

Unit 6: Bioenergetics

Short Questions

SHORT ANSWER QUESTIONS EXERCISE

Q1. Differentiate between action spectrum and absorption spectrum?

Ans.

Absorption Spectrum	Action Spectrum
A graph showing different wavelength absorbed by pigments is called absorption spectrum.	A graph showing effectiveness of different wavelength on the rate of process of photosynthesis is called action spectrum.

Q2. How is photosynthesis a redox reaction?

Ans. As CO_2 photosynthesis is redox (reduction-oxidation) reaction where CO_2 is reduced to form glucose and water is oxidized to release oxygen.

Q3. Which molecule contributes Oxygen to glucose during photosynthesis? Water or carbon dioxide?

Ans. It is carbon dioxide that contributes oxygen to glucose while oxygen of water is released into atmosphere.

Q4. State the role of CO_2 in photosynthesis.

Ans. CO_2 acts as source of carbon for making sugars during photosynthesis. Sugar is formed by the reduction of CO_2 by using ATP and NADPH. In this way, CO_2 acts as the source of carbon for making sugars.

Q5. Define electron transport chain.

Ans. An electron transport chain is a series of protein complexes and other molecules which transfer electrons from electron donors to electron acceptors via redox reactions.

Q6. What do you mean by glycolysis?

Ans. Glycolysis is breakdown of glucose molecule into two molecules of pyruvic acid.

Q7. What is the main structural difference between chlorophyll-a and chlorophyll-b?

Ans. Chlorophyll-a has CH_3 at second pyrrole ring while chlorophyll-b has CHO.

Q8. How can a cell synthesize ATP through substrate-level phosphorylation?

Ans. A cell can synthesize ATP through substrate level phosphorylation with the help of enzyme.

Q9. Can pyruvic acid enter Krebs cycle as such? If not, what changes are made to it before Krebs cycle?

Ans. Pyruvic acid cannot enter Krebs cycle as such. It is first converted into acetyl CoA.

Q10. Differentiate between C-3 and C-4 photosynthesis?

Ans. In C3-plants CO_2 reacts with ribulose bis PO4 molecule and results in a 3-C stable molecule 3 phosphoglyceric acid while in C4-plant, CO_2 combine with phosphoenol pyruvic acid (3-C molecule) and results in a 4-Carbon stable compound oxaloacetic acid.

SLO BASED SHORT QUESTION ANSWERS

Bioenergetics

Q11. What is bioenergetics?

Ans. Bioenergetics is the study of how energy flows through living systems. It explores the processes through which cells store and expend energy.

★Q12. What is main source of energy in food chain?

Ans. Nearly all the energy used by living organisms on Earth comes from photosynthesis. Plants, algae, and certain bacteria capture sunlight and convert it into chemical energy, forming the base of the food chain.

Q13. Write a note on ATP?

Ans. Cells use a special energy currency for their reactions. This currency is actually a nucleotide called adenosine triphosphate (ATP). When cells store energy, they make ATP. When cells need energy, they break ATP. A molecule of ATP has three subunits i.e., adenine, (a nitrogen containing base); ribose (a five-carbon sugar) and three phosphate groups.

Photosynthesis

Q14. Define photosynthesis. Write its equation?

Ans. Photosynthesis involves the use of light energy that is absorbed and converted into chemical energy by photosynthetic pigments. Photosynthesis in plants can be summarized as:



★Q15. What is compensation point?

Ans. At dawn and dusk, when light intensity is low, the rate of photosynthesis and respiration may be equal for a short time. Thus, the oxygen released from photosynthesis is just equal to the amount required for cellular respiration. Also, the

carbon dioxide released by respiration is just equal to the amount required by photosynthesizing cells. At this moment there is no net gas exchange between leaves and atmosphere. This is termed as compensation point.

★Q16. How much solar energy is converted by plant into chemical energy?

Ans. Plants convert only about 1-2% of the solar energy they receive into chemical energy during photosynthesis. Despite this seemingly low efficiency, this conversion is enough to sustain almost all life on Earth.

Q17. What is action spectrum?

Ans. The different wavelengths are also differently effective in photosynthesis. The effectiveness of different wavelengths of light is determined in terms of action spectrum. For getting action spectrum of light, a plant is illuminated with different colours of light one by one. While providing each colour, the rate of photosynthesis is measured by measuring the amount of oxygen emitted from leaves. The data is plotted in a graph called action spectrum.

Q18. Write the role of light in photosynthesis?

Ans. Light plays a crucial role in photosynthesis, providing the energy required to drive the chemical reactions that transform simple molecules into complex organic compounds. Light energy is absorbed by chlorophyll. The absorbed light energy is converted into chemical energy, which is in turn stored in organic compounds in the form of C-H bond energy.

Q19. Write the role of water in photosynthesis?

Ans. Oxygen released during photosynthesis comes from water, and so water is an important source of atmospheric

oxygen which most organisms need for aerobic respiration and thus for obtaining energy to live.

Q20. Write about parts of chlorophyll molecule.

Ans. A molecule of chlorophyll consists of two parts.

1. Hydrophilic head: It is made of porphyrin ring made up of four pyrole rings with magnesium atom in center.

2. Hydrophobic tail: Tail is made of long hydrocarbon chain. It anchors the molecule in the thylakoid membrane.

★Q21. From where land and aquatic plants get CO₂?

Ans. About 10% of total photosynthesis is carried out by terrestrial plants, the rest occurs in oceans, lakes and ponds. Aquatic photosynthetic organisms use dissolved CO₂, bicarbonates and soluble carbonates as carbon source. Land photosynthesis organisms use atmospheric CO₂ as carbon source.

Q22. Write Role of Photosynthetic Pigments?

Ans. Photosynthetic pigments are present in thylakoid membranes. These pigments capture light energy necessary for photosynthesis. Some of the pigments are chlorophyll a, chlorophyll-b, xanthophylls, carotenes. Different pigments absorb light of different wavelengths (colours).

Q23. Give composition of photosystem.

Ans. Each photosystem consists of two parts

1. Antenna complex: It has many pigment molecules reaction center.

2. Reaction center: The reaction center has one or more molecules of chlorophyll-a which pass the high energy electrons to primary electron acceptor.

Q24. What is reaction center?

Ans. The reaction centre has one or more molecules of chlorophyll-a which pass the light energy electron to a primary electron acceptor. This passes them on the series of electron carriers called electron transport chain.

★Q25. Give role of Carotenoids?

Ans. Carotenoids, such as beta-carotene, play dual role in photosynthesis. They capture light energy in the blue and green regions of the spectrum and protect the photosynthetic apparatus from damage by excess light.

Q26. What are accessory pigments and their role?

Ans. Accessory pigments include all the pigments, other than chlorophyll-a, which can gather light for photosynthesis. Chlorophyll b is an accessory pigment and others are carotenoids (carotenes and xanthophylls) and phycobilins. Chlorophyll b and carotenoids are found in plants while phycobilins are found in the red algae and cyanobacteria.

When accessory pigments absorb light, they pass on the energy towards chlorophyll a. It is generally believed that the order of transfer of energy in plants is;

Carotenoids → Chlorophyll b → Chlorophyll-a

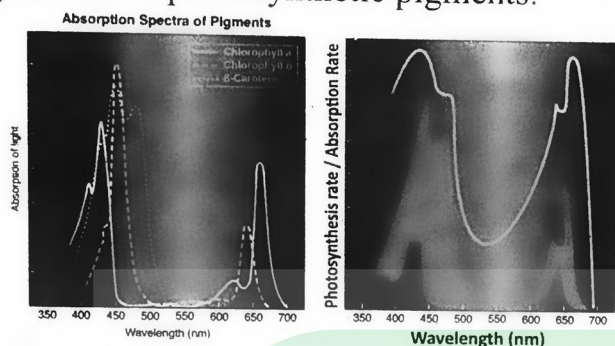
★Q27. Why more than one pigment are present in plants?

Ans. Some wavelengths are not absorbed by chlorophyll-a are very effectively absorbed by chlorophyll-b and vice-versa. Such differences increase the range of light absorbed by both chlorophylls.

Q28. What is Absorption Spectrum and Action Spectrum?

Ans. A graph showing different wavelengths absorbed by a pigment is called absorption spectrum of the pigment. Absorption spectrum of chlorophylls

indicates that absorption of blue light (430 nm) and red light (670 nm) is maximum. Absorption peaks of carotenoids are different from those of chlorophylls. Action spectrum of photosynthesis also shows that blue and red parts lights are the most effective. This means that the action spectrum of photosynthesis coincides with the absorption spectrum of photosynthetic pigments.



★Q29. What happens in light and dark reaction?

Ans. During light dependent (light) reaction, light energy is absorbed and converted into chemical energy, which is in the form of reducing and assimilating powers i.e., NADPH and ATP.

Light independent (dark) reactions use NADPH and ATP for the reduction CO_2 and thus store chemical energy in the form of C-H bond energy.

Q30. What is non-cyclic photophosphorylation?

Ans. It is a way of production of ATPs during light dependent reactions. In this both photosystems i.e., PS-I and PS-II participate and two electron chains are involved. During this ATP and NADPH are produced alongwith evolution of O_2 .

Q31. What is photolysis?

Ans. When water molecule reacts with oxidized chlorophyll in PS-II, it breaks into two hydrogen ions, an oxygen atom and two electrons. This water splitting step of photosynthesis is called photolysis.

Q32. Why non-cyclic photophosphorylation is called z-scheme?

Ans. The zigzag path taken by electrons through PS-II and PS-I and electron transport chains is called z-scheme.

Q33. What is chemiosmosis?

Ans. Chemiosmosis is the mechanism in which thylakoid membranes couple the redox reactions with the synthesis of ATP.

Q34. Why light independent reactions are called Dark reaction?

Ans. These are called dark reactions because these can occur in the absence as well as in the present of light, as long as ATP and NADPH are available.

★Q35. Why calvin cycle is also known as C-3 pathway?

Ans. Since the product of initial carbon fixation is a three-carbon compound, the Calvin cycle is also known as C-3 pathway.

Q36. Which enzymes mediate first reaction of calvin cycle?

Ans. Rubisco (Ribulose bis Phosphate Carboxylase and oxygenase) mediates the first reaction of Calvin cycle.

Q37. Which molecules from Calvin cycle make the sugar?

Ans. During calvin cycle one molecule of glyceraldehyde 3PO_4 is produced which combines with another G3P and make Glucose during Calvin cycle.

★Q38. What is main source of atmospheric O_2 ?

Ans. The oxygen produced during photolysis of water is the main source of atmospheric oxygen.

Cellular Respiration

Q39. What are the types of respiration?

Ans.

1. **Anaerobic respiration** (fermentation) takes place in the absence of oxygen.
2. **Aerobic respiration** takes place in the presence of oxygen.

In the first step of both these types, glucose is split into two molecules of pyruvic acid ($C_3H_4O_3$) in a process called glycolysis. The next reactions of pyruvic acid are different in anaerobic and aerobic respiration.

★**Q40. Differentiate between external respiration and cellular respiration?**

Ans. The exchange of CO_2 and O_2 between the organism and its environment is called external respiration or breathing. Cellular respiration is the process by which energy is made available to cells in a step-by-step oxidation of food in the cells.

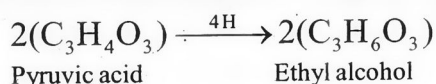
Q41. What do you know about anaerobic respiration?

Ans. In anaerobic respiration, glucose is not completely oxidized. This type of respiration yields relatively small amount of energy from glucose molecule. As a result of anaerobic respiration, one glucose molecule yields only two ATPs (only about 2% of the energy present in glucose). The energy in two ATPs is equivalent to 14.6 kcal.

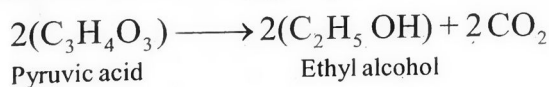
Q42. Define types of fermentation?

Ans.

a. **Alcoholic Fermentation:** In primitive prokaryotic cells (bacteria) and in some eukaryotic cells such as yeast, pyruvic acid is further broken down by alcoholic fermentation into alcohol (C_2H_5OH) and CO_2 .



b. **Lactic Acid Fermentation:** In lactic acid fermentation, each pyruvic acid molecule is converted into lactic acid $C_2H_6O_3$ in the absence of oxygen gas.



★**Q43. How glucose is absorbed by cell?**

Ans. Glucose enters cells from the tissue fluid by passive transport using a specific glucose carrier. This carrier can be controlled (gated) by hormones such as insulin.

★**Q44. What is gluconeogenesis?**

Ans. Pyruvic acid can also be turned back into glucose by reversing glycolysis. This is called gluconeogenesis.

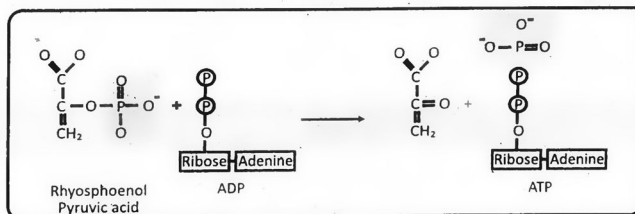
Q45. Mention four stages of aerobic respiration?

Ans.

1. Glycolysis
2. Pyruvic acid oxidation
3. Krebs Cycle
4. Electron transport chain

Q46. What is substrate-level phosphorylation?

Ans. In this process, an enzyme transfers a phosphate group from an organic substrate molecule to ADP. The products are a new organic molecule and a molecule of ATP. For example; during the last step of glycolysis, an enzyme transfers phosphate group from phosphoenol pyruvic (PEP) acid to ADP. As a result, ADP becomes ATP and PEP is changed into pyruvic acid. Substrate-level phosphorylation accounts for only a small percentage of the ATP that a cell generates. This reaction can be shown as:



Q47. How many ATP are obtained from aerobic oxidation of glucose?

Ans. In aerobic oxidation of glucose 38 molecules of ATPs are obtained. However, 2 ATP molecules are consumed in NADPH transfer therefore net profit of aerobic oxidation of glucose is 36 ATP.

Q48. Which organic molecules act as fuel for cellular respiration?

Ans. Free glucose molecules are not common in our diet. Rather, we consume **sucrose** and other disaccharides, **starch**, **fats** and **proteins**. Proteins may also be used as fuel but they must be digested to their constituent amino acids. Typically, a cell uses most of the amino acids to make its own proteins.

Lipids are excellent cellular fuel because they contain many carbon-hydrogen bonds. They are first hydrolysed into glycerol and fatty acids. Glycerol is converted to glyceraldehyde 3-phosphate, an intermediate in glycolysis, while the fatty acids are changed into acetyl CoA. In this way both the fatty acids and the glycerol enter cellular respiration.

Photorespiration

★Q49. What is significance of C-4 photosynthesis?

Ans. In C-4 photosynthesis, the energy cost for making a glucose molecule is almost double. However, in hot climates, in which photorespiration would otherwise remove more than half of the carbon fixed, it is the best compromise available.

Q50. Define Photorespiration?

Ans. It is respiratory activity that occurs in green cells in the presence of light resulting in release of CO₂.

Q51. Under which circumstances photorespiration occurs?

Ans. When relative concentration of CO₂ decreases and there is more oxygen in leaf cells, rubisco adds O₂ in RuBP instead of CO₂. It results in the break down of RuBP into two molecules i.e., one phosphoglycerate and one phosphoglycolate (2-C).

Q52. What is Rubisco? Give its function.

Ans. Rubisco is an enzyme, which is most abundant protein on earth.

It combines 3 molecules of CO₂ with 3 molecules of five carbon sugar named ribulose biphosphate to form six molecules of a three carbon compound called 3-phosphoglyceric acid.

Q53. How many organelles are involved in photorespiration?

Ans. Following these organelles are involved in photorespiration.

1. Chloroplast
2. Peroxisome
3. Mitochondria

Q54. Give names of C-4 plants and CAM plants?

Ans. 1. **C-4 plants:** corn, sugarcane and sorghum.

2. **CAM-plants:** Cacti, pineapple, etc.

Q55. Why Calvin cycle is also known C-3 pathway?

Ans. Since the product of initial carbon fixation is a three-carbon compound, the calvin cycle is also known as C-3 pathway.

LONG QUESTIONS (EXERCISE)

Q1. What are photosynthetic pigments and what role they play in the absorption and conversion of light energy?

Ans. See Q4. of theory.

Q2. How are the absorption spectra of chlorophyll 'a' and 'b' different?

Ans. See Q5. of theory.

Q3. Describe and illustrate how photosynthetic pigments are organized in thylakoid membrane?

Ans. See Q6. of theory.

Q4. Describe how the role of water in photosynthesis can be explained through experiment.

Ans. See Q3. of theory.

Q5. What are the events that capture light and convert it into chemical energy during light dependent reactions?

Ans. See Q8. of theory.

Q6. Illustrate the cyclic photophosphorylation.

Ans. See Q9. of theory.

Q7. Describe light independent reactions of photosynthesis in terms of paragraph and illustrate in terms of Calvin cycle.

Ans. See Q10. of theory.

Q8. What happens with glucose in anaerobic respiration and how different organisms modify the end products?

Ans. See Q12. of theory.

Q9. How is glucose broken down to pyruvic acid in glycolysis?

Ans. See Q14. of theory.

Q10. Describe how Krebs cycle is the completion of the oxidation of glycolytic products.

Ans. See Q16. of theory.

Q11. Explain the passage of electron through electron transport chain.

Ans. See Q17. of theory.

Q12. Define chemiosmosis. How would you relate it with electron transport chain?

Ans. See Q17. of theory.

Q13. Through which ways proteins and fats enter cellular respiration?

Ans. See Q21. of theory.

Q14. Define photorespiration and present it in proving that "photosynthesis is not perfect".

Ans. See Q22. of theory.

Q15. What are the effects of temperature on the oxidative activity of Rubisco?

Ans. See Q22. of theory.

Q16. How is the process of C₄ photosynthesis an adaptation to deal with the problem of photorespiration?

Ans. See Q23. of theory.

INQUISITIVE QUESTIONS

Q1. Why does cellular respiration release energy more efficiently than fermentation?

Ans. Because in cellular respiration there is complete breakdown of glucose into CO₂ and H₂O while in fermentation there is incomplete breakdown of glucose.

Q2. Why is the conversion of glucose into ATP during cellular respiration considered a more efficient use of energy than burning glucose directly?

Ans. The conversion of glucose into ATP during cellular respiration is considered a more efficient use of energy than burning glucose directly, because cellular respiration is an enzyme-controlled process. So, most of the energy released is not wasted but converted into ATPs for use by the cell.

Q3. Why might a disruption in either photosynthesis or respiration processes affect global carbon and oxygen cycles?

Ans. During photosynthesis CO₂ is used and oxygen is released while during respiration oxygen is used and CO₂ is released so both processes play a role in maintaining the CO₂ and O₂ levels in the atmosphere. Any disruption in their processes can cause an imbalance of their concentration in the atmosphere. Hence resulting in environmental pollution.