Functional biology of plants

Science, Biology

Photosynthesis

1. Explain how photosynthesis and respiration are linked in order to provide you with energy from the food you eat.

Photosynthesis and respiration are complementary processes of energy conversion in plant and animal systems. Cellular respiration involves cells utilizing carbon compounds together with oxygen to form high-energy molecules that fuel cellular activities (Audesirk, Audesirk & Byers, 2008). During this process, carbon dioxide, a by-product of the process, would be released into the air. On the other hand, plants would absorb this released carbon dioxide during photosynthesis and give out oxygen. This continuous cycle shows the interdependence of the two processes.

During photosynthesis, plants through chlorophyll capture sunlight energy and convert inorganic molecules of water and carbon dioxide into energy organic molecules. This occurs in two steps, namely, light-dependent and light-independent reactions. The light-dependent reaction is a step where electrons found in the chlorophyll get invoked and the active electrons get transferred to electron transport systems. On the other hand, light-independent reactions occur as a cycle of chemical reactions referred to as Calvin cycle. Audesirk et al. (2008) categorize this cycle into three steps, namely; carbon fixation, glyceraldehydes-3 phosphate, G3P, synthesis and the ribulose biphosphate, RuBP generation.

Carbon fixation entails carbon being assimilated from carbon dioxide into a larger molecule. A plant protein, referred to as rubisco, would then fix carbon in photosynthetic organisms and accept oxygen instead of carbon dioxide, CO2. This forms a CO2 molecule which combines with the RuBP molecule producing an unstable molecule containing six carbon molecules. This immediately splits into two molecules of phosphogyleric acid, PGA. In the G3P synthesis, various reactions cause the energy from adenosine triphosphate, ATP and NADPH to propagate the conversion of the six PGA molecules into six G3P molecules (Audesirk et al., 2008). G3P is a sugar with three carbon molecules. Finally, RuBP would be generated through reactions that utilize ATP produced due to the light reactions of the six G3P molecules. The regenerated RuBP serves as an important ingredient for the repetition of the Calvin cycle, causing the release of the last G3P molecule.

The energy from the sun captured by chloroplasts during photosynthesis enables glucose to be produced from CO2 and H2O, with oxygen being the by-product. Cells then break down this glucose, generating energy that gets captured and stored in ATP, an energy carrying molecule (Hodson & Bryant, 2012). The ATP would then carry energy to cells where it breaks off releasing energy. The resultant molecule, referred to as adenosine diphosphate, ADP could be converted further to adenosine monophosphate, AMP, releasing more energy. The released energy would be utilized for cellular functions. To fuel further activities, cells replenish the supply of ATP.

2. In the absence of oxygen, some cells and organisms can use glycolysis coupled to fermentation to produce energy from the sugar created by photosynthesis. Explain the role of fermentation in allowing an organism to generate energy for its cell(s) in the absence of oxygen.

In the absence of oxygen, cells exclusively rely on glycolysis so as to produce ATP. Here, fermentation would cause hydrogen atoms resulting from glycolysis to be donated to organic molecules. According to Audesirk et al.

(2008), it allows NADH, a product of glycolysis, to revert back to nicotinamide adenine dinucleotide, NAD. This process needs to be continuous for the sustainability of glycolysis. Through cellular respiration, organisms regenerate NAD, a process that encompasses energetic electrons in NAHD being given to the electron transport chain, ETC.

+NADH+NAD+

Organic moleculeReduced organic molecule

Nonetheless, oxygen would be required for this to occur. Thus, for organisms not to access oxygen, it would be mandatory for fermentation to take place. This could take place through lactic acid fermentation where pyruvate ferments to lactate. Alternatively, it could occur through alcoholic fermentation where electrons and H from NADH cause the conversion of pyruvate into CO2 and ethanol as opposed to lactate. This causes the release of NAD, making it available for acceptance of more high-energy electrons.

3. Cells use enzymes as biological catalysts to increase or accelerate the rate of reactions, such as those in photosynthesis of glycolysis. This allows reactions to occur under conditions that sustain life. Explain how an enzyme catalyzes a reaction. Include in your essay the three main steps of the cycle of enzyme-substrate interactions.

Enzymes are specialized catalytic proteins which alter the rate with which a chemical reaction occurs without getting consumed by the reaction (Hodson & Bryant, 2012). To catalyze a reaction, the enzymes first bind to a specific chemical reactant, known as substrates. These substrates only bind on restricted regions in the enzyme, referred to as active sites, and would be held in the interaction through a weak bonding. The selective combination of substrates, temporary chemical bonds, distorted existing bonds and substrate orientation promotes the occurrence of specific chemical reactions to particular enzymes. Resembling a lock and key interaction, it results in the formation of an enzyme-substrate complex. After this interaction, both the active site and the substrate change shape. In the second step referred to as catalysis by Audesirk et al. (2008), the substrate gets converted into a product. Finally, this product fails to fit into the active site as required, thus causing the enzyme to be free. These enzymes emerging from the reaction would be in their original states and could catalyze other reactions over and over again.

How is enzyme activity regulated by the cell?

Enzyme activity would be regulated by the cell through activation or inhibition as need be. Some enzymes would be inactivated and would only be activated under appropriate temperature and pH. Through a competitive inhibitor that competes for the active site with the substrate, the site becomes unavailable for the enzyme to bind with the substrate. Enzyme activity could also be subjected to allosteric regulation, defined by Audesirk et al. (2008) as the effect on protein’s biological functioning due to the presence of a compound that is not directly involved in the function (known as allosteric effectors) or enzyme regulation due to cooperative involvement between various binding sites. Non-competitive inhibitors block the active site away from action of enzyme or binding the enzyme at a varied location thus preventing the substrate from binding to it. To speed up a reaction, cells increase the amount of enzymes and decrease this amount when there is need to slow down a reaction.

References

Audesirk, T., Audesirk, G., & Byers, B. (2008). Biology: Life on earth with physiology (8th ed.). San Francisco, CA: Benjamin Cummings.

Hodson, M. J. & Bryant, J. A. (2012). Functional biology of plants. Hoboken, NJ: John Wiley & Sons.