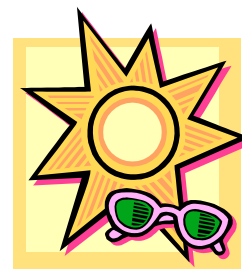


Let the Sun Shine: An Introduction to Photosynthesis

Why?

We know that all living things require energy for life processes. This energy is released from food during the process of respiration. We've all seen proof of this in little children who have eaten too much sugar! How does energy "get into" food such as sugar? From where does all of this energy originate?



Learning Objectives

Students will:

- Identify the source of energy for photosynthesis
- Identify colors of light used by chlorophyll.
- Identify reactants and products of photosynthesis.
- Describe why photosynthesis is an energy conversion reaction.
- Explain the effects of light intensity and temperature on the rate of photosynthesis.

Prerequisites

ATP is the energy used in biological systems.

Organic compounds contain carbon, hydrogen and oxygen; Inorganic compounds do not.

Energy is stored in the chemical bonds of glucose.

Light is a form of energy.

Vocabulary

Glucose

Chemical bond energy

Inorganic

Photosynthesis

Chlorophyll

Chloroplast

Pigment

Model 1

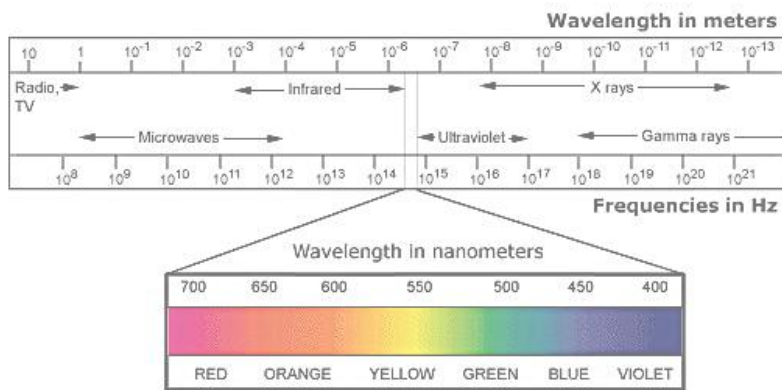


Figure 1: Electromagnetic Spectrum

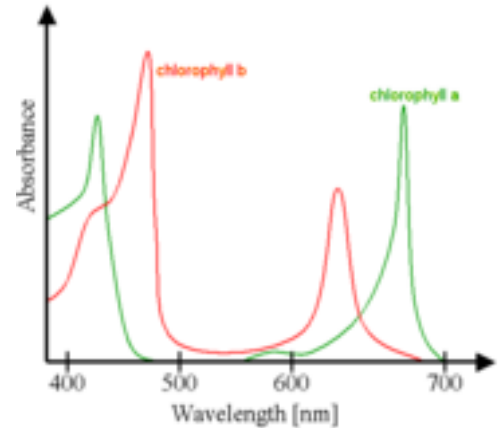


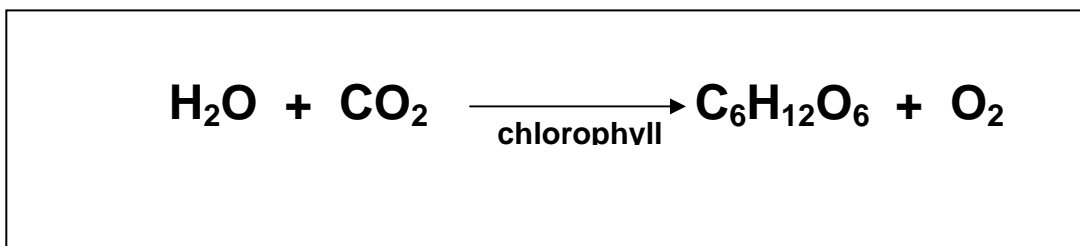
Figure 2: Action Spectrum for Chlorophyll

Key Questions:

1. What color of light has a wavelength of 700nm?
2. At what two wavelengths does chlorophyll "a" absorb light the best?
3. What two colors of light are used best by chlorophyll "a"?
4. What color of light does chlorophyll "a" not use at all?
5. In what organelle would you find chlorophyll?
6. Pigments are defined as substances that interact with light to absorb only certain wavelengths. Explain why you think chlorophyll should be considered a pigment.
7. Many plants contain pigments other than chlorophyll. What do you think is their purpose?

Model 2

Figure 3: Equation for Photosynthesis



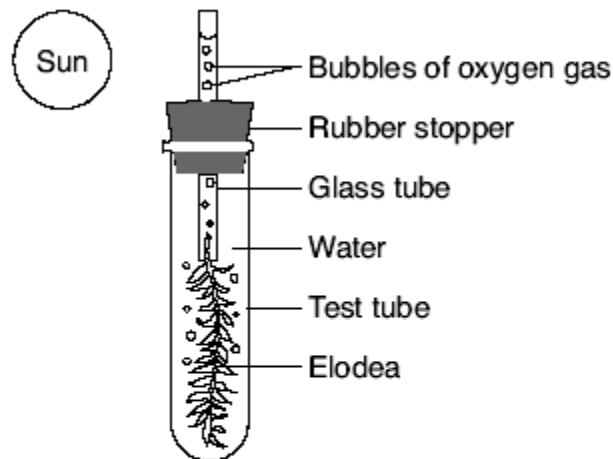
Key Questions:

1. What two products are made during the photosynthesis reaction?
2. What two inorganic molecules are used to make glucose?
3. What is the purpose of chlorophyll in this equation?
4. In what organelle would the above reaction occur?
5. Where does the energy come from to run this reaction? Explain how you know this based on the equation.
6. Explain why you think photosynthesis is considered an *energy conversion* reaction.
7. Give examples of how both products of photosynthesis are important to other living things.

Exercises

1.

A small water plant (elodea) was placed in bright sunlight for five hours as indicated below. Bubbles of oxygen gas were observed being released from the plant.



Since oxygen gas is being released, it can be inferred that the plant is

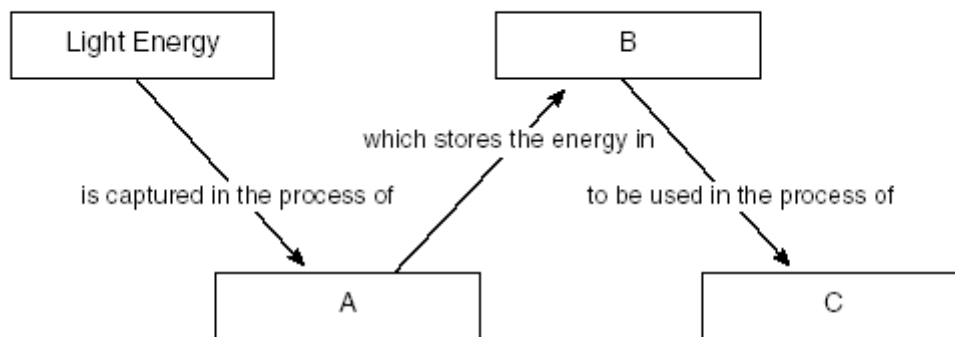
- | | |
|-----------------------|----------------------------------|
| (1) producing glucose | (3) releasing energy from water |
| (2) making protein | (4) carrying on active transport |

What substance did the plant most likely absorb from the water for the process that produces the oxygen gas?

- | | |
|------------------------|---------------|
| (1) dissolved nitrogen | (3) an enzyme |
| (2) carbon dioxide | (4) a hormone |

2.

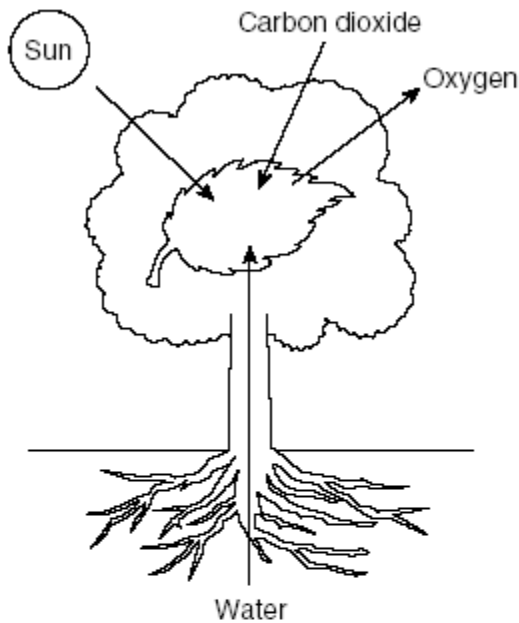
Which set of terms best identifies the letters in the diagram below?



	A	B	C
(1)	photosynthesis	inorganic molecules	decomposition
(2)	respiration	organic molecules	digestion
(3)	photosynthesis	organic molecules	respiration
(4)	respiration	inorganic molecules	photosynthesis

3.

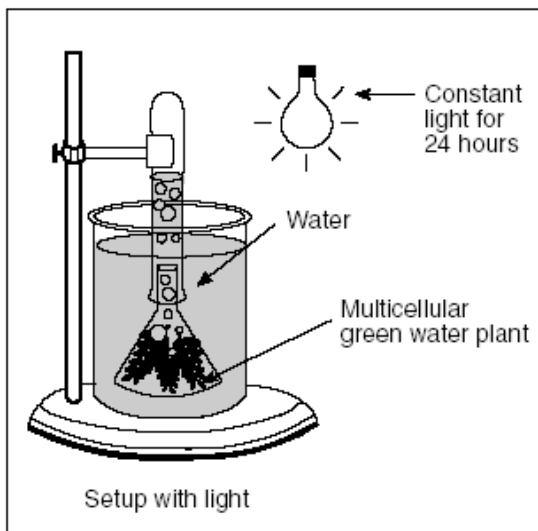
The diagram below represents events associated with a biochemical process that occurs in some organisms.



Which statement concerning this process is correct?

- (1) The process represented is respiration and the primary source of energy for the process is the Sun.
- (2) The process represented is photosynthesis and the primary source of energy for the process is the Sun.
- (3) This process converts energy in organic compounds into solar energy which is released into the atmosphere.
- (4) This process uses solar energy to convert oxygen into carbon dioxide.

4.



a. What gas is being released by the plant?

b. What high energy organic molecule is being made by this plant?

c. What is the purpose of the green pigment in the chloroplast of the plant?

Model 3

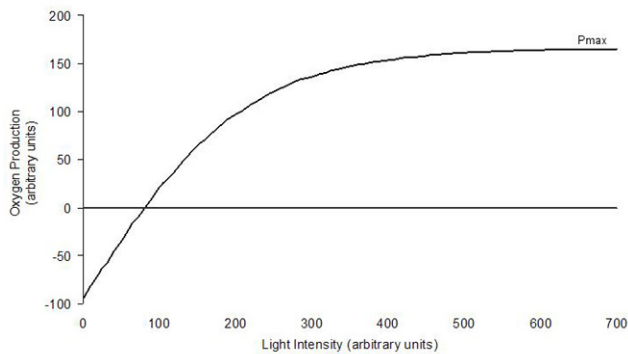


fig.4 The effect of light intensity on rate of photosynthesis

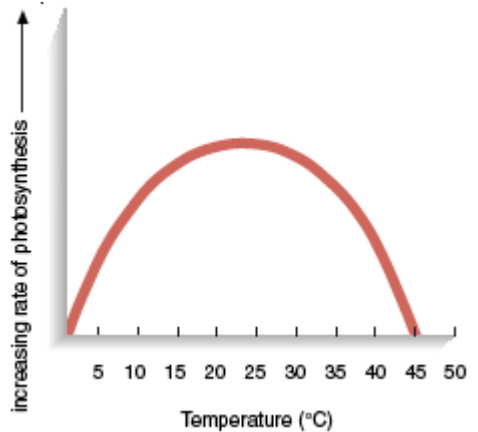


fig. 5 The effect of temperature on rate of photosynthesis

Key Questions

1. At what temperature(s) is/are the rate of photosynthesis the greatest?
2. At what light intensity(s) is/are the rate of photosynthesis the greatest?
3. Why is the rate of photosynthesis measured in units of oxygen production? Explain how you could use another molecule to determine rate of photosynthesis?
4. Explain why you think photosynthesis happens at a slower rate when there is less light available.
5. You want to set up a greenhouse. Based on these graphs, what conditions would help you grow the best plants? Explain your answer.
6. Why do you think the two variables of light intensity and temperature have different effects on the rate of photosynthesis? In other words, why are the graphs different shapes?

7. Based on the graphs, what part(s) of the world would have the highest rates of photosynthetic activity? Explain your answer.

Instructor's Guide: *Let the Sun Shine: An Introduction to Photosynthesis*

Standards Connections

Connections to the *National Science Education Standards*:

- The energy for life primarily derives from the sun. Plants capture energy by absorbing light and using it to form strong (covalent) chemical bonds between the atoms of carbon-containing (organic) molecules. In addition, the energy stored in bonds between the atoms (chemical energy) can be used as sources of energy for life processes.

Connections to the *New York State Living Environment Core Curriculum*:

- 5.1a The energy for life comes primarily from the sun. Photosynthesis provides a vital connection between the sun and the energy needs of living organisms.
- 5.1b Plant cells and some one-celled organisms contain chloroplasts, the site of photosynthesis. The process of photosynthesis uses solar energy to combine the inorganic molecules carbon dioxide and water into energy-rich organic compounds (e.g., glucose) and release oxygen into the environment.

Hints For Facilitation

Model 1 #3: Remind students that the question is looking for “colors” not wavelength. It is OK for students to give a color range.

Model 1 #4: It is appropriate for students to give a range of color for this question.

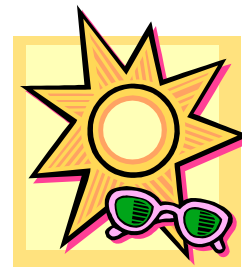
Model 2 #5: This question requires that students make a connection between Model 1 and Model 2. Teachers may have to lead students to the answer by first directing students to the word chlorophyll in the equation and then reminding them that pigments absorb light energy.

Model 3 #6 Teachers may have to remind students about the role of enzymes in this reaction and how temperature affects enzymes.

Model 3 #7 Teachers need not worry about exact locations. It is only important that students pick a location with much light and warm temperature.

Why?

We know that all living things require energy for life processes. This energy is released from food during the process of respiration. We've all seen proof of this in little children who have eaten too much sugar! How does energy "get into" food such as sugar? From where does all of this energy originate?



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Photosynthesis

Chlorophyll

Chloroplast

Pigment

Model 1

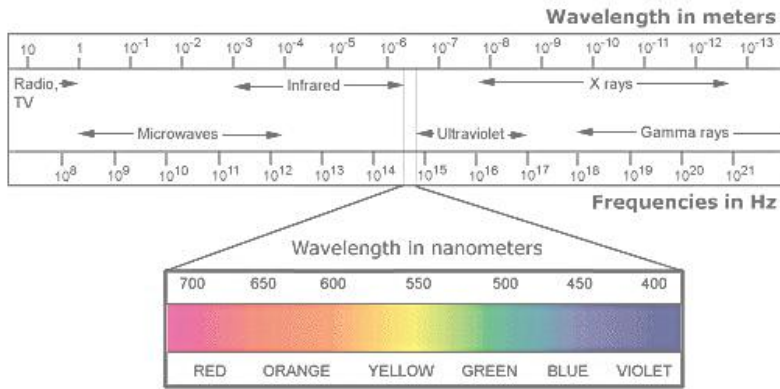


Figure 1: Electromagnetic Spectrum

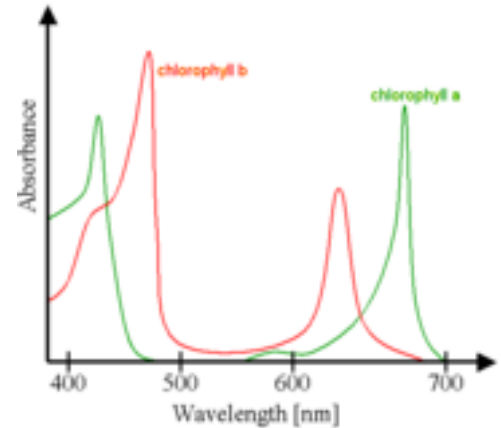


Figure 2: Action Spectrum for Chlorophyll

Key Questions:

1. What color of light has a wavelength of 700nm?

red

2. At what two wavelengths does chlorophyll "a" absorb light the best?

~675 nm and 425 nm

3. What two colors of light are used best by chlorophyll "a"?

red-orange and violet-blue

4. What color of light does chlorophyll "a" not use at all?

Green-yellow

5. In what organelle would you find chlorophyll?

chloroplast

6. Pigments are defined as substances that interact with light to absorb only certain wavelengths. Explain why you think chlorophyll should be considered a pigment.

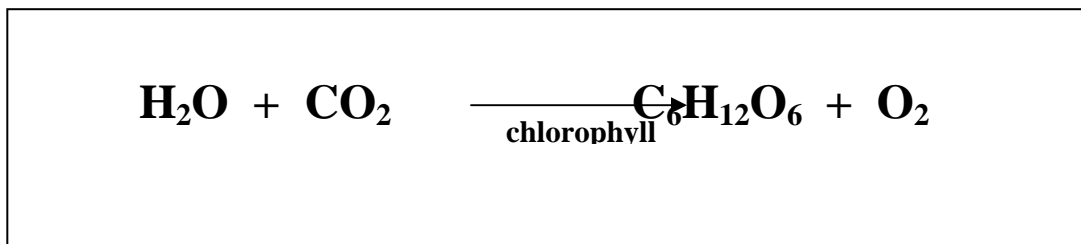
When looking at the absorption spectrum graph, I can see that chlorophyll only absorbs light of certain wavelengths. This meets the criteria of the definition.

7. Many plants contain pigments other than chlorophyll. What do you think is their purpose?

Pigments other than chlorophyll might absorb light at other wavelengths or these pigments might absorb wavelengths that chlorophyll does not absorb.

Model 2

Figure 3: Equation for Photosynthesis



Key Questions:

1. What two products are made during the photosynthesis reaction?

Glucose and oxygen

2. What two inorganic molecules are used to make glucose?

Water and carbon dioxide

3. What is the purpose of chlorophyll in this equation?

Chlorophyll is a pigment that absorbs light energy.

4. In what organelle would the above reaction occur?

chloroplast

5. Where does the energy come from to run this reaction? Explain how you know this based on the equation.

The energy must come from sunlight. Chlorophyll is seen in the equation to absorb light.

6. Explain why you think photosynthesis is considered an *energy conversion* reaction.

This is an energy conversion reaction because the energy in light is converted into chemical bond energy in glucose.

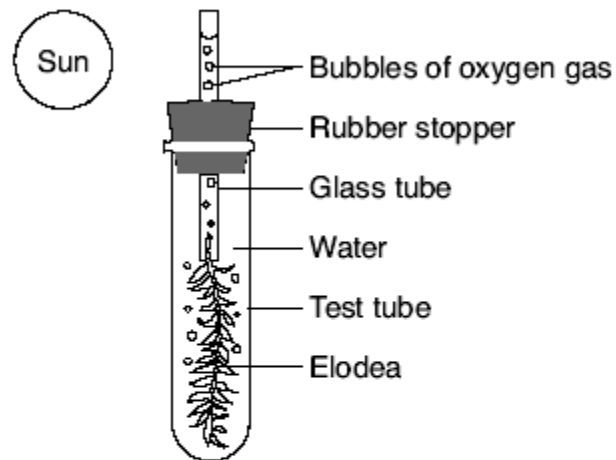
7. Give examples of how both products of photosynthesis are important to other living things.

The glucose is used for food, the oxygen is used for breathing or aerobic respiration.

Exercises

1.

A small water plant (elodea) was placed in bright sunlight for five hours as indicated below. Bubbles of oxygen gas were observed being released from the plant.



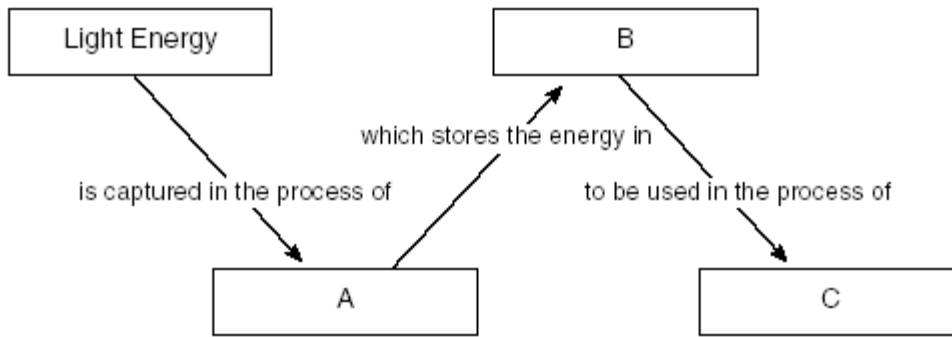
Since oxygen gas is being released, it can be inferred that the plant is

- (1) producing glucose
- (2) making protein
- (3) releasing energy from water
- (4) carrying on active transport

What substance did the plant most likely absorb from the water for the process that produces the oxygen gas?

- (1) dissolved nitrogen
 - (2) carbon dioxide
 - (3) an enzyme
 - (4) a hormone
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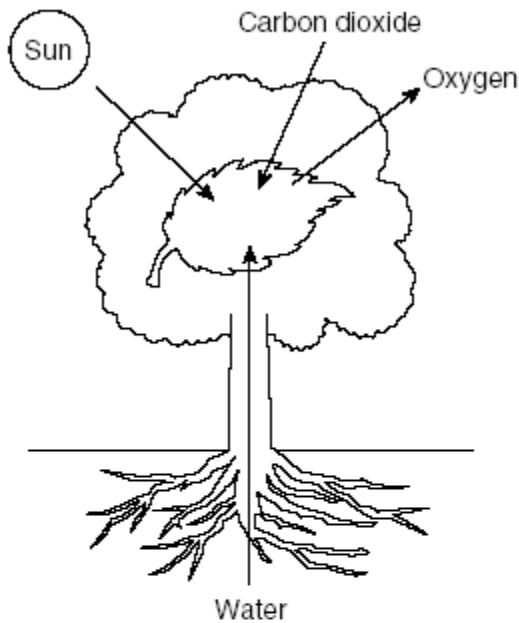
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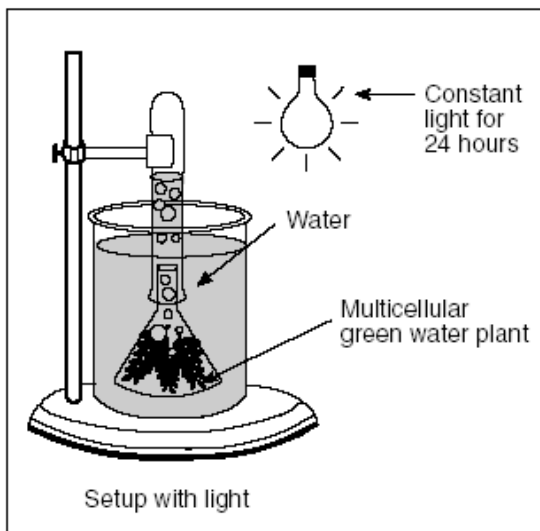
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- (4) This process uses solar energy to convert oxygen into carbon dioxide.

4.



a. What gas is being released by the plant?

Oxygen

b. What high energy organic molecule is being made by this plant?

Glucose

c. What is the purpose of the green pigment in the chloroplast of the plant?

To absorb light energy

Model 3

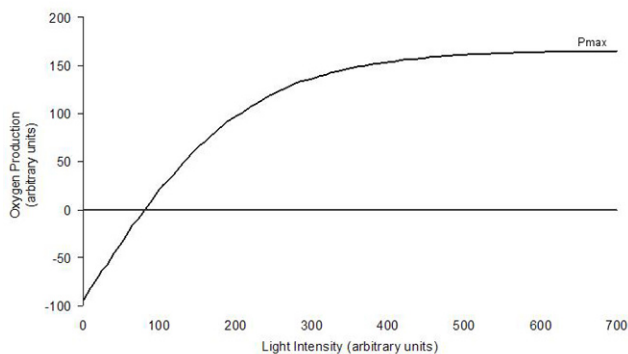


fig.4 The effect of light intensity on rate of photosynthesis

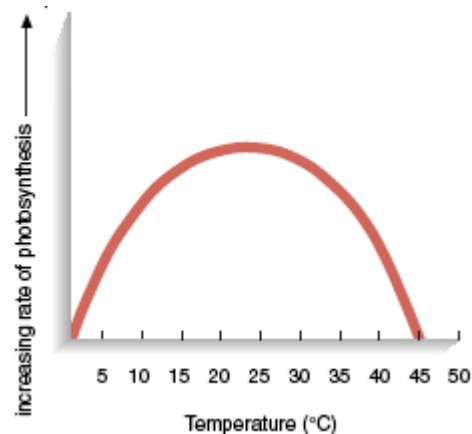


fig. 5 The effect of temperature on rate of photosynthesis

Key Questions

1. At what temperature(s) is/are the rate of photosynthesis the greatest?

~25°C

2. At what light intensity(s) is/are the rate of photosynthesis the greatest?

Above 500 units

3. Why is the rate of photosynthesis measured in units of oxygen production? Explain how you could use another molecule to determine rate of photosynthesis?

Since oxygen is being produced during the reaction, we can measure how fast the reaction is happening by how much oxygen is produced per unit time. We could measure the rate of glucose production as well. Conversely, we could measure the uptake of carbon dioxide or water to measure the rate of photosynthesis.

4. Explain why you think photosynthesis happens at a slower rate when there is less light available.

Light provides energy for the reaction. The less light that is available, the energy available to run the reaction, the slower photosynthesis occurs.

5. You want to set up a greenhouse. Based on these graphs, what conditions would help you grow the best plants? Explain your answer.

My greenhouse would have to be around 25°C since that is the optimum temperature and have a light intensity of about 500 units since photosynthesis happens best at these conditions.

6. Why do you think the two variables of light intensity and temperature have different effects on the rate of photosynthesis? In other words, why are the graphs different shapes?

Student answers will vary. However, students should be directed to the temperature curve and recognize that enzymes are affected by temperature. The input of light does not require enzymes and therefore will not dip when light intensity reaches optimum level.

7. Based on the graphs, what part(s) of the world would have the highest rates of photosynthetic activity? Explain your answer.

Student answers will vary, but should show an understanding that warm temperatures and sufficient light are necessary.