells?

Building Vocabulary
If the statement is true, write true. If it is false, change the underlined word to make it true.

11. The process by which cells “withdraw” energy from glucose is called photosynthesis.

12. Respiration provides energy for cells without using oxygen.
History of Fermentation

People have known about and used fermentation for thousands of years. But it has been only in the past two hundred years that scientists have come to understand this important process. In 1854, the French chemist Louis Pasteur determined that fermentation is caused by yeast. His work was influenced by the earlier work of Theodor Schwann, the German scientist who helped develop the cell theory. Around 1840, Schwann concluded that fermentation is the result of processes that occur in living things. In 1907, a German chemist named Eduard Buchner received the Nobel prize for showing that enzymes in yeast cells cause fermentation. About two decades later, two other scientists determined exactly how enzymes cause fermentation. Their names are Arthur Harden and Hans Euler-Chelpin, and they won the Nobel prize for their work in 1929. By the 1940s, technology was developed to use fermentation to produce antibiotics.

Why is understanding fermentation so important that it has led to the awarding of Nobel prizes? Fermentation is a very useful process. Today it is used to produce industrial chemicals, medicines such as antibiotics, and alcoholic beverages, as well as to make bread rise and to preserve many types of food. Some of these uses have been known for thousands of years. For example, the Chinese used fermented soybean curd to treat skin infections 3,000 years ago, and they started using fermented tea to treat a variety of illnesses as early as 220 B.C. The use of fermentation to make bread rise and to produce alcoholic beverages is as old as the development of agriculture itself, which most scholars date to about 8000 B.C.

1. Use the information provided in the passage above to make a timeline of the history of fermentation.
2. What contribution did Louis Pasteur make to the understanding of the process of fermentation?
3. What are two of the oldest uses of fermentation?
4. How is fermentation used in medicine today?
1. 

2. 

**CAUTION:** Bromthymol blue can stain skin and clothing. Avoid spilling or splashing it on yourself.

3. 

4. 

**CAUTION:** Use the straw to breathe out only. Do not suck the solution back through the straw.

5. 

6. 

**CAUTION:** If you have a medical condition that limits your ability to exercise, do not take part in the exercise portion of this experiment.
1. Measuring

2. Drawing Conclusions

3. Predicting

4. Controlling Variables

5. Communicating

Obtain your teacher’s approval before beginning your experiment.
The regular sequence of growth and division that cells undergo is known as the **cell cycle**. The cell cycle is divided into three main stages.

The first stage of the cell cycle is called **interphase**. During interphase, the cell grows, makes a copy of its DNA, and prepares to divide into two cells. During the first part of interphase, the cell grows to full size and produces all the structures it needs. In the next part of interphase, the cell makes an exact copy of the DNA in its nucleus in a process called **replication**. At the end of DNA replication, the cell contains two identical sets of DNA.

Once interphase is complete, the second stage of the cell cycle begins. **Mitosis** is the stage during which the cell’s nucleus divides into two new nuclei. During mitosis, one copy of the DNA is distributed into each of the two daughter cells. Scientists divide mitosis into four parts, or phases: prophase, metaphase, anaphase, and telophase. During prophase, the threadlike chromatin in the cell’s nucleus condenses to form double-rod structures called **chromosomes**. Each identical rod in a chromosome is called a chromatid. The two chromatids are held together by a structure called a centromere. As the cell progresses through metaphase, anaphase, and telophase, the chromatids separate from each other and move to opposite ends of the cell. Then two nuclei form around the chromatids at the two ends of the cell.

After mitosis, the final stage of the cell cycle, called **cytokinesis**, completes the process of cell division. During cytokinesis, the cytoplasm divides, distributing the organelles into each of the two new cells. Each daughter cell has the same number of chromosomes as the original parent cell. At the end of cytokinesis, each cell enters interphase, and the cycle begins again. The length of each stage and cell cycle varies, depending on the type of cell.

DNA replication ensures that each daughter cell will have all of the genetic information it needs to carry out its activities. The two sides of the DNA ladder are made up of alternating sugar and phosphate molecules. Each rung of the DNA ladder is made up of a pair of molecules called nitrogen bases. There are four kinds of nitrogen bases: adenine, thymine, guanine, and cytosine. Adenine only pairs with thymine, and guanine only pairs with cytosine. DNA replication begins when the two sides of the DNA molecule unwind and separate. Next, nitrogen bases that are floating in the nucleus pair up with the bases on each half of the DNA molecule. **Because of the way in which the nitrogen bases pair with one another, the order of the bases in each new DNA molecule exactly matches the order in the original DNA molecule.** Once the new bases are attached, two new DNA molecules are formed.
Cell Processes and Energy  •  Guided Reading and Study

Cell Division

This section explains how cells grow and divide.

Use Target Reading Skills

As you read, make a cycle diagram that shows the events in the cell cycle, including the phases of mitosis. Write each event in a separate circle.

The Cell Cycle

1. Cell grows and makes a copy of DNA.

   [Diagram showing the cell cycle with ellipses and arrows connecting the events]

   - [Blank section for cell cycle events]
   - [Blank section for cell cycle events]
   - [Blank section for cell cycle events]
   - [Blank section for cell cycle events]
   - [Blank section for cell cycle events]

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Cell Processes and Energy  •  Guided Reading and Study

Cell Division (continued)

Stage 1: Interphase

1. The regular sequence of growth and division that cells undergo is called the _____________________.

2. List three things that the cell is doing during interphase.
   a. ________________________________________________________________
   b. ________________________________________________________________
   c. ________________________________________________________________

3. Circle the letter of the specific process during which the cell copies its DNA.
   a. interphase  
   b. cytokinesis  
   c. replication  
   d. division

Stage 2: Mitosis

4. Circle the letter of each sentence that is true about mitosis.
   a. The cell makes a copy of its DNA.
   b. The cell membrane pinches in around the middle of the cell.
   c. The cell’s nucleus divides into two new nuclei.
   d. One copy of DNA is distributed into each daughter cell.

Match the phases of mitosis with the events that occur in each.

<table>
<thead>
<tr>
<th>Event</th>
<th>Phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>5. The centromeres split and the chromosomes separate.</td>
<td>a. prophase</td>
</tr>
<tr>
<td>6. The chromatin condenses to form chromosomes.</td>
<td>b. metaphase</td>
</tr>
<tr>
<td>7. A new nuclear envelope forms around each region of chromosomes.</td>
<td>c. anaphase</td>
</tr>
<tr>
<td>8. The chromosomes line up across the center of the cell.</td>
<td>d. telophase</td>
</tr>
</tbody>
</table>

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9. Label the parts of the structure in the diagram below.

Stage 3: Cytokinesis

10. During cytokinesis the ________________________ divides, distributing the organelles into each of the two new cells.

11. Is the following sentence true or false? During cytokinesis in plant cells, the new cell membrane forms before the new cell wall does.
   __________________________

Structure and Replication of DNA

12. Why does a cell make a copy of its DNA before mitosis occurs?
   __________________________________________________________________________
   __________________________________________________________________________

13. Circle the letter of each molecule that makes up the sides of the DNA ladder.
   a. deoxyribose
   b. glucose
   c. phosphate
   d. oxygen
14. Name the nitrogen bases that pair up to make up the rungs of the DNA ladder.
   a. ___________________________ pairs with ________________________.
   b. ___________________________ pairs with ________________________.

15. Complete the flowchart to show what happens during DNA replication.

   **DNA Replication**

   The two sides of the DNA molecule
   ___________________________ and ___________________________.

   Nitrogen bases floating in the nucleus pair up with the
   ___________________________ on each half of the DNA molecule.

   When the new bases are attached, two new
   ___________________________ are formed.
Cell Division

Understanding Main Ideas
Fill in the blanks in the table below. Then answer the questions that follow in the spaces provided.

Phases of Mitosis

<table>
<thead>
<tr>
<th>Phase</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prophase</td>
<td>1. ________________</td>
</tr>
<tr>
<td></td>
<td>2. ________________ Chromosomes attach to spindle fibers</td>
</tr>
<tr>
<td>Anaphase</td>
<td>3. ________________</td>
</tr>
<tr>
<td></td>
<td>4. ________________ New nuclear envelope forms</td>
</tr>
</tbody>
</table>

5. Which stage of the cell cycle usually lasts longest?
   _______________________________________________________________________

6. During which stage of the cell cycle does DNA replication occur?
   _______________________________________________________________________

7. During which stage of the cell cycle does the cell membrane pinch the cell in two?
   _______________________________________________________________________  

Building Vocabulary
Match each term with its definition by writing the correct letter in the blank.

   ___ 8. Regular sequence of growth and division that cells undergo   a. interphase
   ___ 9. First stage of the cell cycle                              b. mitosis
   ___ 10. Process in which DNA is copied                          c. cell cycle
   ___ 11. Stage of the cell cycle during which the cell’s nucleus divides d. cytokinesis
   ___ 12. Doubled rod of condensed chromatin                      e. replication
   ___ 13. Final stage of the cell cycle                           f. chromosome
Cell Processes and Energy  •  Skills Lab

Multiplying by Dividing

Problem
How long do the stages of the cell cycle take?

Skills Focus
observing, calculating

Materials
microscope
colored pencils
calculator (optional)
prepared slides of onion root tip cells undergoing cell division

Procedure

1. Place the slide on the stage of a microscope. Use low power to locate a cell in interphase. Then switch to high power, and make a labeled drawing of the cell. CAUTION: Slides and coverslips break easily. Do not allow the objective to touch the slide. If the slide breaks, notify your teacher. Do not touch broken glass.

2. Repeat Step 1 to find cells in prophase, metaphase, anaphase, and telophase. Then copy the data table into your notebook.

3. Return to low power. Find an area of the slide with many cells undergoing cell division. Switch to the magnification that lets you see about 50 cells at once (for example, 100 ×).

4. Examine the cells row by row, and count the cells that are in interphase. Record that number in the data table under First Sample.

5. Examine the cells row by row four more times to count the cells in prophase, metaphase, anaphase, and telophase. Record the results.

6. Move to a new area on the slide. Repeat Steps 3–5 and record your counts in the column labeled Second Sample.

7. Fill in the column labeled Total Number by adding the numbers across each row in your data table.

8. Add the totals for the five stages to find the total number of cells counted.
Analyze and Conclude

1. Observing Which stage of the cell cycle did you observe most often?

________________________________________________________________________

2. Calculating The cell cycle for onion root tips takes about 720 minutes (12 hours). Use your data and the formula below to find the number of minutes each stage takes.

\[
\text{Time for each stage} = \frac{\text{Number of cells at each stage}}{\text{Total number of cells counted}} \times 720 \text{ min}
\]

3. Communicating Use the data to compare the amount of time spent in mitosis with the total time for the whole cell cycle. Write your answer in the form of a paragraph.

More to Explore

Examine prepared slides of animal cells undergoing cell division. Use drawings and descriptions to compare plant and animal mitosis.
Cancer

Guide for Reading

- How is cancer related to the cell cycle?
- What are some ways that cancer can be treated?

Cancer is a disease in which cells grow and divide uncontrollably, damaging the parts of the body around them. There are more than 100 types of cancer. Cancer can occur in almost any part of the body. Cancers are often named by the place in the body where they begin. In the United States today, lung cancer is the leading cause of cancer deaths among both men and women.

Scientists think that cancer begins when something damages a portion of the DNA in a chromosome. The damage causes a change in the DNA called a mutation. Cancer begins when mutations disrupt the normal cell cycle, causing cells to divide in an uncontrolled way. Without the normal controls on the cell cycle, the cells grow too large and divide too often. As the cell divides over and over, the repeated divisions produce more and more abnormal cells. In time, these cells form a tumor. A tumor is a mass of abnormal cells that develops when cancerous cells divide and grow uncontrollably. Some of the cancerous cells may break off the tumor and enter the bloodstream. In this way, the cancer can spread to other areas of the body.

There are three common ways to treat cancer: surgery, radiation, and drugs that destroy the cancer cells. When a cancer is detected before it has spread, surgery is usually the best treatment. If doctors can completely remove the cancerous tumor, a person may be cured. If, however, the cancer has spread or the tumor cannot be removed, doctors may use radiation. Radiation consists of beams of high-energy waves. Fast-growing cancer cells are more likely than normal cells to be destroyed by radiation. Chemotherapy is the use of drugs to treat a disease.

Cancer treatment drugs are carried throughout the body by the bloodstream. These drugs kill cancer cells or slow their growth. Scientists continue to look for new ways to treat cancer. If scientists can discover how the cell is controlled, they may find ways to stop cancer cells from multiplying.

People can reduce their chances of developing cancer by avoiding smoking, eating a healthful diet, and protecting their skin from bright sunlight. When people repeatedly inhale tobacco smoke, lung cancer and other forms of cancer may result. Eating more fruits and vegetables instead of fatty meats and fried foods may help lower the risk for some types of cancers. Most skin cancers are caused by ultraviolet light in sunlight. If people limit their exposure to bright sunlight, they can reduce their risk of getting skin cancer.
Cancer

This section explains what happens when cells grow out of control.

Use Target Reading Skills

Preview Figure 17. Then write two questions that you have in the graphic organizer below. As you read, answer your questions.

How cancer spreads

Q. What is a tumor?

A.

Q.

A.

What Is Cancer?

1. What is cancer?

________________________________________________________________________

________________________________________________________________________

2. Circle the letter of each event that can cause cancer to begin.
   a. A cell divides normally.
   b. A change in DNA affects the cell cycle.
   c. A cell divides too often.
   d. A cell stops dividing.
3. Complete the flowchart below, which describes how cancer begins and spreads.

**Growth and Spread of Cancer**

- A(n) __________________________ occurs in a cell, causing a change in the DNA.
- A(n) __________________________, or mass of cells that divide uncontrollably, forms.
- Cancer spreads to other parts of the body when cancer cells enter the ________________.

4. How can a mutation affect the function of cells?
   - _______________________________________________________________________
   - _______________________________________________________________________
   - _______________________________________________________________________

5. Is the following sentence true or false? DNA contains all the instructions necessary for life. ______________

**Treating and Preventing Cancer**

6. List three ways in which doctors usually treat cancer.
   a. _______________________________________________________________________
   b. _______________________________________________________________________
   c. _______________________________________________________________________

7. Why is radiation used to treat cancer?
   - _______________________________________________________________________
   - _______________________________________________________________________
   - _______________________________________________________________________
8. Why is chemotherapy an effective way to treat cancer?
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

9. Name two things that can cause cancer.
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

10. What kind of diet may help lower a person’s risk of some kinds of cancer?
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
Complete the concept map below. Then answer the questions that follow.

1. ____________________

    cause

    cancer

    which leads to a cell mass called a

    which can be treated by

2. ____________________

3. ____________________

4. ____________________

5. ____________________

Write your answers on a separate sheet of paper.

6. How do mutations lead to cancer?
7. How can cancer spread from a tumor to other parts of the body?
8. What are two ways the risk of some types of cancer can be reduced?

Fill in the blank to complete each statement.

9. ____________________ is a disease in which cells grow and divide uncontrollably.
10. A change in the DNA is called a(n) ____________________.
11. A(n) ____________________ is a mass of abnormal cells.
12. The use of drugs to kill cancer cells is called ____________________.
Cancer is a leading cause of death in the United States. Cancer death rates by age and sex in the United States for 1980 and 1990 are given in the table below.

<table>
<thead>
<tr>
<th>Age at Death (years)</th>
<th>Males 1980</th>
<th>Males 1990</th>
<th>Females 1980</th>
<th>Females 1990</th>
</tr>
</thead>
<tbody>
<tr>
<td>25–34</td>
<td>13</td>
<td>13</td>
<td>14</td>
<td>13</td>
</tr>
<tr>
<td>35–44</td>
<td>44</td>
<td>39</td>
<td>53</td>
<td>48</td>
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<tr>
<td>45–54</td>
<td>197</td>
<td>163</td>
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<tr>
<td>55–64</td>
<td>521</td>
<td>533</td>
<td>362</td>
<td>376</td>
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<tr>
<td>65–74</td>
<td>1,093</td>
<td>1,122</td>
<td>607</td>
<td>677</td>
</tr>
<tr>
<td>75–84</td>
<td>1,791</td>
<td>1,915</td>
<td>903</td>
<td>1,010</td>
</tr>
<tr>
<td>85 and older</td>
<td>2,370</td>
<td>2,740</td>
<td>1,256</td>
<td>1,372</td>
</tr>
</tbody>
</table>

Note: The death rate is the number of deaths for that sex and age group per 100,000 people of that sex and age group in the United States population.

1. In which age groups of males were there declines in cancer death rates between 1980 and 1990?
2. In which age groups of females were there declines in cancer death rates between 1980 and 1990?
3. Which sex had higher death rates from cancer at all ages over 54 years of age in both 1980 and 1990?
4. Which sex and age group had the biggest increase in cancer death rates from 1980 to 1990?
5. What percent of males aged 85 years and older died from cancer in 1980? In 1990?
Key Terms

Answer the clues to solve the crossword puzzle.

Clues down
1. An organism that makes its own food
3. The final stage of the cell cycle in which the cytoplasm divides
4. The regular sequence of growth and division that cells undergo is the cell ______________.
5. Condensed genetic material, or chromatin, that is double stranded

Clues across
1. A disease in which cells grow and divide uncontrollably
2. A mass of abnormal cells
3. The use of drugs to kill cancer cells
4. A pigment found in chloroplasts
5. A change in DNA
6. Colored chemical compound in plants that absorbs light
7. Openings on the undersides of leaves
8. The first stage of the cell cycle in which the cell prepares to divide
9. Provides energy for cells without using oxygen
10. The stage of the cell cycle in which the cell’s nucleus divides
Connect the Concepts

Cell Processes and Energy • Connecting Concepts

Develop a concept map that uses the Key Concepts and Key Terms from this chapter. Keep in mind the big ideas of this chapter. The concept map shown is one way to organize how the information in this chapter is related. You may use an extra sheet of paper.
Stomata Functions

**Key Concept**
Pairs of guard cells open and close tiny holes called stomata, which allow certain materials to pass into and out of the plant.

**Skills Focus**
observing, inferring, measuring, calculating

**Time**
60 minutes

**Materials** *(per group)*
microscope slide
coverslip
water
plastic dropper
lettuce leaf, fresh
forceps
iodine solution
compound microscope
paper towel
leaves from two different plants
metric ruler

Alternate materials: Ask students to bring in any plants they have.

**Advance Preparation**
The iodine solution should be about 1–2%, the strength usually sold over the counter in pharmacies.

For Part B, determine whether the types of leaves you are providing need to be blanched. The lower epidermis of some types of leaves—such as fresh lettuce and spinach, *Coleus*, *Tradescantia*, and *Peperomia*—usually peels off easily. Other leaves may need to be placed in boiling water for a few minutes before their epidermises become loose. Students can compare leaves from houseplants, garden plants, or wild-growing plants.

**Teaching Tips**
- You may wish to review how to focus the microscope. Discuss other precautions students should take to avoid damaging the microscopes or their slides.
- IMPORTANT: The area of a leaf must be determined before it is blanched.
- If air bubbles form under the coverslip, gently tap the coverslip with the eraser end of a pencil.
- Another method for finding the area of the leaf involves tracing the leaf on graph paper, counting the number of squares in the leaf’s area, then calculating the area of each square and multiplying by the number of squares.
- (More to Explore) Be sure students understand that there are many acceptable ways to carry out these estimates. Urge them to explain why their chosen method is reasonable.
- (More to Explore) Sample for a coleus plant: About 300,000 stomata per leaf $\times$ 15 leaves $=$ 4,500,000 stomata on the whole plant
- (More to Explore) Sample for a tree with 1 million stomata per leaf: About 10 main branches per tree $\times$ 10 smaller branches per main branch $\times$ 100 leaves per smaller branch $= 10,000$ leaves per tree; then $10,000$ leaves per tree $\times$ 1 million stomata per leaf $= 10$ billion stomata per tree
- (More to Explore) If students have learned to use scientific notation, they can use that method of working with large numbers to carry out these calculations.
Stomata Functions

Pre-Lab Discussion

During photosynthesis, plants capture light energy and convert it into chemical energy that is stored in sugar molecules. The two raw materials needed for this process are water and carbon dioxide. Plants obtain water through their roots. They obtain carbon dioxide, a gas, through tiny openings, or pores, called stomata (singular *stoma*). Most of the stomata are located in the plant’s leaves. The stomata must be open to allow carbon dioxide to pass into the leaf. The open stomata also allow water and oxygen to pass out of the leaf.

The opening and closing of the stomata is carried out by guard cells. When guard cells absorb water, they swell, and the stomata open, as shown in Figure 1. When guard cells lose water, the swelling is reduced, and the stomata close, as shown in Figure 2. Stomata are adaptations that help plants survive. When they are open, they allow carbon dioxide to enter. When they are closed, they help prevent the loss of water from the plant.

In this investigation, you will determine the number of stomata on different types of leaves.

1. Are the stomata usually open or closed during photosynthesis? Explain.

________________________________________________________________________
________________________________________________________________________

2. Are stomata usually open or closed during dry periods? Explain.

________________________________________________________________________
________________________________________________________________________
Problem
Approximately how many stomata are present on a typical leaf?

Materials (per group)
- microscope slide
- coverslip
- water
- plastic dropper
- lettuce leaf, fresh
- forceps
- iodine solution
- compound microscope
- paper towel
- leaves from two different plants
- metric ruler

Safety  Review the safety guidelines in Appendix A.
Wipe up spills immediately. Coverslips and slides break easily, so handle them carefully. Tell the teacher if a slide breaks. If your microscope has a mirror, do not use it to reflect direct sunlight. Eye damage can occur if direct sunlight is used as a light source. Iodine solution can stain skin and clothing. If you spill any solution on your skin, rinse it off immediately with cold running water, and tell the teacher.

Procedure
Part A: Identifying Guard Cells
1. Prepare to make a wet mount by placing a drop of water in the center of a microscope slide.
2. Obtain a fresh lettuce leaf, and turn it over so that it curves downward. You are now looking at the lower epidermis, or bottom, of the lettuce leaf. Locate the large central rib in the leaf.
3. Bend the leaf backward against the curve until it breaks, as shown in Figure 2 on the next page. Use forceps to carefully remove a small piece of the thin epidermal layer.
4. Spread out the epidermis specimen in the water drop on the slide. Be sure that no part of the epidermis is folded over.

5. Add a drop of iodine to the water. **CAUTION:** Iodine is poisonous, and it can cause stains. Handle it carefully. Then hold a coverslip at the angle shown in Figure 4, and gently lower it over the specimen. Touch the edge of a paper towel to one side of the coverslip to remove excess water.

6. Observe the slide with a microscope under low power. **CAUTION:** When using the microscope, follow safe procedures described in Appendix A. Look for different types of cells. Most of the cells you see will have an irregular shape. The rest of the cells, which are shaped like sausages, appear in pairs. The paired cells are the guard cells. Notice whether they are open or closed.

7. On the next page, make a labeled drawing of the epidermis under low power.

8. Examine a pair of guard cells under high power, and make a labeled drawing beside the one you drew in Step 7.

**Part B: Comparing the Number of Stomata in Different Leaves**

1. Obtain freshly cut leaves from two different kinds of plants. Record the types of plants you are using in the Data Table.

2. Use a metric ruler to determine the approximate length and width of the first leaf in millimeters. If the leaf has an irregular shape, estimate the length and width as closely as you can. Multiply the length times the width to find the area in square millimeters (mm²). Record the area in the Data Table.
Stomata Functions (continued)

3. Use the procedures from Part A to examine a section of the lower epidermis of the leaf.

4. Observe the slide under low power. Count the number of stomata in your field of view. Record this number in the appropriate column in the Data Table.

5. The field of view under low power is usually about 1.33 mm$^2$. To determine the total number of stomata in the leaf, use the equation below. Record the results in the Data Table.

\[
\frac{\text{total area of the leaf in mm}^2}{1.33 \text{ mm}^2 \text{ in field of view}} \times \text{number of stomata in field of view} = \text{___ stomata}
\]

6. Repeat Steps 2 through 5 for the second leaf. Wash your hands thoroughly when you are finished handling the materials.

Observations

<table>
<thead>
<tr>
<th>Epidermis</th>
<th>Guard Cells</th>
</tr>
</thead>
<tbody>
<tr>
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<td></td>
</tr>
</tbody>
</table>
Analyze and Conclude

1. How do the number and shape of the guard cells compare with the number and shape of the cells around them?
   __________________________________________________________________________
   __________________________________________________________________________

2. How do guard cells control the stomata?
   __________________________________________________________________________
   __________________________________________________________________________
   __________________________________________________________________________

3. How do the number of stomata compare for the two leaves you examined at low power?
   __________________________________________________________________________
   __________________________________________________________________________
   __________________________________________________________________________

4. How did the number of stomata per leaf compare?
   __________________________________________________________________________
   __________________________________________________________________________
Stomata Functions (continued)

Critical Thinking and Applications
1. Can photosynthesis occur if the stomata are closed? Explain.
   __________________________________________
   __________________________________________
   __________________________________________

2. The stomata tend to be closed during dry periods. How does that pattern aid the survival of the plant?
   __________________________________________
   __________________________________________

More to Explore
Find a way to estimate the number of stomata on a specific plant. You could start with the number of stomata on a single leaf. You may be able to count or estimate the number of leaves on a plant directly. However, if the plant is large and has a huge number of leaves, develop a method for estimating the number of leaves. For example, estimate the number of main branches of a tree; then estimate the number of smaller branches on the main branch; then estimate the number of leaves on a smaller branch; then multiply to find the total. (*Hint: Use round numbers and any other math strategies you know to simplify your work.*)