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) |