Unit 3: Cell Energy

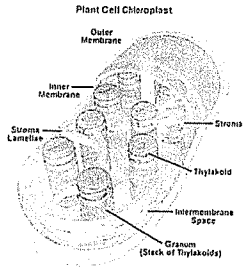
Review Worksheets

Name_____ Date_____ Period_____

Photosynthesis: Making Energy

Chloroplasts

Photosynthesis is a process in which sunlight energy is used to make glucose. The site of photosynthesis is in the **chloroplast** - an organelle found in the leaves of green plants. The main functions of chloroplasts are to produce food (**glucose**) during **photosynthesis**, and to store food energy. Chloroplasts contain the pigment, *chlorophyll*. Chlorophyll absorbs most of the colors in the color spectrum, and reflects only green and yellow wavelengths of light. This is why we see leaves as green or yellow - because these colors are reflected into our eyes.



1. What is photosynthesis? _____
2. Where does photosynthesis occur? _____
3. What are chloroplasts and where are they found? _____
4. What are the two main functions of chloroplasts? _____
5. Why doe most leaves appear green? _____
6. What is the primary pigment found in the chloroplast? _____

Photosynthesis

Glucose is another name for sugar. The molecular formula for glucose is $C_6H_{12}O_6$. Plants make sugar by using the energy from sunlight to transform CO_2 from the air with water from the ground into glucose. This process, called photosynthesis occurs in the chloroplast of the plant cell. During this process, oxygen (O_2) is created as a waste product and is released into the air for us to breath. The formula for photosynthesis is:

(reactants) (products)

$$CO_2 + H_2O + \text{sunlight} \longrightarrow C_6H_{12}O_6 + O_2$$

This formula says that carbon dioxide + water molecules are combined with the energy from sunlight to produce sugar and oxygen. The reactants in photosynthesis (what is used) are CO_2, water and sun. The plant gets water from the ground through its roots. The plant collects carbon dioxide from the air. Much of the carbon dioxide comes from living organisms that exhale (breath it out) it, but some also comes from factory smokestacks and car fumes.

7. What is the formula for photosynthesis? _____
8. What three things are used to make glucose in photosynthesis? _____

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9. Where does the water come from? _____
10. Where does the water enter the plant? _____
11. Name 3 some sources of CO_2. _____
12. What type of energy does the plant use to convert CO_2 and H_2O into sugar? _____

The products are **glucose** and **oxygen**. The glucose produced is used by the plant for energy and growth. We also use this glucose by eating plants. The oxygen produced is released into the air for us to breath. Photosynthesis is essential for all life on earth, because it provides food and oxygen. Plants are considered autotrophs because unlike us humans, they can make their own food using this process.

13. What is produced in photosynthesis? _____
14. What is the glucose used for? _____
15. What is the oxygen used for? _____
16. Here are three different ways to visualize the photosynthesis reaction: Is it easier for you to understand the reaction by using pictures, words, or symbols (see above)? Why?

_____

_____

Complete the table:

Photosynthesis in pictures	Photosynthesis in words	Photosynthesis in symbols

Essential Question: Describe, using scientific terms, how plants turn sunlight into energy? Make sure to refer to the chemical equation to photosynthesis and discus the reactants and products.

_____

_____

_____

_____

_____

_____

Name: _____ Date: _____ Period: 1 2 3 4 5 6

Assignment #:

The Mitochondria & Cellular Respiration

DIRECTIONS: Read, answer, color and label.

Mitochondria are the powerhouses of the cell because they "burn" or break the chemical bonds in glucose to release energy to do work in a cell. Remember that this energy originally came from the sun and was stored in chemical bonds by plants during photosynthesis. Glucose, a simple sugar, and other **carbohydrates** made by plants during photosynthesis are broken down by the process of **aerobic cellular respiration** (requires oxygen) in the mitochondria of the cell. This releases **energy** (ATP) for the cell. The more active a cell (such as a muscle cell), the more mitochondria it will have. The mitochondria are about the size of a bacterial cell and are often peanut-shaped. Mitochondria have their own DNA and a **double membrane** like the nucleus and the chloroplast. The **outer membrane** is smooth, while the **inner membrane** has many folds called **cristae** which help to increase the surface area of the membrane.

1. Why are mitochondria called the powerhouse of the cell? _____
2. What simple sugar is broken down in the mitochondria? _____
3. Where does the energy in glucose come from originally? _____
4. Where is this energy stored in glucose? _____
5. What cell process occurs in the mitochondria? _____
6. Why is cellular respiration an aerobic process? What does this mean? _____
7. What energy is released when the chemical bonds of glucose are broken? _____
8. Why do some cells have more mitochondria? Give an example. _____

_____

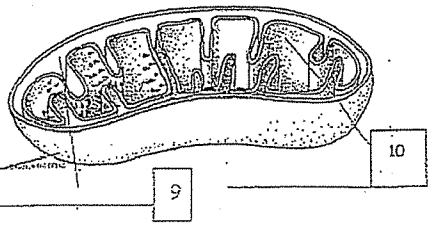
9. Name two other organelles besides the mitochondria that contain DNA and have a double membrane.

_____ _____

10. Describe the outer membrane of the mitochondria. _____
11. Why is the inner mitochondrial membrane folded? _____
12. What are the folds called? _____

Color and label the outer membrane (8) purple and the cristae (9) red on Figure 3. The cristae greatly increase the surface area of the membrane so that the carbohydrates (simple sugars) can combine with oxygen to produce ATP (adenosine triphosphate). The electron transport chain takes place across the membranes of the cristae (9) (crista, singular). Inside the cristae is a space called the matrix that contains enzymes needed for the Kreb's Cycle. ***Color and label*** the matrix (10) yellow on Figure 3.

FIGURE 3 - MITOCHONDRIA

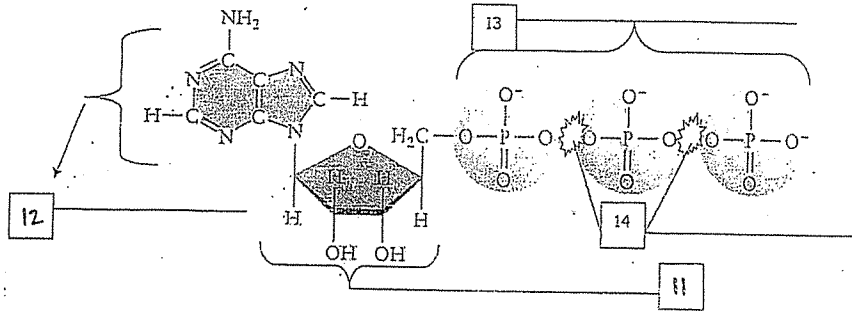


Adenosine triphosphate (ATP) is the energy molecule used by cells to do work. It is a nucleotide consisting of a **nitrogen-containing base** (adenine, thymine, cytosine or guanine), a **5-carbon sugar**, and 3 phosphate groups. ATP is able to store and transport chemical energy within cells. The last two phosphate groups are joined by high-energy bonds. When these bonds are broken, energy is released for cells to use and ADP forms. Enzymes help to break and reform these high-energy bonds.

1. What does ATP stand for? _____
2. What three things make up an ATP molecule? _____ _____ _____
3. How many high-energy bonds does ATP contain? _____
4. Where are these high energy bonds found in ATP? _____
5. What helps weaken these bonds so energy can be released and then later help reform them? _____
6. When ATP loses a phosphate group, _____ is released for cells and a molecule of _____ forms.

In Figure 4, ***color*** the 5-carbon sugar (11) red and ***label*** it ribose (11). ***Color and label*** the nitrogen base (12) blue. ***Color and label*** the 3 phosphate groups (13) yellow, and ***color and label*** the 2 high-energy bonds (14) green.

FIGURE 4 - ATP MOLECULE



Summary Questions:

1. What is the energy molecule of the cell called? _____
2. What macromolecule made by plants is "burned" in the mitochondria? _____
3. How would the number of mitochondria in an insect's wing compare to the amount found in other cells in an insect's body? Explain your answer.

_____

_____

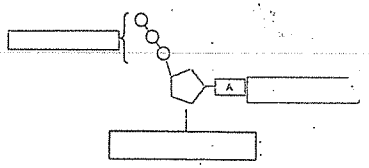
_____

4. What product(s) of photosynthesis is/are used in cellular respiration? _____
5. What is the advantage of having a folded inner membrane in the mitochondria?

_____

_____

6. What is the diagram right representing? _____



1. Label and color the 3 phosphate groups purple.
2. Label and color the 5-carbon sugar (ribose) red.
3. Label and color the adenine base yellow.

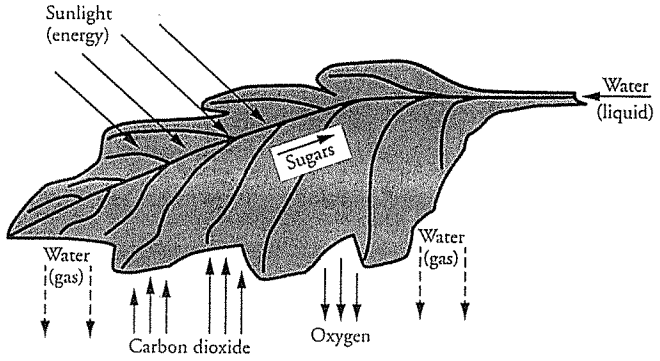
Photosynthesis: What's in a Leaf?

What is the relationship between structure and function in a leaf?

Why?

What would the world be like without leaves—no grass for ball fields, no beautiful landscaping? It would also mean no oxygen for animals and no food for heterotrophs. Leaves are like living machines that recycle the carbon and oxygen in our environment. This process, driven by the sun's energy, allows for a constant supply of oxygen and food for the inhabitants of Earth.

Model 1 – Leaf Sun-Catcher



General Equation for Photosynthesis

Reactants → Products

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

1. List three things entering the leaf in Model 1.

2. List three substances leaving the leaf.

3. Which substance is both entering and leaving?

4. Veins are important structures that carry materials through the leaf. Label the central vein in the leaf diagram.

5. How is the substance you identified in Question 3 changed between its entry and its exit?

6. Use the general equation for photosynthesis and Model 1 to answer the following questions.
   a. What are the reactants for photosynthesis?

   b. Where do these reactants enter the leaf?

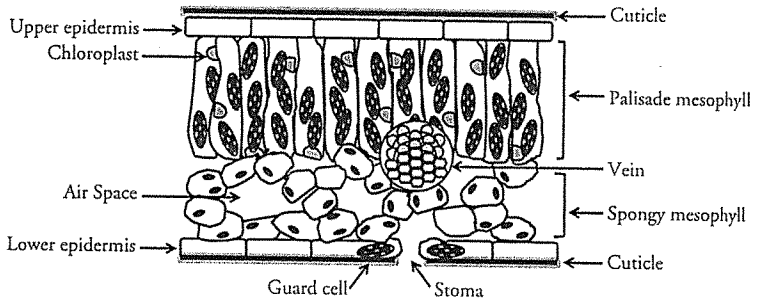
   c. What are the products of photosynthesis?

   d. From where do the products leave the leaf?

7. Categorize all the components involved in photosynthesis as either matter or energy.

STOP

Model 2 – Cross Section of the Internal Structure of a Leaf



8. List the layers of the leaf starting at the upper cuticle all the way to the lower cuticle.

Read This!

Inside plant veins are two different types of tissues. **Xylem** carries water and minerals up from the roots of the plant and **phloem** carries the sugars (nutrients) away from the leaf to areas where the plant is growing or to storage areas in the plant.

9. Describe the position of the vein(s) in each model.
   a. In the leaf in Model 1.

   b. Within the leaf cross section in Model 2.

10. How does the placement of veins help to carry out their function of transporting materials to and from the leaf?

11. Look back at your answers to Questions 1–3 and the photosynthesis equation. In the appropriate locations on Model 2, mark with labels and arrows what is entering the leaf and what is exiting the leaf.

12. Which kind(s) of cells have chloroplasts in them?

13. Remembering the function of chloroplasts, in which part(s) of the leaf is photosynthesis taking place?

14. The green color of chloroplasts is due to a pigment in them that absorbs light energy. Knowing this, infer which layer inside a leaf gives the whole leaf its green color. Write one complete sentence to express your reasoning.

15. Through which layer(s) does light energy travel to reach the palisade mesophyll?

16. List at least three differences between the cells of the palisade mesophyll and the cells that make up the other areas within the leaf.

17. How would the cylindrical shape of the palisade mesophyll cells increase the amount of photosynthesis that the leaf can carry out?

18. What would be the advantage(s) to having no chloroplasts in the cells of the spongy mesophyll?

19. Suppose there were many chloroplasts in the cells of the upper epidermis. How would that change the amount of sunlight reaching the chloroplasts in the palisade layer?

20. Considering its locations and your previous knowledge of the word, what do you think might be the function of the epidermis?

Read This!

The cuticle covering the upper and lower epidermis of land plants is made of a waxy substance that repels water in much the same way as wax on a paper cup.

21. What is the purpose of having a water-tight covering?

22. Look carefully at the lower surface of the leaf in Model 2.
   a. What structure is found between guard cells?

   b. How would you describe this structure?

   c. How would this affect the ability of the leaf to retain water especially in dry conditions?

23. Suggest a way in which the stoma and guard cells arrangement might work to control the amount of water that is leaving the leaf.

24. What is the relationship between the stoma and an air space?

25. Looking back at Model 1, what gases might you find inside the air spaces?

26. During the time that stomata (the plural of stoma) are closed, gases cannot enter or leave. Explain how this would affect the plant's ability to do photosynthesis.

27. How would the cuticle and stomata work together to maintain the leaf's function?

Name: _____ Date: _____ Per: _____ Assigment #

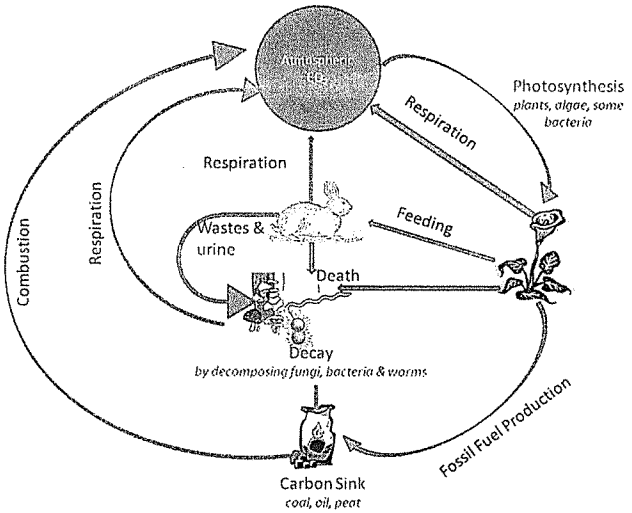
NUTRIENT CYCLES

(How are nutrients recycled through ecosystems?)

Why?

We have learned the importance of recycling our trash. It allows us to use something again for another purpose and prevents the loss of natural resources. But what happens to the waste in nature? Why aren't we up to our necks in poop? Why is there always a supply of water? Why is there oxygen to breathe and carbon dioxide for photosynthesis? Organic compounds in nature are also recycled. This recycling process converts the complex organic compounds to simple, inorganic compounds, which then can be returned to the nutrient cycle and be used in nature again and again.

Model 1: The Carbon Cycle



1. Name two ways that carbon (usually in the form of CO_2) enters the atmosphere.

2. What process uses CO_2 from the atmosphere?

3. What organisms carry out that process?

4. Wastes and dead organisms must be broken down in order for their components to be used again. What organisms in the cycle carry out this process?

5. What would happen if decomposition did not occur?

6. Not all dead organisms are acted on by decomposers. Instead of being immediately recycled, the carbon from some organisms is kept in a type of long-term storage, or **carbon sink**. Answer the questions below about this long-term storage.
   a. List three materials that contain this stored carbon.
   b. What is the collective term for these three materials?
   c. How do modern humans use these carbon stores?
   d. How does our use of these carbon stores affect the amount of CO_2 in the atmosphere?

Read This!

Carbon dioxide (CO_2) is one of the so-called **greenhouse gases**. These gases hold heat energy in the atmosphere which raises the overall temperature of the Earth. This helps maintain the earth's biosphere, but also has led to environmental concerns.

7. What is another way in which human activity is increasing the amount of atmospheric CO_2, and what are potential global effects of these changes in CO_2 levels?

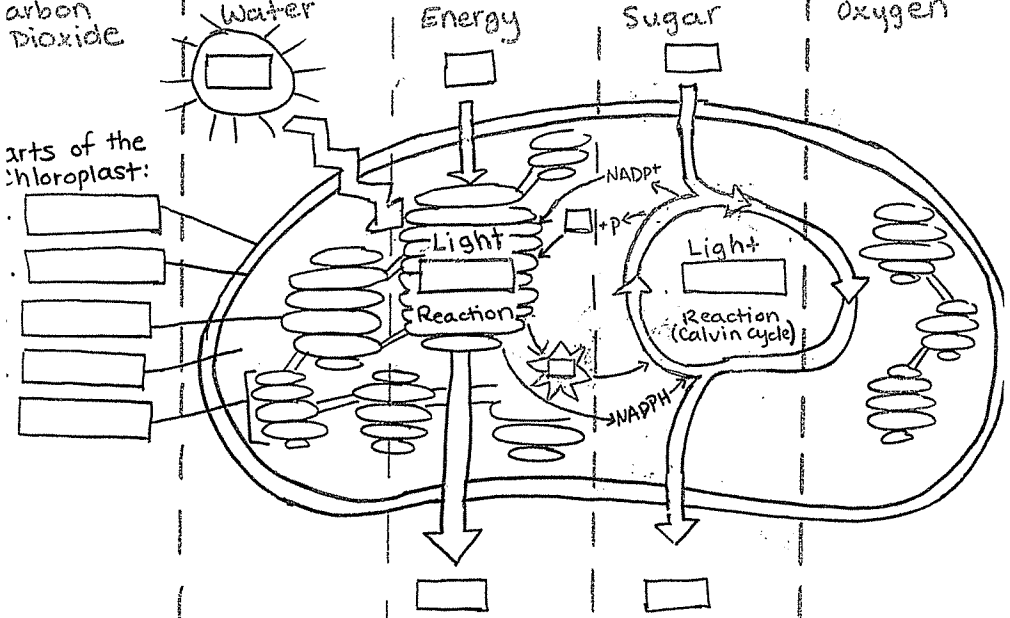
STOP

Photosynthesis

Equation:

[ ] + [ ] + [ ] → [ ] + [ ]

arbon Dioxide | Water | Energy | Sugar | Oxygen



his pro cess is [ ]

which mea ns it takes [ ] energy in. [ ] means n and [ ] means heat or energy.

only done in [ ]

[ ] means self. and [ ] means nurishment.

Organisms that do this are:

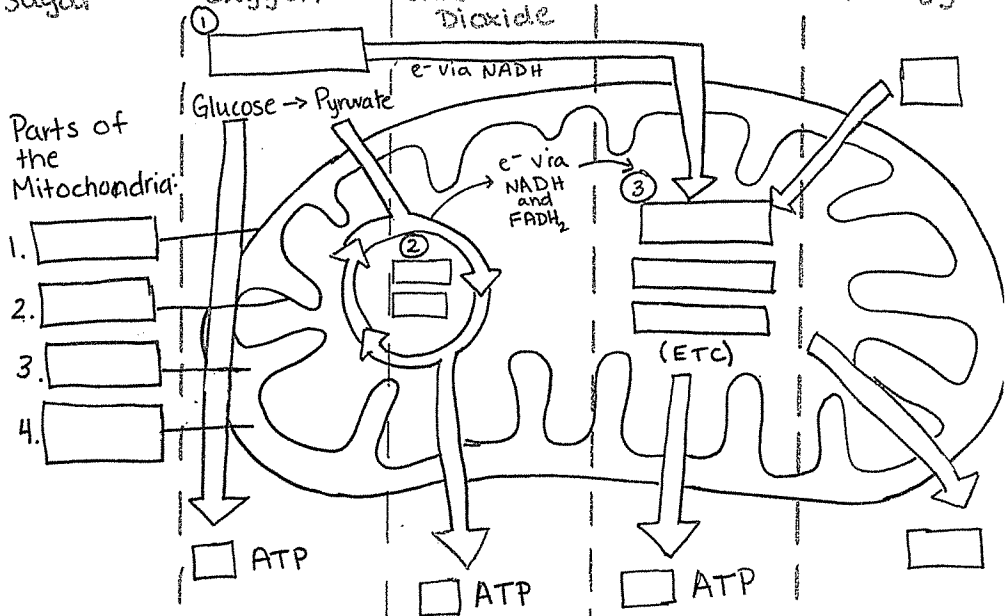
1 – [ ]
2 – [ ]
3 – [ ]
4 – [ ]

Cellular Respiration

Equation:

[ ] + [ ] → [ ] + [ ] + [ ]

Sugar | oxygen | Carbon Dioxide | Water | Energy



This pro cess is [ ]

which mea releases [ ] means out. [ ] means energy.

ns it [ ] energy. And [ ] heat or

Done by both [ ] and [ ].

Organisms that do this are:

1 – [ ]
2 – [ ]
3 – [ ]
4 – [ ]

Name: _____ Date: _____ Assignment #: _____
Period: 1 2 3 4 5 6

Connecting Photosynthesis & Cellular Respiration

Video Introduction: Photosynthesis & Respiration

DIRECTIONS: Watch the video and then answer the following in your own academic sentences.
https://www.youtube.com/watch?v=JEnjph9miK4 (4 min)

1. Where does cellular respiration occur?

2. Why is cell respiration important for all living organisms?

3. What are the raw materials used in photosynthesis?

Modeling the Relationship Between Photosynthesis & Cellular Respiration

DIRECTIONS: Examine and color the model according to the directions that follow. Focus on the key details to answer the questions below.

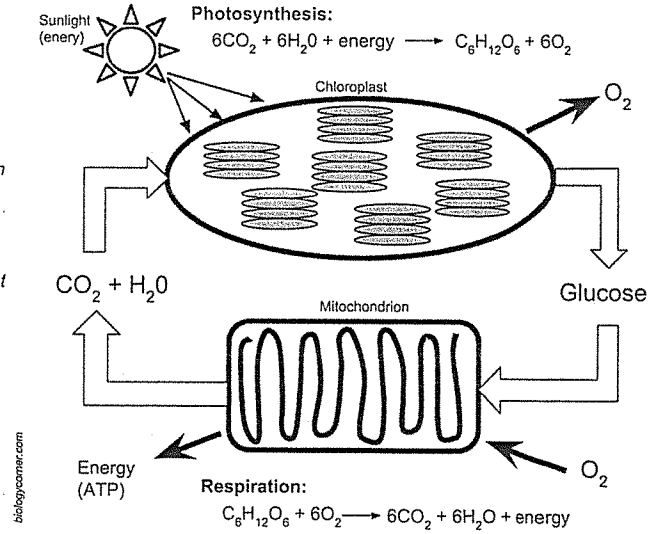
1. In what cell organelle does photosynthesis occur?

2. What are the three things needed for photosynthesis? List them below and highlight them on the diagram in green.

3. What are the two products of photosynthesis? List and highlight yellow.

4. In what cell organelle does cellular respiration occur?

5. What are the two things needed for cellular respiration? List and highlight blue.



6. What are the three products of cellular respiration? List and highlight purple.

7. What things are recycled (used over and over again) during photosynthesis and respiration?

8. One hypothesis regarding the extinction of dinosaurs is that a meteor hit the earth causing an explosion so powerful that dust blocked out the sun. Consider the model above and explain why would this have caused a mass extinction?

9. When you walk your dog, you are using energy from the sunlight to power this activity. Explain.

DIRECTIONS: Cut out the molecule cards provided and arrange into a balanced chemical equation to model the balanced chemical reactions of photosynthesis & cellular respiration. THEN write the full balanced chemical equation for each reaction on the line provided. If you need a hint, check out the article…

PHOTOSYNTHESIS:
Balanced chemical equation: _____ → _____

→

CELLULAR RESPIRATION:
Balanced chemical equation: _____ → _____

→

WEST Photosynthesis & Cell Respiration HS-LS1-5, HS-LS2-5.

ENERGY TRANSFER AND UTILIZATION

Two cells are illustrated in this schematic diagram of energy capture, transfer, and utilization in land plants. The upper cell represents a photosynthetic cell as found in green plant parts; the lower cell represents a nonphotosynthetic cell as found in nongreen plant parts such as a root cell. Most photosynthetic land plants have both photosynthetic and nonphotosynthetic cells, and the nonphotosynthetic cells must rely upon the output of photosynthetic cells for their energy requirements.

Color light energy (A). In the photosynthetic cell, color chloroplast (B), photosynthesis (C), carbon dioxide (D), carbohydrate (E), water (F), oxygen (G), and starch (H). Color total paths of carbohydrate and water in both cell types.

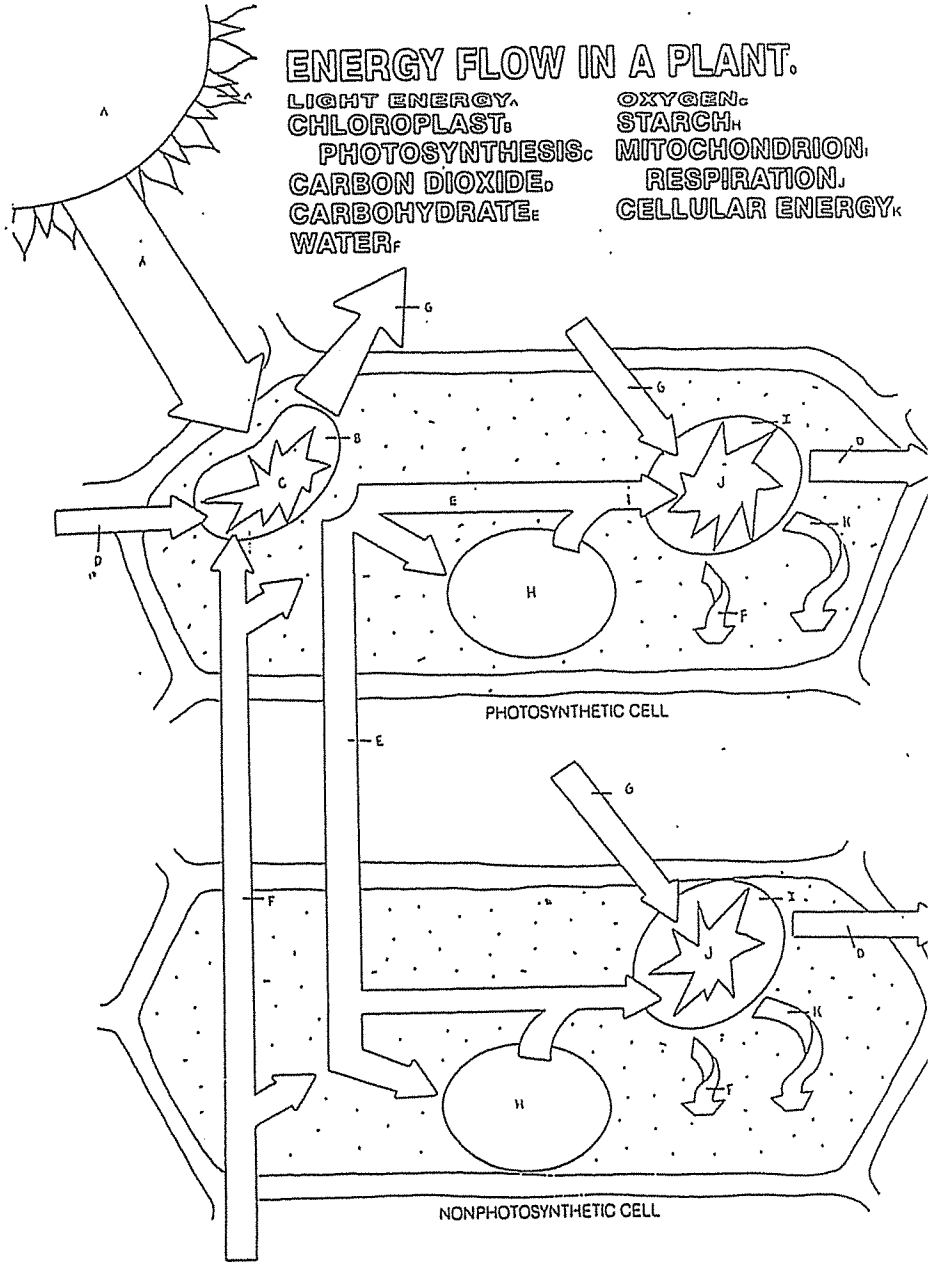
In photosynthetic cells, *light energy* is captured within the *chloroplasts* by *photosynthesis*. Because unstable *light energy* cannot be directly used as an energy source for cell function, it is first transformed into a stable chemical energy form, *carbohydrate*. During this process, photolysis, or the light-induced splitting of *water*, releases large amounts of *oxygen* within the *chloroplasts*. *Water* is brought into the plant and transported to photosynthetic cells by nonphotosynthetic cells. Some *carbohydrate* is used directly, but cells specialized for *photosynthesis* produce more *carbohydrate* than is needed for their immediate use. Some is stored as *starch* within the photosynthetic cells, but most excess *carbohydrate* is transported to nonphotosynthetic cells.

In both photosynthetic and nonphotosynthetic cells, color the mitochondria (I), respiration (J), and cellular energy (K). Color carbon dioxide (D), oxygen (G), and starch (H) in the nonphotosynthetic cell.

Respiration, the breakdown of *carbohydrate* compounds with an accompanying release of *cellular energy*, occurs primarily within the *mitochondria*. *Carbohydrates* formed directly from *photosynthesis* may be used by the cell, but *starch* reserves are used when *photosynthesis* is supplying an inadequate amount of *carbohydrate*. At night, only *starch* reserves are used in most plants because *photosynthesis* is not occurring. Carbon released by the breakdown of *carbohydrate* compounds is liberated as *carbon dioxide*. Atmospheric *oxygen* enters the *mitochondria*, where it combines with hydrogen to form *water* during *respiration*. *Cellular energy* released from the *carbohydrates* is retained in an energy-carrying compound, ATP, which distributes it to areas of energy utilization within the cell.

Photosynthesis occurs within photosynthetic cells only when *light energy* is available. *Respiration*, however, is a continuous process within both photosynthetic and nonphotosynthetic cells because life processes demand a continual supply of *cellular energy*. During daylight hours, green plants liberate more *oxygen* through *photosynthesis* than they require for *respiration*. They also take in more *carbon dioxide* than they release. However, during nighttime hours, only *respiration* is occurring, and plants then use *oxygen* and liberate *carbon dioxide*, thereby drawing upon the available atmospheric *oxygen*.

This plate also presents an example of specialization of cells within a multicellular organism. In unicellular organisms, each cell must retain the ability to perform all functions necessary for life. In multicellular organisms, cells may become specialized to perform specific functions, such as *photosynthesis*, more efficiently. Specialization often involves the loss of other functions, and specialized cells depend upon the output of other cells for needs they can no longer fulfill. Thus, the photosynthetic cells illustrated depend upon nonphotosynthetic cells for their supply of *water*, and the nonphotosynthetic cells depend upon the photosynthetic cells for their energy material, *carbohydrate*.



Connecting Cellular Respiration and Photosynthesis

https://www.ck12.org/biology/cellular-respiration-and-photosynthesis/lesson/Connecting-Cellular-Respiration-and-Photosynthesis-MS-LS/

DIRECTIONS: *Read and annotate the article. Summarize by addressing each focus question as you read.*

Photosynthesis and cellular respiration are connected through an important relationship. This relationship enables life to survive as we know it. The ***products*** *of one process are the* ***reactants*** *of the other. Notice that the equation for* ***cellular respiration*** *is the direct opposite of* ***photosynthesis****:*

- *Cellular Respiration:* $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + energy$
- *Photosynthesis:* $6CO_2 + 6H_2O + (light)\ energy \rightarrow C_6H_{12}O_6 + 6O_2$

SUMMARY: How are the chemical reactions shown above related?

Photosynthesis makes the glucose that is used in cellular respiration to make ATP. The glucose is then turned back into carbon dioxide, which is used in photosynthesis. While water is broken down to form oxygen during photosynthesis, in cellular respiration oxygen is combined with hydrogen to form water. While photosynthesis requires carbon dioxide and releases oxygen, cellular respiration requires oxygen and releases carbon dioxide. It is the released oxygen that is used by us and most other organisms for cellular respiration. We breathe in that oxygen, which is carried through our blood to all our cells. In our cells, oxygen allows cellular respiration to proceed. Cellular respiration works best in the presence of oxygen. Without oxygen, much less ATP would be produced.

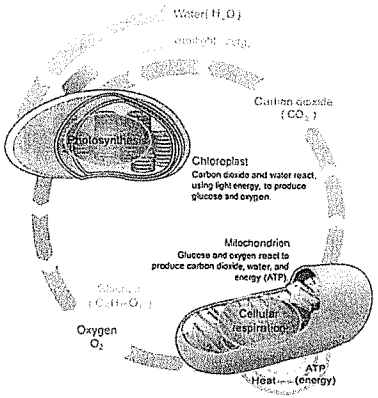
SUMMARY: Why is cellular respiration important for your survival?

Cellular respiration and photosynthesis are important parts of the ***carbon cycle****. The* ***carbon cycle*** *is the pathways through which carbon is recycled in the biosphere. While cellular respiration releases carbon dioxide into the environment, photosynthesis pulls carbon dioxide out of the atmosphere. The exchange of carbon dioxide and oxygen during photosynthesis (****Figure*** *below) and cellular respiration worldwide helps to keep atmospheric oxygen and carbon dioxide at stable levels.*

SUMMARY: How do photosynthesis and cell respiration play a role in the carbon cycle?

OBSERVE THE IMAGE: Cellular respiration and photosynthesis are direct opposite reactions. Energy from the sun enters a plant and is converted into glucose during photosynthesis. Some of the energy is used to make ATP in the mitochondria during cellular respiration, and some is lost to the environment as heat.

SUMMARY: How are the functions of the chloroplast and the mitochondria connected?



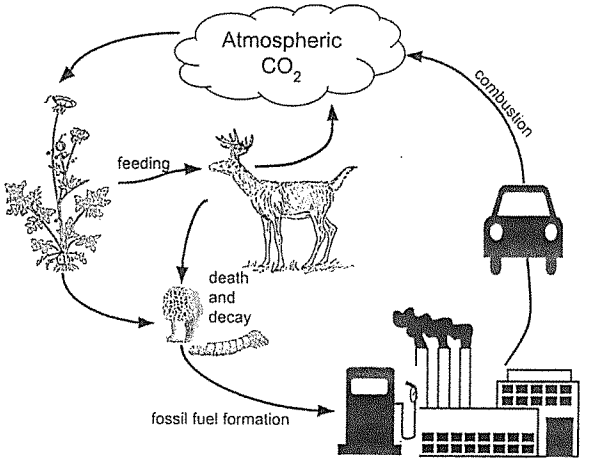
How is this related to Carbon Cycling?

DIRECTIONS: *Use the model to answer the following in your own academic sentences.*

1. The model is missing two labels. Locate where each of the following processes are being illustrated and label them on the diagram. Write a short description of the processes.

Cellular Respiration:

Photosynthesis:



2. How do animals obtain the carbon that they respire?

3. Large areas of land are being developed. In the process thousands of trees are being removed and burned. How would this affect the cycle?

4. List and describe 3 different actions that would decrease the amount of atmospheric CO_2:
   a)
   b)
   c)

5. How does the diagram illustrate the relationship between respiration and photosynthesis? Explain this relationship and it's importance.

WEST Photosynthesis & Cell Respiration HS-LS1-5. HS-LS2-5.

Cellular Respiration Review Sheet

1. The goal of cellular respiration is to make _____.
2. These are the two main types of cellular respiration we studied.
3. Anaerobic respiration occurs in the absence of _____ (but aerobic respiration needs this)
4. In glycolysis, one molecule of glucose is split into two molecules of _____.
5. Is energy needed to begin glycolysis?
6. How many net ATP are made during glycolysis?
7. In anaerobic respiration, what process occurs after glycolysis?
8. What are the two types of fermentation we studied?
9. In lactic acid fermentation, the pyruvic acid produced during glycolysis is converted to _____.
10. During alcoholic fermentation, the pyruvic acid made during glycolysis is converted to carbon dioxide and _____.
11. Alcoholic fermentation is used to make _____.(several possible correct answers)
12. If a person feels discomfort in his or her muscles after strenuous exercise, you can conclude that his or her muscle cells have been doing _____.
13. What is the first step of cellular respiration (whether it is anaerobic or aerobic)?
14. In order, what are the three steps of aerobic respiration?
15. Where in the cell does glycolysis occur?
16. Where in the cell does fermentation occur?
17. Where in the cell does the Krebs cycle occur?
18. Where in the cell does the ETC occur?
19. How many ATP has been made during cellular respiration after glycolysis is over?
20. During the Krebs cycle how many ATP Molecules are created?
21. In aerobic respiration, after glycolysis and the Krebs Cycle are over, how many total ATP's have been made? (with the energy in one molecule of glucose)?
22. As hydrogen ions move down the concentration gradient through the ATP synthase, the energy released in this process is used to convert ADP to _____.
23. Which of the three stages of aerobic respiration makes the most ATP?
24. In aerobic respiration, how many ATP can be made from one molecule of glucose?
25. When oxygen combines with electrons and hydrogen ions, what is formed?

Photosynthesis:

1. Which organelle is involved in photosynthesis? List and describe the parts of this organelle.

2. Explain what happens to energy during photosynthesis. In what form does it enter photosynthesis? In what form does it exist during photosynthesis? In what form does it leave photosynthesis? How is this related to the overall goal of photosynthesis?

3. Plants absorb energy with **light-absorbing** molecules called:

4. What is the primary pigment involved in photosynthesis? Why do plants also contain accessory pigments?

5. A student exposed one plant to only red light and another to only green light. Which should grow better and why?

6. Write the basic equation for photosynthesis using the names of the molecules involved. Identify the products and reactants. Is light a product or reactant? If not, what does it supply to the equation?

7. A student is collecting gas being given off by a plant in direct sunlight. The gas is most likely:

Cellular Respiration and Fermentation

1. What are the products and reactants of cellular respiration? Where does the reaction take place in cells?

2. How is energy transformed during cellular respiration? In what form does it enter cellular respiration? In what form does it leave cellular respiration? How is this related to the overall goal of cellular respiration?

3. What is a calorie? Briefly explain how cells use a high-calorie molecule such as glucose.

4. Compare and contrast photosynthesis and cellular respiration in terms of product, reactant, and energy transformations in each.

5. Why are photosynthesis and cellular respiration considered opposite reactions?

7. Compare and contrast fermentation and cellular respiration in terms of product, reactant, and energy