Cell Respiration Q & A

1. How do cells obtain energy for their functioning?

Cells obtain energy for their metabolic reactions from the breaking of organic molecules with high energetic content. This energy is mostly stored as ATP molecules.

The process of obtaining energy in order to produce ATP molecules is named cellular respiration.

2. What is the compound that is phosphorylated for ATP formation? What is the resulting compound when ATP liberates energy?

ATP, or adenosine triphosphate, is formed after the binding of one phosphate (phosphorylation) to one ADP (adenosine diphosphate) molecule. This is a process that stores energy into the produced ATP molecule.

When ATP gives energy to the cellular metabolism it loses one of its phosphates and ADP reappears.

ADP can also lose more phosphates and generate AMP (adenosine monophosphate) or even non-phosphorylated adenosine. Adenosine production from ATP is a solution used in tissues that need urgent oxygen supply, for example, in the heart during myocardial infarction (heart attack), since adenosine has a local vasodilator effect thus providing faster vasodilation than other physiological methods.

3. What are the types of cell respiration?

There are two types of cell respiration: aerobic cell respiration, a reaction with participation of molecular oxygen (O2), and anaerobic cell respiration, without participation of molecular oxygen but with other inorganic molecules as oxidant. There are several varieties of anaerobic cell respiration, the main one is fermentation.

4. Under which conditions do aerobic cells carry out fermentation?

Some cells that usually obtain energy from aerobic cellular respiration can carry out fermentation when oxygen is not available.

There are bacteria and fungi that under absence of oxygen use their anaerobic metabolic capability for energetic supply. Muscle cells carry out fermentation too when oxygen is scarce.

5. What is the difference between aerobic and anaerobic beings?

Aerobic organisms are those whose cells do not survive without oxygen since they depend on aerobic cell respiration to obtain energy for ATP production. Anaerobic organisms are those that live or can live under oxygen-lacking environments.

6. What is the difference between facultative anaerobic beings and obligate anaerobic beings?

Facultative anaerobic beings, like the fungi Saccharomyces cerevisiae, a brewing yeast, can survive under oxygen-poor environments carrying out fermentation. However when oxygen is available these beings carry out aerobic respiration.

Obligate anaerobic beings are those that cannot survive when oxygen is present. Some fungi, some bacteria (like the agent of botulism Clostridium botulinum, and the agent of tetanus, Clostridium tetani) and some protozoans are examples of obligate anaerobes.

7. What are the two types of fermentation? What are their chemical equations?

The two main types of fermentation are alcoholic fermentation and lactic fermentation.

In alcoholic fermentation pyruvic acid, an intermediate molecule, is converted into ethanol with liberation of carbon dioxide. The alcoholic fermentation equation is as follows:

$C_6H_{12}O_6 + 2\ ADP + P \rightarrow 2\ C_2H_5OH + 2\ CO_2 + 2\ ATP$

In lactic fermentation pyruvic acid is transformed into lactic acid and there is no production of carbon dioxide. The lactic fermentation equation is:

$C_6H_{12}O_6 + 2\ ADP + P \rightarrow 2\ C_3H_5OOH + 2\ ATP$

8. In general what are the reagents and products of fermentation?

In fermentation glucose (sugar) is degraded into pyruvic acid (each glucose molecule forms two pyruvic acid molecules). In this process two molecules of ATP are produced.

According to the type of fermentation, pyruvic acid can produce ethanol and carbon dioxide (in alcoholic fermentation) or lactic acid (in lactic fermentation). There are other varieties of fermentation in which pyruvic acid can generate acetic acid (acetic fermentation), propionic acid,

isopropanol (an alcohol too), etc. The type of fermentation depends on the species of the involved organisms.

9. Why in cake and bread manufacture are alcoholic fermenting organisms used and not lactic fermenting organisms?

Fermentation has the function of making cakes and breads grow. This is accomplished by liberation of carbon dioxide in alcoholic fermentation as the gas passes through the dough and makes it grow. In lactic fermentation there is no liberation of carbon dioxide and the desired result would not be obtained.

10. To what substance is the acidic flavor of fermented milk due?

Some bacteria ferment milk lactose by lactic fermentation producing lactic acid. This product is responsible for the acidic flavor of yogurts, curd and milk.

11. How can the knowledge about fermentation explain the origin of muscle cramps and pains after intense physical exertion?

A typical fermentation process due to oxygen scarcity happens in the muscle tissue. Under intense use muscles demand too much energy (ATP) and consume much more oxygen to produce that energy. High consumption leads to oxygen scarcity and the muscle cells begin to make lactic fermentation trying to satisfy their energetic needs. In this situation muscle pain, cramps and fatigue are due to the lactic acid released by fermentation.

12. How many ATP molecules are produced for each glucose molecule used in fermentation? How many ATP molecules are produced for each glucose molecule used in aerobic respiration?

In fermentation from one glucose molecule two ATP molecules are produced. In aerobic respiration, a much more productive process, from one glucose molecule 36 ATP molecules are made.

13. Which is the cell organelle that is specialized in aerobic respiration?

14. Of which main compounds is the mitochondrion structure made?

Mitochondria are organelles delimited by two lipid membranes. The inner membrane invaginates to the interior of the organelle forming cristae and delimiting an internal space known as the mitochondrial matrix.

15. What are the three phases into which the cell respiration is divided?

The three phases of aerobic cell respiration are glycolysis, Krebs cycle and respiratory chain (also known as the electron transport chain).

16. What is glycolysis? What are the products of this process?

Glycolysis, the first stage of the aerobic cell respiration, is a process in which glucose is degraded (broken) to form two pyruvic acid molecules along with the formation of two ATP and two NADH.

Glycolysis is a complex reaction implying the formation of several intermediate molecules until pyruvic acid molecules are made. Although two ATP molecules are consumed in the reaction, there is also production of four molecules of ATP, thus a positive balance of two ATP molecules is obtained. Two NADH molecules are also produced. In glycolysis the 6-carbon structure of glucose is broken and two organic chains of three carbons each are made; these chains give birth to two pyruvic acid molecules.

17. Does glycolysis occur within the mitochondria?

Glycolysis happens in the cytosol and not within the mitochondria. Pyruvic acid molecules later enter mitochondria to participate in the next phase of the aerobic cell respiration.

18. How many ATP molecules are made after glycolysis?

Glycolysis is a process similar to glucose degradation in fermentation. It produces (final balance) two molecules of ATP for each broken glucose.

19. What is NAD? What is the role of the NAD molecule in glycolysis?

NAD (nicotinamide adenine dinucleotide) is a hydrogen acceptor necessary as reductant (to receive hydrogen) in some reactions in which it is reduced and converted into NADH2. During glycolysis two NAD molecules retrieve hydrogens liberated after an intermediate reaction thus forming NADH2.

20. What happens during aerobic respiration to the pyruvic acid molecules made by glycolysis? What is the sequence of reactions that then follows?

The pyruvic acid molecules made in cytosol by glycolysis enter into the mitochondria.

Within the mitochondria each pyruvic acid molecule is converted into one molecule of acetyl-CoA (acetyl coenzyme A) with liberation of one carbon dioxide. The Krebs cycle (also known as citric acid cycle), the second stage of aerobic respiration, then begins.

21. What is the official name of pyruvic acid?

Pyruvic acid is 2-oxopropanoic acid. It is thus a molecule made of three linearly bound carbons with one extremity forming the organic acid function (COOH) and the middle carbon binding to an oxygen atom by double bond.

22. Why can it be said that each glucose molecule runs the Krebs cycle twice?

Each glucose molecule "cycles" the Krebs cycle twice because after glycolysis each used glucose has generated two pyruvic acid molecules and each pyruvic acid is converted in a 1:1 proportion into acetyl CoA. Each acetyl CoA then cycles the Krebs cycle once.

23. Why is the Krebs cycle also called the final common pathway of the degradation of organic compounds?

The Krebs cycle is called the final common pathway of the degradation of organic compounds because it is also possible to generate acetyl CoA from the degradation of lipids and proteins. Since acetyl CoA is the substrate that triggers the Krebs cycle, this process is called the final common pathway for being activated by other organic molecules (lipids and proteins) and not only by glucose.

The organism uses energetic reserves of fat and proteins to cycle the Krebs cycle when undergoing malnutrition or when there is no glucose available for the cells.

24. What are the final energetic products of each round of the Krebs cycle? Where is most part of the utile energy at the end of Krebs cycle found?

After each round of the Krebs cycle two carbon dioxide molecules, eight protons (hydrogen ions) captured by NAD and FAD (a hydrogen acceptor too) and one ATP molecule are produced.

During the Krebs cycle acetyl CoA is degraded. At the end the utile energy is incorporated into hydrogens transported by FADH2 and NADH2 molecules.

25. How many carbon dioxide molecules are liberated after each cycle of the Krebs cycle? For a single glucose how many carbon dioxide molecules were already liberated by the aerobic respiration at that point?

Each round of the Krebs cycle liberates two carbon dioxide molecules.

At the end of the cycle all carbon atoms from the original glucose molecule degraded in glycolysis are already liberated incorporated into carbon dioxide molecules. That occurs because for each glucose two pyruvic acid molecules were made by glycolysis. Each of these two pyruvic acids then is converted into acetyl CoA with liberation of one carbon dioxide molecule (two in total). Since each of the two produced acetyl CoA cycles the Krebs cycle once, from the initial glucose two rounds of the Krebs cycle is generated and so four other carbon dioxide molecules are made.

All of the six carbons of the glucose molecule are then incorporated into six carbon dioxide molecules (two made during acetyl CoA formation and four during the two cycles of the Krebs cycle).

26. Where in mitochondria does the process called respiratory chain occur? Which are the products of the Krebs cycle used in that final phase of the aerobic respiration?

Respiratory chain, or the electron transport chain, is performed by protein systems located in the inner membrane of the mitochondria. Energized electrons of hydrogen atoms transported by NADH2 and FADH2 are the products of the preceding phases used in the respiratory chain.

27. What are cytochromes?

Cytochromes are proteins of the internal mitochondrial membrane that are specialized in electron transfer and participate in the respiratory chain. Energized electrons liberated by the hydrogen donors NADH2 and FADH2 (then reconverted into NAD and FAD) pass through a sequence of cytochromes losing energy in each passage. The energy is then used in the synthesis of ATP.

28. How in the respiratory chain do electrons from FADH2 and NADH2 passing through cytochromes liberate energy for the ATP synthesis? What is this ATP synthesis called?

FADH2 and NADH2 oxidate into FAD and NAD and liberate hydrogen ions and highly energized electrons in the beginning of the respiratory chain.

The energy lost by electrons that pass through the cytochromes is used to pump protons (hydrogen ions) out of the inner mitochondrial membrane (to the region between the inner and the outer membranes of the mitochondrion). Hydrogen concentration gradient between the inner and the outer spaces delimited by the inner membrane forces protons (hydrogen ions) to return to the mitochondrial matrix (the region inside the inner membrane) however that return is only possible if hydrogen ions pass through an enzymatic complex called ATP synthetase embedded in the inner membrane. In that passage the ATP synthetase phosphorylates ADP and then ATP molecules are produced.

Hydrogen liberated in the mitochondrion then combines with oxygen to form water. As a reaction that depends on oxygen this type of ATP synthesis is called oxidative phosphorylation.

29. Until the Krebs cycle, aerobic respiration can be described without mentioning oxygen, the chemical element after which the reaction gets its name. Where in the process does this chemical element take part? What is its importance?

Oxygen enters the aerobic respiration in its final phase, the respiratory chain. It is of fundamental importance because it is responsible for the maintenance of the hydrogen concentration gradient between the spaces separated by the inner mitochondrial membrane. This gradient promotes the functioning of the ATP synthetase and thus the phosphorylation of ADP to form ATP. In the space inside the inner membrane oxygen binds to free hydrogens to form water and this hydrogen consumption keeps the hydrogen gradient and the proton traffic through the ATP synthetase.

The entire aerobic respiration process has the intent to make the ATP synthetase work. Aerobic beings, for example, we humans, need to breathe oxygen to maintain that hydrogen concentration gradient and keep the ATP synthetase working.

30. How does the poison cyanide act upon the aerobic respiration?

Cyanide is a poison that inhibits the last cytochrome of the respiratory chain, interrupting the ATP formation and thus leading the cell to death.

31. What is anoxia?

Anoxia is a situation in which there is no available oxygen in the cell. Whitout oxygen the respiratory chain stops, there is no ATP production, the cell does not obtain energy and dies.

Anoxia can be caused, for example, by pulmonary insufficiency (drowning, extensive pulmonary injuries, etc.), by obstructions, halts and deficiencies in tissue circulation (atherosclerosis of the coronary arteries that irrigate the myocardium, tourniquets, heart arrest), by hemolysis (lysis of red blood cell) or hemoglobin diseases (anemias, fetal erythroblastosis), etc.

32. How many ATP molecules are made after the aerobic respiration and what is the net energetic gain of the process?

After aerobic respiration 38 ATP molecules are made with the consumption of one glucose molecule (but two of these ATP are consumed by glycolysis). The net gain of the process is then 36 ATP molecules per glucose molecule.

33. What is the general equation of the aerobic respiration (also representing ADP and phosphate)?

The general equation of the aerobic respiration is:

$C_6H_{12}O_6 + 6\ O_2 + 36\ ADP + 36\ P \rightarrow 6\ CO_2 + 6\ H_2O + 36\ ATP$

34. Why can the consumption of molecular oxygen indicate the metabolic rate of aerobic organisms?

Molecular oxygen (O_2) consumption has direct relation to the cell metabolic rate in aerobic cells and so to the metabolic rate of the organisms. Cells having higher metabolic activity demand more energy and such energy comes from ATP molecules. As there is need for ATP production, the intensity of aerobic cell respiration is also higher and then more oxygen is consumed.

The Photosynthesis Process - Q&A Review

1. What is the primary source of energy for living beings on earth?

The sun, center of our planetary system and star of the milky way galaxy (our galaxy), is the source of the energy that is processed and consumed by living beings. Intense nuclear reactions in the sun liberate light and other energetic radiations into the surrounding space. Some of this energy reaches our planet.

2. How is light from the sun transformed into chemical energy to be used by the living beings on earth?

Light from the sun is transformed into chemical energy contained in organic material by the photosynthesis process. In photosynthesis light, water and carbon dioxide react and highly energetic glucose molecules and molecular oxygen are made.

3. What is the chemical equation of photosynthesis?

The chemical equation of photosynthesis is the following:

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

4. Which are the living beings that carry out photosynthesis? Which is the cell organelle responsible for the absorption of light for the photosynthesis process in plants and algae?

There are many beings (including all animals) that do not carry out photosynthesis. There are also autotrophic beings that do not perform photosynthesis but they perform chemosynthesis. Plants, algae and cyanobacteria are photosynthetic beings.

In plants and algae, light is absorbed by chlorophyll, a molecule present in cytoplasmic organelles called chloroplasts.

5. Are there chloroplasts in cyanobacteria?

In cyanobacteria there are no chloroplasts and the chlorophyll layers are dispersed in cytosol.

6. Which chemical element is central in the chlorophyll molecule?

The chemical element that is central in the chlorophyll molecule is magnesium. One atom of magnesium is present in the center of an amalgam of eight nitrogen-containing carbon rings.

7. How do chloroplasts multiply?

Like mitochondria chloroplasts have their own DNA, RNA and ribosomes and they self-replicate through binary division.

8. How can the hypothesis that asserts that chloroplasts as well as mitochondria were primitive prokaryotes that associated in mutualism with primitive anaerobic eukaryotic cells be corroborated?

The described hypothesis is known as the endosymbiotic hypothesis about the evolutionary origin of mitochondria and choloroplasts.

Mutualism is explained as: mitochondria and chloroplasts can offer energy and nutrients to the cell in exchange for protection. The hypothesis is strengthened since those organelles have their own DNA, RNA and protein synthesis machinery and they divide themselves through binary division like bacteria do.

9. What are the main structures of chloroplasts?

Chloroplasts are involved by two membrane layers, the outer and the inner membranes. Inside the organelle the formative unit is called the granum, a coin-shaped structure that, piled with others grana, forms several structures called thylakoids. The thylakoids fill the chloroplast and an intergrana membrane permeates the interior of the organelle.

10. In which chloroplast structure are chlorophyll molecules found?

Chlorophyll molecules are placed in an organized manner in order to enhance the exposure to light on the thylakoid surfaces.

11. What do ATP and ADP mean? What are the roles of these molecules for the cellular energetic metabolism?

ATP is an abbreviation of adenosine triphosphate, a molecule made of adenosine bound to three inorganic phosphates. ADP is an abbreviation of adenosine diphosphate, two molecules of phosphate bound to adenosine. ATP is a molecule that stores energy for the cell. When ATP hydrolyzes and becomes ADP energy is liberated and then consumed by several metabolic reactions of the organism.

12. What is ADP phosphorylation? What respectively are photophosphorylation and oxidative phosphorylation?

ADP phosphorylation is the addition of one inorganic phosphate in the molecule of adenosine diphosphate thus creating ATP (adenosine triphosphate) and incorporating energy. The phosphorylation is oxidative when the energy incorporated comes from the breaking of organic molecules having oxygen as reagent, as in aerobic cellular respiration. The reaction is called photophosphorylation when the energy source is light, as in photosynthesis.

The energy incorporated into ATP is disposable (liberated) to other cellular reactions when ATP hydrolyzes and ADP is formed again.

13. What are the stages into which photosynthesis is divided?

Photosynthesis is divided into the photochemical stage, or light reactions, and the chemical stage.

14. What are the processes of the photochemical stage of the photosynthesis process?

Photolysis of water, with liberation of molecular oxygen, and photophosphorylation of ADP, with production of ATP and NADPH, are the processes that occur during the photochemical stage of photosynthesis.

15. How is the photic energy absorbed by chlorophyll transfered to ATP molecules in photophosphorylation? How will be the resulting ATP used?

Light excites chlorophyll and energizes electrons that jump off the molecule. The energy liberated when these electrons escape is used in the phosphorylation of ADP, forming ATP. The enzyme that catalyzes the reaction is the ATP synthase.

The resulting ATP is then consumed in the next chemical stage of photosynthesis to energetically enrich carbon dioxide for the formation of glucose.

16. Is it correct to consider water decomposition by the action of light the basis of the photosynthesis process?

Besides ADP photophosphorylation, photic energy is also responsible for the breaking of water molecules during photosynthesis in a process known as water photolysis. In this reaction water molecules are exposed to photic energy and liberate protons (hydrogen ions), highly energetic electrons and molecular oxygen (O2). Later the hydrogen atoms will be incorporated into carbon dioxide molecules to form glucose. Since water is the hydrogen donor for photosynthesis it is correct to say that the water photolysis is the basis of the process.

17. What are the chemical substances produced by water photolysis? What is the destination of each of those substances?

Free electrons, hydrogen ions and molecular oxygen are liberated, after the water photolysis.

The electrons will replace those electrons lost by chlorophyll molecules in photophosphorylation. The hydrogen ions will be incorporated into hydrogen acceptor molecules (NADP) and later will be used in the synthesis of glucose during the chemical stage. Molecular oxygen is liberated to the atmosphere.

18. In sulfur photosynthetic bacteria what is the molecule that donates hydrogen for photosynthesis?

In sulfur photosynthetic bacteria the substance that donates hydrogen is hydrogen sulfide (H2S) and not water. Therefore there is no liberation of molecular oxygen but there is production of molecular sulfur (S2). (Oxygen and sulfur have same number of valence electrons.)

19. Why is it said that during photosynthesis carbon dioxide is enriched to form glucose?

During photosynthesis carbon dioxide is energetically enriched with hydrogen from water. Water broken by photolysis is the hydrogen donor of the reaction. Glucose is made of carbon and oxygen atoms obtained from carbon dioxide and of hydrogen atoms obtained from water.

20. What is the complete chemical equation of photosynthesis?

The complete chemical equation of photosynthesis is the following:

6 CO2 + 12 H2O + light --> C6H12O6 + 6 H2O + 6 O2

21. What is an example of a lab experiment that shows the variation of the photosynthesis efficiency in relation to different photic energy frequencies to which the reaction is exposed? Was it expected that green light frequency favored the reaction?

The experiment: Plants of same species and ages are placed each under (respecting their photoperiods) light sources emitting only one of the colors of the light spectrum (violet, anil, blue, green, yellow and red). The experiment is executed with each of the colors and after days each plant's development is compared. Those plants whose development was normal performed satisfactory photosynthesis while those with abnormal development underused the offered light.

Chlorophyll is green because it reflects the green light frequency, i.e., it does not "use" the green range of the electromagnetic spectrum. Thus green light does not favor photosynthesis (curiously green is the light that plants "dislike").

22. What are the divisions of white light according to the electromagnetic spectrum? Which are the two most efficient colors for photosynthesis?

The color divisions of the electromagnetic spectrum in decreasing order of frequency are: red, orange, yellow, green, blue, anil and violet. When mixed together these colors generate white.

Experimentally it is verified that the most useful colors for photosynthesis are blue and red.

23. What is NADP and NADPH?

NADP is the abbreviation of the nicotinamide adenine dinucleotide phosphate cation, a hydrogen acceptor. NADPH is made when NADP binds to one hydrogen atom and it is the form that actually transports hydrogen.

24. Photosynthesis is the most important producer of molecular oxygen (O2) on our planet. From which molecule do oxygen atoms liberated by photosynthesis come? From which other molecule could one suspect they have come? What are the destinations of those oxygen atoms?

The oxygen atoms liberated as molecular oxygen by the photosynthesis process come from water.

One indeed could suspect that those oxygen atoms would have come from carbon dioxide. Oxygen atoms from carbon dioxide however are incorporated into glucose molecules and into water molecules liberated in the chemical stage of photosynthesis.

25. Where do the photochemical and the chemical stages of photosynthesis occur?

The photochemical stage of the photosynthesis process occurs mainly on the thylakoids (the green part) and the chemical stage occurs in the stroma (the colorless framework) of the chloroplasts.

26. Which are the subproducts of the photochemical stage that are essential for the chemical stage of photosynthesis?

The chemical stage of photosynthesis depends on NADPH and ATP produced in the "light reactions" (photochemical stage).

27. What are the roles of NADPH and ATP in the chemical stage of photosynthesis?

NADPH acts as reductant of carbon dioxide, it delivers highly energetic hydrogens to precursor molecules during the glucose formation process. ATP is an energy source for the reactions of chemical stage.

28. Why is the nickname "dark reactions" not entirely correct for the chemical stage of photosynthesis?

"Dark reactions" is not a correct name for the chemical stage of photosynthesis since the reactions of the chemical stage also occur in the presence of light.

29. What is the general chemical equation of photosynthesis? Why doesn't that equation clearly show the real origin of the molecular oxygen liberated?

The general equation of photosynthesis is:

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

Water molecules are also produced in the chemical stage of photosynthesis as the following complete equation reveals:

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

Water molecules are present in the reagent side as well in the product side of the equation. Pure mathematical simplification of stoichiometric coefficients however leads to elimination of water from the product side and it then seems that 6 molecules of molecular oxygen (O_2), i.e., 12 atoms of oxygen, are made for each 6 molecules of water, i.e., 6 oxygen atoms, in the reagent side. Thus a false impression that 6 other oxygens come from carbon dioxide is created.

30. What are the three main limiting factors of photosynthesis?

The three main limiting factors of photosynthesis process are light intensity, carbon dioxide concentration and temperature.

31. Photosynthesis rate varies according to the photic energy intensity. Does the same occur in aerobic respiration? What happens to the glucose balance as a result of these variations?

In a photosynthetic being the aerobic respiration rate can be superior, inferior or equal to the photosynthesis rate. Respiration rate depends on the energetic needs of the plant while the photosynthesis rate varies, as other conditions are maintained, with the variation of light energy.

In a situation in which the respiration rate is greater than the photosynthesis rate glucose consumption is higher than glucose production. In a situation in which the respiration rate is lower than photosynthesis rate there is accumulation of glucose (positive balance). In a situation in which the rates are equal all molecular oxygen produced by the photosynthesis process is used in respiration and all carbon dioxide liberated by respiration is consumed in photosynthesis and so there is no positive balance of glucose nor depletion of carbohydrate stores.

32. What is the compensation point? What is the implication of the compensation point for the plant growth?

The (photic) compensation point is the photic energy intensity under which aerobic respiration rate equals photosynthesis rate. In this situation all produced glucose is consumed and there is no incorporation of material into the plant and thus the plant growth discontinues.

33. Why is the carbon dioxide concentration a limiting factor of the photosynthesis process? When the carbon dioxide concentration is increased indefinitely is photosynthesis also increased indefinitely?

The availability of carbon dioxide is a limiting factor for the photosynthesis process because this gas is a reagent of the reaction.

Since enzymes catalyze the building of organic molecules with carbon atoms from carbon dioxide photosynthesis stops as soon as these enzymes become saturated, i.e., when all their activation centers are bound to their substrates. In that situation an increase of the carbon dioxide concentration will not increase the photosynthesis rate.

34. Why do some trees lose their green color in the autumn?

In autumn days become shorter and nights longer thus there is a reduction of the photosynthesis rate and some plants prepare themselves for the winter making nutrient stores. In this process, nutrients from the leaves travel towards storage sites: limbs, trunk and roots. With less chlorophyll produced in leaves the typical green color of the plant fades.