

# Similarities between photosynthesis and aerobic respiration



**ASSIGN  
BUSTER**

Photosynthesis and aerobic respiration are both part of a cyclic process of biochemical reactions. Photosynthesis requires the products of aerobic respiration (carbon dioxide and water), while aerobic respiration requires the products of photosynthesis (glucose and oxygen). Together, these reactions are involved in how cells make and store energy. The energy transfers in both processes and in how the gas exchange between oxygen and carbon dioxide occurs and the end products that result from each process are somewhat opposite processes, thus aerobic respiration and photosynthesis are in some ways complete opposites of each other. Photosynthetic organisms such as plants use solar energy to reduce carbon dioxide into carbohydrates. During respiration glucose is oxidised back to carbon dioxide, in the process, releasing energy that is captured in the bonds of ATP. Although these two energy producing processes differ in their uses and also their goals, they do have several similarities.

Photosynthesis is a chemical process that takes place in the presence of sunlight, wherein plants manufacture their food and build stores of energy. This phenomenon occurs in chlorophyll containing plant cells. Chlorophyll is a pigment found in plant leaves that gives the plant its green colour.

Chlorophyll absorbs the light energy and utilises it to produce carbohydrates from carbon dioxide and water. These carbohydrates produced are used by the plants as a source of immediate energy for growth, reproduction, and absorption of nutrients. The chemical reaction produces oxygen which is released into the atmosphere.

Photosynthesis can be summed up by the following equation:

$6\text{CO}_2 + 6\text{H}_2\text{O} + \text{Sunlight} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2$ , (fig1 below illustrates the process of photosynthesis)

Occurring in the chloroplast light reaction converts solar energy to chemical energy of ATP and NADPH. The light reactions use the solar power of photons absorbed by Photosystem I and II. These are light gathering antennas containing the chlorophyll primarily responsible for absorbing the light. Electrons are also carried from Photosystem I and II via NADPH to the Calvin cycle. The Calvin cycle uses ATP & NADPH to convert  $\text{CO}_2$  to sugar.  $\text{CO}_2$  enters the cycle & leaves as sugar. The sugar product of the Calvin cycle is not glucose but a 3 carbon sugar called 3-Phosphoglycerate. This 3-Phosphoglycerate with the addition of another phosphate group from ATP forms glyceraldehyde-3-phosphate. In order for one of these G3P molecules to be synthesised the cycle must take place 3 times, fixing 3 molecules of  $\text{CO}_2$ . There are 3 phases of the Calvin cycle, the carbon fixation phase, the carbon reduction phase and the regeneration phase.

Cellular respiration is the process of oxidising food molecules or breaking down chemical bonds of glucose into carbon dioxide and water. The energy released in the process is trapped in the form of ATP and used by different energy consuming activities of the cell. It is a set of metabolic reactions that unlike photosynthesis which occurs in the chloroplast, cellular respiration occurs in the mitochondria. The complete breakdown of glucose into carbon dioxide and water involves two major steps: glycolysis and aerobic respiration. Glycolysis is the anaerobic catabolism of glucose that occurs in all the cells and produces two molecules of ATP. Aerobic respiration is the process in which the pyruvate molecules produced by glycolysis undergoes <https://assignbuster.com/similarities-between-photosynthesis-and-aerobic-respiration/>

further breakdown in the presence of oxygen and generates thirty four molecules of ATP.

This reaction can be described as follows:

$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + \text{Energy (38 ATP)}$  (fig 2 below illustrates cellular respiration)

Cellular respiration beginning here with glycolysis catabolises glucose into 2 molecules of pyruvate. The net yield from glycolysis is 2 ATP & 2 NADH per glucose. Electrons are carried from here to the electron transport chain via NADH. Pyruvate enters the mitochondrion where it gets modified to Acetyl CoA. This then enters the Krebs cycle. The Krebs cycle completes the oxidation of the organic fuel to  $CO_2$ . Electrons produced here are carried via NADH & FADH<sub>2</sub> to the electron transport chain & oxidative phosphorylation. In the Krebs cycle a further 2 ATP is produced. Once there has been a sufficient energy shuttle of NADH from glycolysis, a maximum yield of 34 ATP is produced by oxidative phosphorylation. This then gives a maximum of 38 ATP produced.

Photosynthesis is a reduction-oxidation reaction, just like respiration. In respiration energy is released from sugars when electrons associated with hydrogen are transported to oxygen (the electron acceptor), and water is formed as a by-product. The mitochondria use the energy released in this oxidation in order to synthesize ATP. In photosynthesis, the electron flow is reversed, the water is split (not formed), and the electrons are transferred from the water to  $CO_2$  and in the process the energy is used to reduce the  $CO_2$  into sugar. In respiration the energy yield is 686 kcal per mole of <https://assignbuster.com/similarities-between-photosynthesis-and-aerobic-respiration/>

glucose oxidized to CO<sub>2</sub>, while photosynthesis requires 686 kcal of energy to boost the electrons from the water to their high-energy perches in the reduced sugar — light provides this energy.

Outlined above are the main differences between the two processes.

However, photosynthesis and cellular respiration are two processes that both involve electron transport chains and they both affect concentrations of carbon dioxide and oxygen in the atmosphere. Both photosynthesis and cellular respiration provide energy to the organism's cells.

It is interesting to note the structural similarities between Chlorophyll, that plays an important role in photosynthesis and Haemoglobin that is involved in cellular respiration. Both structures are practically identical except for the fact that haemoglobin has a central Iron atom and chlorophyll possesses a central Magnesium atom. Haemoglobin is a protein that carries oxygen in the blood. Where chlorophyll is known for its green pigment, haemoglobin is known for its deep red pigment.

Both photosynthesis and respiration are also similar in that they both undergo chemiosmosis. Chloroplasts and mitochondria generate ATP by this same basic mechanism. In both kinds of organelles, electron transport chains pump protons (H<sup>+</sup>) across a membrane from a region of low H<sup>+</sup> concentration to an area of high H<sup>+</sup> concentration. The protons then diffuse back across the membrane through ATP synthases, driving the synthesis of ATP. (fig 3 below illustrates this.)

To conclude from this, photosynthesis and cellular respiration are the most vital biochemical pathways to life. They both include cycles, stages and <https://assignbuster.com/similarities-between-photosynthesis-and-aerobic-respiration/>

many enzymes to function. Although their similarities can be easily recognised, it is their differences that make them stand apart as opposite processes. Photosynthesis requiring light in order to produce its end product, carbohydrate, and cellular respiration requiring carbohydrate in order to produce its end product energy.