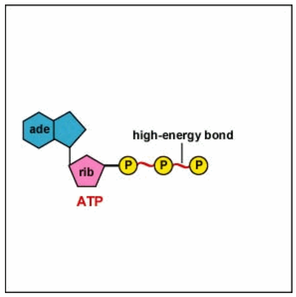
Energy Flow in living things

The total amount of energy in the universe stays the same; it just changes from one form to another. The chemical energy in gasoline can change to heat energy and energy of motion. The transformation of energy takes place in all of the life processes in living things. All of the energy on Earth comes from the sun. The sun's energy is what drives the chemical reactions and the processes of life. This solar energy is trapped in by the chloroplast in a plant cell, mostly found in plant leaves and stems. Here the chloroplast can carry out the process of photosynthesis. A few chemical reactions take place in the chloroplast to transform the solar energy into chemical energy. Carbon dioxide and water are required for photosynthesis which produces carbohydrates (i.e. sugars in candy bar) and oxygen (O_2). The bonds of the carbohydrates now contain some of the sun's energy. Oxygen is given off as a waste product of photosynthesis and is expelled from the plant leaf into the atmosphere.

Plants, humans, and many other living things use carbohydrates as their essential source of energy. Carbohydrates are transformed to a usable form for cells in mitochondria. Carbohydrates are transported to the mitochondria where they combine with oxygen in a process of respiration (also called cellular respiration). During chemical reactions in the mitochondria, the energy from carbohydrates is released and used to form the energy-rich molecule called adenosine triphosphate (ATP). Carbon dioxide and water are the waste products of cellular respiration. These are the reactants needed for photosynthesis. This is an energy cycle in living things.



Autotrophs and heterotrophs

All of the life processes on Earth require the use energy. Energy enters all of the ecosystems on Earth from the sun. The sun must supply a steady flow of energy because energy cannot be recycled. When an organism uses energy, most of it becomes unusable to any other organism. The organisms on Earth that gather energy from the sun are called producers, or autotrophs. These organisms produce usable energy for the rest of the organisms on Earth. These producers are able to take inorganic molecules, such as carbon dioxide and water, then use the sun's energy to chemically create organic molecules, or food, such as glucose. This process is called photosynthesis. Organisms which can do this are plants, algae, some bacteria, and some protists. These are the most abundant organisms on Earth. The amount of sunlight trapped and changed into a usable form for life is a small amount compared to the amount that strikes Earth, but it is enough to sustain life on Earth.

Some organisms on Earth are not able to produce their own food. They must look for and consume organic molecules that have already been created by one of the producer species. These organisms that cannot create their own food are called consumers, or heterotrophs. Consumers get their energy directly or indirectly from producers. The amount of energy available to the heterotrophs (consumers) when they consume the producers is not the same as would be available to the producer if it used the stored carbohydrates themselves.

Photosynthesis

Photosynthetic organisms use the most abundant form of energy available—the sun. These organisms are plants, algae, some bacteria and some protists. The photosynthesis reaction can be summarized in the equation:

Carbon dioxide + water → glucose + oxygen + water

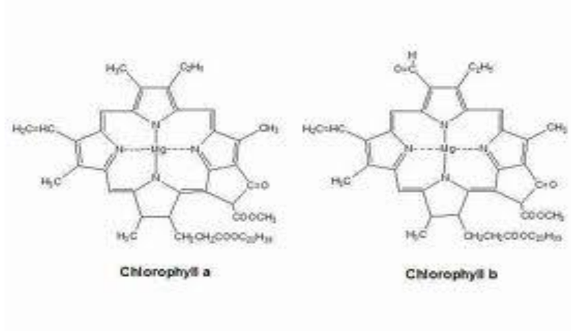
$$6\ CO_2 + 6\ H_2O \rightarrow C_6H_{12}O_6 + 6\ O_2 + 6\ H_2O$$

Photosynthesis has three stages:

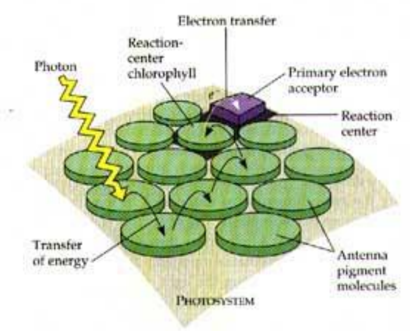
1. The capture of light energy
2. The conversion of light energy into chemical energy
3. The storage of chemical energy in sugar

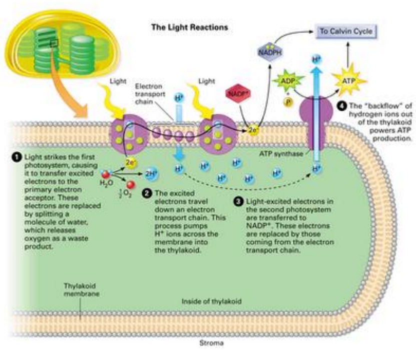
The first two stages are called the Light Reaction while the third stage is called the Dark Reaction.

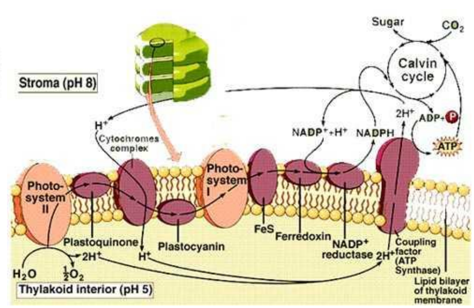
1. **The capture of light energy**



White light is a form of radiant energy made up of seven different wavelengths of light called the visible spectrum (red, orange, yellow, green, blue, indigo, violet energy—ROY G BIV). Red light has the longest wavelength and the least amount of energy, and violet has the shortest wavelength and the greatest amount of energy. Chlorophyll, the green pigment found in food-producing cells, is a very complex molecule made up of more than 120 atoms. The arrangement of all these atoms in the molecule help chlorophyll trap certain wavelengths of light energy. Red light energy and blue light energy are trapped the most efficiently, while green light energy is trapped the least. This is why chlorophyll appears green, because this light energy cannot be trapped and is reflected back into your eye from the molecule. Chlorophyll is found in the chloroplast. Chloroplasts are double-membrane bound, oval-shaped organelles found in cells of autotrophic organisms. A leaf cell has an average of about 50 chloroplasts in its cytoplasm. Each chloroplast contains all the chlorophyll and enzymes needed to complete the complex reactions of photosynthesis. There are internal double-membrane bound structures called **thylakoids** that are stacked in structures called **grana** located throughout the interior of the chloroplast. The rest of the interior of the chloroplast is filled with a protein liquid called **stroma.** The chlorophyll traps the light energy in the electrons of its atoms. Electrons that receive energy from outside the atom move to a higher electron shell around the nucleus, creating a form of potential energy. This stored energy is realized when the electrons fall back to their original shells and release the energy.







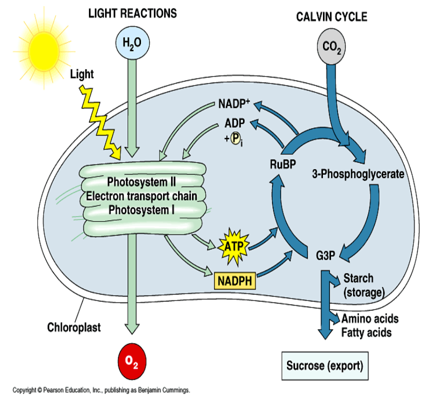
2. The conversion of light energy into chemical energy

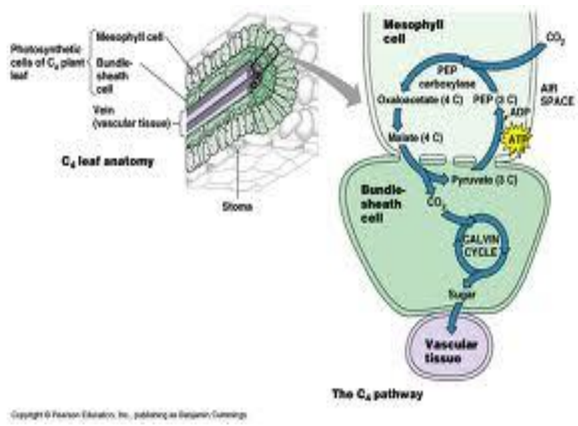
The energy released from the electrons in the chlorophyll is used to do two things: split water molecules and make ATP. When the water molecule is split in the chemical process called photolysis, hydrogen ions (H+) and hydroxide ions (-OH) are formed. Oxygen is released from the hydroxide ion into the environment. The hydrogen ions as well as high-energy electrons associated with them are collected by a coenzyme called NADP. NADP brings these hydrogen ions and electrons, which have potential energy in them, to the next step of the photosynthesis process. Some of the energy from the electrons in chlorophyll is used to change ADP into ATP. This ATP will also be used in the next step of photosynthesis.

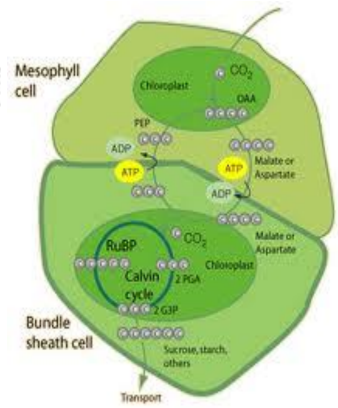
So light energy is converted into chemical energy in the form of ATP and the ions of hydrogen are held in place in the coenzyme NADP.

3. Storing chemical energy in sugar molecules

This third stage of photosynthesis is sometimes referred to as the “dark reaction.” It is not called this because it occurs at night, but because it does not involve the absorption of light energy. The dark reaction is also sometimes called the Clavin cycle, named after Melvin Calvin who discovered many of the steps of the process. In the dark reaction, carbon dioxide, which is brought into the photosynthetic organism from the environment, is chemically reduced by the hydrogen ions produced in the earlier steps of this process.







Factors that affect the rate of food production:

The rate of photosynthesis is affected by factors within the environment, including

Wavelengths of visible light	Temperature
Carbon dioxide concentration	Amount of chlorophyll available within the organism