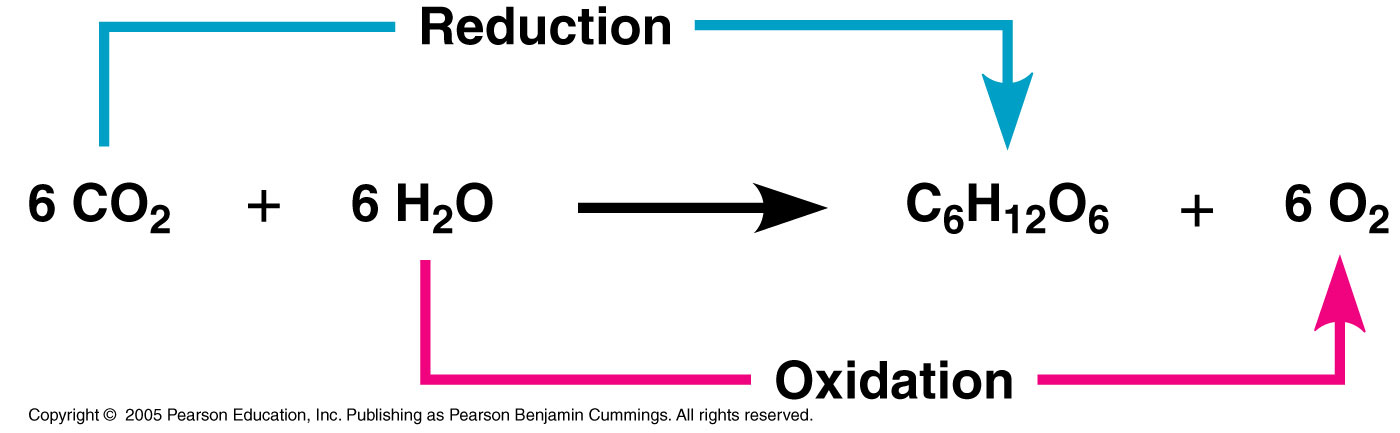
Chapter 7: Photosynthesis

1. Introduction
   1. Photosynthesis fuels all \_\_\_\_\_
      1. Plants are \_\_\_\_\_, which
         1. Sustain themselves
         2. Do not usually consume organic molecules derived from \_\_\_\_\_ organisms.
         3. Make their own food through the process of \_\_\_\_\_, in which they convert \_\_\_\_\_ and \_\_\_\_\_ to \_\_\_\_\_\_\_\_\_\_and other organic molecules.
         4. 6H2O + 6CO2 + Light 🡪 C6H12O6 + 02

\_\_\_\_\_ + \_\_\_\_\_ + Energy 🡪 \_\_\_\_\_ + \_\_\_\_\_

* + 1. Types of organisms
       1. \_\_\_\_\_autotrophs: use the energy of \_\_\_\_\_ to produce organic molecules.
       2. \_\_\_\_\_autotrophs: are \_\_\_\_\_ that use inorganic chemicals as their energy source.
       3. \_\_\_\_\_trophs: are \_\_\_\_\_ that feed on plants or animals or decompose organic material.
  1. Photosynthesis Occurs in Chloroplasts in Plant Cells
     1. Chlorophyll
        1. Is an important \_\_\_\_\_ in chloroplasts.
        2. Is responsible for the \_\_\_\_\_ color of plants
        3. Plays a central role in converting solar energy to \_\_\_\_\_.
     2. Chloroplasts
        1. Are concentrated in the cells of the \_\_\_\_\_, the green tissue in the interior of the leaf.
     3. \_\_\_\_\_
        1. Are the tiny pores in the \_\_\_\_\_ that allow:
           1. \_\_\_\_\_ to enter
           2. \_\_\_\_\_ to exit
     4. Veins
        1. In the leaf deliver \_\_\_\_\_ absorbed by the roots
     5. T\_\_\_\_\_
        1. The chloroplasts consist of an envelope of \_\_\_\_\_, which enclose an inner compartment filled with a thick fluid called \_\_\_\_\_ that contains a system of interconnected membranous sacs called thylakoids
        2. They are often concentrated in stacks called \_\_\_\_\_
        3. They have an internal compartment called the \_\_\_\_\_, which has functions analogous to the outer compartment of a mitochondria in the generation of ATP.
        4. Thylakoid membrane
           1. Houses much of the machinery that converts \_\_\_\_\_ into chemical energy.
           2. Chlorophyll molecules are embedded into the thylakoid membrane and capture \_\_\_\_\_.
  2. Photosynthesis is a \_\_\_\_\_ Process, as is Cellular Respiration
     1. Photosynthesis, like Cell Respiration, is a \_\_\_\_\_ (oxidation-reduction) process.
     2. CO2 becomes reduced to \_\_\_\_\_as electrons, along with hydrogen ions (H+) \_\_\_\_\_, are added to it.
     3. Water molecules are \_\_\_\_\_ when they lose electrons along with hydrogen ions.

\_\_\_\_\_ are transferred in REDOX reactions.

* + 1. Cellular Respiration uses \_\_\_\_\_ reactions to harvest the chemical energy stored in a glucose molecule.
       1. This is accomplished by \_\_\_\_\_ the sugar and reducing O2 to H2O.
       2. The electrons \_\_\_\_\_ as they travel down the electron transport chain to O2.
    2. In contrast, the \_\_\_\_\_ (food producing) redox reactions require an \_\_\_\_\_.
    3. In photosynthesis
       1. Light energy is captured by \_\_\_\_\_ molecules to boost the energy of electrons.
       2. Light energy is converted to \_\_\_\_\_.
       3. Chemical energy is stored in the chemical \_\_\_\_\_.
  1. Two Stages of Photosynthesis
     1. \_\_\_\_\_ Reactions
        1. Occur in the \_\_\_\_\_ (*location*)
        2. Water is split, providing a source of electrons and giving off \_\_\_\_\_ as a by-product.
        3. ATP is generated from ADP and a \_\_\_\_\_.
        4. Light energy is absorbed by the \_\_\_\_\_ molecules to drive the transfer of \_\_\_\_\_ and H+ from water to the electron acceptor NADP+, reducing it to \_\_\_\_\_.
        5. N\_\_\_\_\_, produced by the light reactions, provides the “reducing power” for the \_\_\_\_\_.
     2. \_\_\_\_\_ Cycle
        1. Occurs in the \_\_\_\_\_ of the chloroplast
        2. The \_\_\_\_\_ is a cyclic series of reactions that assembles sugar molecules using CO2 and the energy-rich products of the light reactions.
        3. During the Calvin Cycle, CO2 is incorporated into organic compounds in a process called \_\_\_\_\_.
        4. After Carbon fixation, the carbon compounds are reduced to \_\_\_\_\_.
        5. The Calvin Cycle is often called the \_\_\_\_\_, or Light-Independent reactions, because none of the steps requires light directly.

1. The Light Reactions: Converting \_\_\_\_\_ Energy into \_\_\_\_\_ Energy
   1. Visible Radiation absorbed by \_\_\_\_\_ drives the Light Reactions
      1. Sunlight contains energy called the \_\_\_\_\_ or radiation.
         1. Visible light is only a small part of the \_\_\_\_\_, the full range of electromagnetic wavelengths.
         2. Electromagnetic energy travels in \_\_\_\_\_.
         3. The \_\_\_\_\_ is the distance between the crests of two adjacent waves.
      2. Light behaves as discrete packets of energy called \_\_\_\_\_.
         1. A \_\_\_\_\_ is a fixed quantity of light energy.
         2. The shorter the wavelength, the \_\_\_\_\_ the energy.
      3. Why does an apple appear red?
         1. When white light strikes an object, some wavelengths are \_\_\_\_\_ and some are reflected.
         2. Wavelengths absorbed cannot be seen.
            1. A \_\_\_\_\_ apple absorbs all wavelengths of white light, except red.
            2. The red \_\_\_\_\_ of light is reflected to our eye, and perceived as red.
         3. A red apple appears red because it reflects light in the red wavelength.
      4. Plant Pigments
         1. Are built into the \_\_\_\_\_
         2. \_\_\_\_\_ some wavelengths of light
         3. \_\_\_\_\_ other wavelengths
      5. We see the color of the wavelengths that are \_\_\_\_\_ by pigments.
      6. For example: Chlorophyll \_\_\_\_\_ green wavelengths.
         1. The energy provided by the sun to fuel \_\_\_\_\_ comes from the wavelengths of light \_\_\_\_\_ absorbs.
         2. Chlorophyll absorbs \_\_\_\_\_ and \_\_\_\_\_ light best.
      7. Carotenoids
         1. Carotenoids are another type of photosynthetic pigment.
         2. They enhance the \_\_\_\_\_ \_\_\_\_\_ of chlorophyll so that more of the sun’s energy can be used in photosynthesis.
         3. They pass along the energy they absorb to the chlorophyll
         4. \_\_\_\_\_ \_\_\_\_\_ are due to the presence of carotenoids in leaves.
         5. Plants stop producing \_\_\_\_\_ during the fall, so they lose their green color.
         6. Carotenoids are still present in the leaves.
         7. Since they \_\_\_\_\_ \_\_\_\_\_ light and reflect other wavelengths (red, orange, yellow, brown), the leaves take on the color of the carotenoid that is present.
      8. When chlorophyll absorbs light, \_\_\_\_\_ is transferred directly to \_\_\_\_\_\_\_\_\_ in the chlorophyll molecule.
      9. This raises the energy level of these electrons. These high \_\_\_\_\_ \_\_\_\_\_ make photosynthesis work.
   2. Two \_\_\_\_\_ connected by an electron transport chain generate \_\_\_\_\_ and \_\_\_\_\_.
      1. In Light Reactions, \_\_\_\_\_ is transformed into the \_\_\_\_\_ energy of \_\_\_\_\_ and \_\_\_\_\_..
      2. To Accomplish this, electrons are
         1. Removed from \_\_\_\_\_\_
         2. Passed from Photosystem II to Photosystem I
         3. Accepted by NADP+, reducing it to \_\_\_\_\_.
      3. Between the two photosystems, the electrons
         1. Move down an \_\_\_\_\_ and
         2. Provide energy fro the synthesis of \_\_\_\_\_.
         3. This takes place in the \_\_\_\_\_ of the chloroplast.
2. The Light Dependent Reaction - Photosystems
   1. Takes place within the \_\_\_\_\_ \_\_\_\_\_.
   2. Photosystems: A collection of pigment molecules (chlorophyll) that serve as the \_\_\_\_\_ \_\_\_\_\_ \_\_\_\_\_.
      1. \_\_\_\_\_ II
         1. The chlorophyll molecules in photosystem II absorb \_\_\_\_\_.
         2. This light energy is absorbed by chlorophyll’s \_\_\_\_\_increasing their energy level.
         3. These \_\_\_\_\_ energy electrons are passed to the \_\_\_\_\_ \_\_\_\_\_ \_\_\_\_\_.
         4. The electrons that were \_\_\_\_\_must now be \_\_\_\_\_.
         5. Enzymes in the thylakoid membrane break apart \_\_\_\_\_ molecules into \_\_\_\_\_ \_\_\_\_\_ \_\_\_\_\_.
         6. The electrons replace the high-energy electrons that chlorophyll has \_\_\_\_\_ to the electron transport chain.
         7. The \_\_\_\_\_ is considered a waste product and is released into the \_\_\_\_\_.
         8. The splitting apart of water molecules is responsible for nearly all of the oxygen in our \_\_\_\_\_.
         9. The \_\_\_\_\_ ions from the water are released inside the thylakoid.
         10. The high-energy electrons move through the electron transport chain from \_\_\_\_\_ to \_\_\_\_\_.
         11. As the electrons are passed down the electron transport chain, \_\_\_\_\_ molecules use the energy from these electrons to create \_\_\_\_\_.
         12. The \_\_\_\_\_ molecules in Photosystem I absorb energy from the \_\_\_\_\_ and use it to re-energize the electrons.
         13. The electron carrier \_\_\_\_\_ picks up these high-energy electrons along with a \_\_\_\_\_ to form \_\_\_\_\_.
      2. The Big Picture
         1. The purpose of the light dependent reaction is to produce \_\_\_\_\_ and \_\_\_\_\_ that are needed for the light \_\_\_\_\_ reactions.
         2. The reaction that takes place in the \_\_\_\_\_ membrane:
            1. Water molecules are continuously \_\_\_\_\_.
            2. \_\_\_\_\_ will accumulate in the thylakoid.
            3. The \_\_\_\_\_ is released into the atmosphere.
            4. The light-dependent reactions pass \_\_\_\_\_ continuously from water to NADPH.
         3. The two photosystems work together using the \_\_\_\_\_ \_\_\_\_\_ from the sun to produce \_\_\_\_\_ and \_\_\_\_\_.
      3. Light reactions take place within the \_\_\_\_\_ \_\_\_\_\_
         1. A Thylakoid Membrane includes numerous copies of
            1. The \_\_\_\_\_ and
            2. The \_\_\_\_\_ transport chain.
         2. Light energy absorbed by the two photosystems drives the \_\_\_\_\_ from water to \_\_\_\_\_.
         3. The electron transport chain helps to produce the concentration gradient of \_\_\_\_\_ across the thylakoid membrane, which drives H+ through ATP synthase, producing \_\_\_\_\_\_\_\_\_.
         4. Photosystem II is a collection of \_\_\_\_\_ molecules that absorb \_\_\_\_\_ \_\_\_\_\_ from the sun.
            1. When \_\_\_\_\_ strikes the surface of the leave, the \_\_\_\_\_ molecules absorb the energy from the sun.
            2. This light energy increases the \_\_\_\_\_ level of the \_\_\_\_\_ in chlorophyll molecules. These high energy electrons are passed to the \_\_\_\_\_ \_\_\_\_\_ \_\_\_\_\_.
            3. The electrons that were \_\_\_\_\_ must now be \_\_\_\_\_.

Enzymes in the thylakoid membrane break apart \_\_\_\_\_ molecules into 2 electrons, 2 H+ ions, and 1 oxygen molecule.

These \_\_\_\_\_ replace the high-energy electrons that chlorophyll has lost to the electron transport chain.

The \_\_\_\_\_ is considered a waste product and is released into the air.

The \_\_\_\_\_ ions from the water are released inside the \_\_\_\_\_ space.

* + - * 1. The high-energy electrons move through the electron transport chain from Photosystem II to \_\_\_\_\_.

As the electrons are passed down the electron transport chain, protein molecules use the energy from these electrons to create \_\_\_\_\_.

* + - * 1. The chlorophyll molecules in Photosystem I absorb \_\_\_\_\_ and use it to re-energize the electrons.
        2. These electrons are passed down a second \_\_\_\_\_ \_\_\_\_\_ \_\_\_\_\_ to the electron acceptor called \_\_\_\_\_.
        3. NADP+ joins with one hydrogen atom and two electrons to form \_\_\_\_\_ in an area outside of the thylakoid.
        4. This area of the chloroplasts is called the \_\_\_\_\_. It is a dense, enzyme-rich \_\_\_\_\_ area of the chloroplast outside of the thylakoid.
        5. Hydrogen ions flow from an area of \_\_\_\_\_ concentration inside the thylakoid space to an area of \_\_\_\_\_ concentration in the \_\_\_\_\_.
        6. The hydrogen is flowing through a protein enzyme called \_\_\_\_\_. As the hydrogen flows through ATP synthase, the \_\_\_\_\_ rotates just like a turbine being turned by water.
        7. As this protein rotates, ATP synthase binds a \_\_\_\_\_ to \_\_\_\_\_ to form \_\_\_\_\_.
        8. Hydrogen ions are pumped back inside the \_\_\_\_\_ \_\_\_\_\_ to keep the concentration of hydrogen very \_\_\_\_\_ inside it.
        9. \_\_\_\_\_ and \_\_\_\_\_ are sent to the \_\_\_\_\_ Cycle
      1. The purpose of the light reaction is to produce the high-energy compounds of \_\_\_\_\_ and \_\_\_\_\_ which will be used in the light independent reactions

1. The Calvin Cycle – Reducing \_\_\_\_\_ to \_\_\_\_\_
   1. This set of reactions may be called by several names
      1. The Calvin cycle
      2. The \_\_\_\_\_ Reaction
      3. The Light-\_\_\_\_\_ Reaction
         1. This occurs in the \_\_\_\_\_ of the Chloroplast.
         2. The purpose of this stage is to take \_\_\_\_\_ and the high-energy products from the light reaction (\_\_\_\_\_ and \_\_\_\_\_) and make \_\_\_\_\_ molecules.
         3. These reactions can occur \_\_\_\_\_ light.
         4. The Calvin Cycle uses CO2 + ATP = G-3-P (Glyceraldehyde-3-Phosphate)
         5. A Plant cell uses \_\_\_\_\_ to make one glucose (6C)
         6. \_\_\_\_\_ of the Calvin Cycle are required to make on molecule of Glucose (6C)
         7. Glucose is used by \_\_\_\_\_ in cellular respiration to make many ATP molecules.
         8. Steps of the Calvin Cycle
            1. Carbon \_\_\_\_\_
            2. \_\_\_\_\_
            3. Release of one molecule of G3P
            4. Regeneration of the starting molecule, Ribulose Biphosphate (RuBP)
         9. Steps of the Calvin Cycle using the chart
            1. \_\_\_\_\_ \_\_\_\_\_ is obtained from the atmosphere. It enters the leave through the pores in the leaf called the \_\_\_\_\_.
            2. The carbon from \_\_\_\_\_ \_\_\_\_\_ is combined with a 5-carbon sugar called \_\_\_\_\_-Ribulose Biphospate. This is referred to as \_\_\_\_\_ \_\_\_\_\_.
            3. This forms a very \_\_\_\_\_ \_\_\_\_\_ that immediately breaks apart into \_\_\_\_\_ three carbon molecules.
            4. A series of reactions involving \_\_\_\_\_ and \_\_\_\_\_ converts this molecule into two molecules of \_\_\_\_\_ (Glyceraldehyde-3-Phosphate), which is a three-carbon compound.

There are two possibilities for G3P:

Two molecules of G3P are combined together to form a molecule of \_\_\_\_\_.

Some of the G3P is converted by a series of reactions into more \_\_\_\_\_ so that the reaction can occur again.

* + 1. To Sum it all up: The energy from the sun has been stored as chemical energy in glucose.

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| --- | --- | --- |
| Event | Photosynthesis | Respiration |
| Function |  |  |
| Reactants |  |  |
| Products |  |  |
| Where it takes place |  |  |
| What happens to glucose |  |  |
| What happens to energy | Energy from sunlight is used; Stored in Glucose | Energy from glucose is used; Stored in ATP |
| Overall reaction | 6CO2 + 6H2O ==> C6H12O6 + 6O2 | C6H12O6 + 6O2 → 6CO2 + 6H2O + Energy (36 or 38 ATP) |