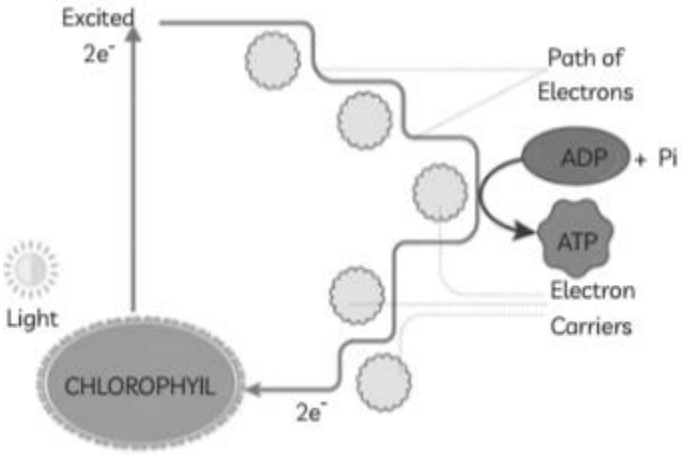
Photosynthesis in Higher Plants

Case Study Based Questions

Read the following passages and answer the questions that follow:

1. The phenomenon of cyclic electron transport was first characterised in higher plant chloroplasts 50 years ago, yet there is still a debate about whether or not this is a physiological process. The recent isolation of mutants that appear to lack cyclic electron transport, as well as new data providing functional evidence for its occurrence, support the notion that this pathway plays an important role in plant responses to stress, providing a pH gradient across the thylakoid membrane to trigger non-photochemical quenching of chlorophyll fluorescence. At present, little is known about the regulation of cyclic electron transport, but it is possible that this is activated in response to a low redox potential in the chloroplast stroma.



(A) The process shown in the figure takes place in:

(a) Stroma

(b) Stroma lamellae

(c) Grana

(d) Matrix

(B) Which photosystem is involved in Cyclic photophosphorylation?

(a) PSI

(b) PS II

(c) PS I and PS II

(d) PS III

(C) Choose the correct option.

(a) The reaction centre is same in both,

(b) PS I is called P680.

(c) Reaction centre is formed by xanthophyll.

(d) PS I is called P700-

(D) Assimilatory power used in Cyclic photophosphorylation is:

(a) ATP

(b) ADP

(c) NADP

(d) NADPH

(E) Statement A: ATPs are used in Electron transport system.

Statement B: ATPs are passed on to the pigments of photosystem I from ETS.

(a) Statement A is incorrect.

(b) Statement B is incorrect.

(c) Both statements are incorrect.

(d) Both statements are correct.

Ans. (A) (b) Stroma lamellae

Explanation: Cyclic photophosphorylation occurs in stroma lamellae.

(B) (a) PSI

Explanation: Photosystem I is involved in cyclic photophosphorylation.

(C) (d) PS I is called P700-

Explanation: Both PS I and PS II consist of different reaction centres. Maximum absorption in photosystem I takes place at 700 nm and therefore it is called P700- Reaction centre is formed by a single molecule of chlorophyll a.

(D) (a) ATP

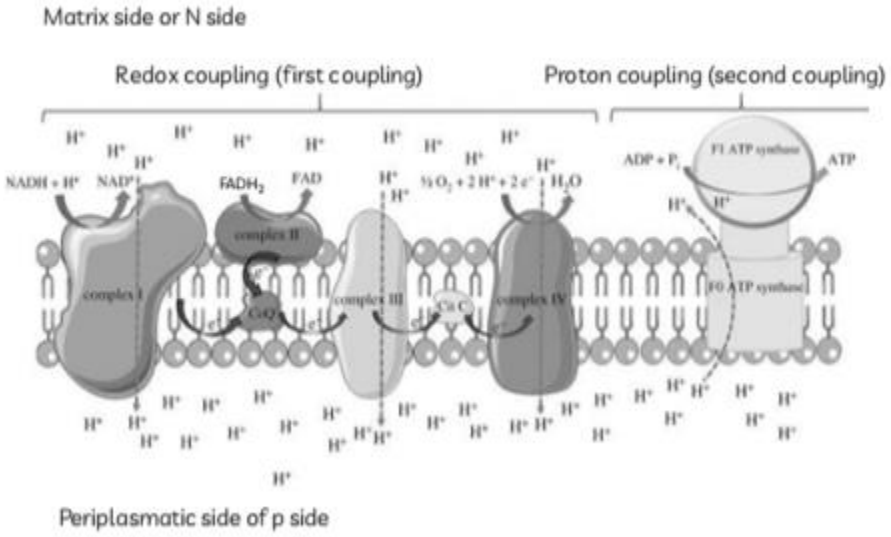
Explanation: The cyclic flow of electrons in cyclic photophosphorylation occurs due to photophosphorylation of Adenosine Diphosphate (ADP) to Adenosine Triphosphate (ATP).

(E) (a) Statement A is incorrect.

Explanation: ETS does not use any ATP, it only passes ATP to pigments of PS I.

2. Understanding how biological systems convert and store energy is a primary purpose of basic research. However, despite Mitchell's chemiosmotic theory, we are far from the

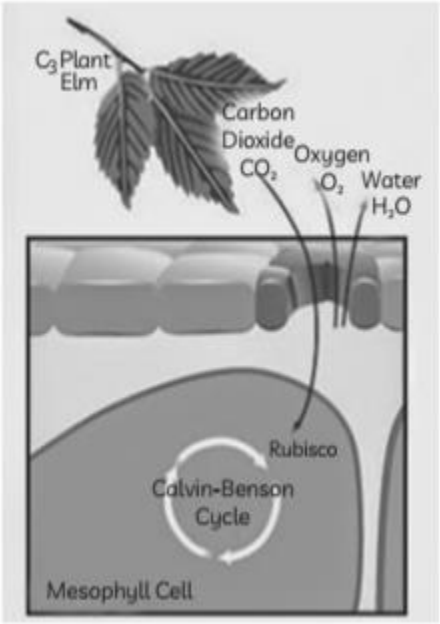
complete description of basic processes such as oxidative phosphorylation and photosynthesis. After more than half a century, the chemiosmotic theory may need updating, thanks to the latest structural data on respiratory chain complexes. In particular, up-to-date technologies, such as those using fluorescence indicators following proton displacements, have shown that proton translocation is lateral rather than transversal with respect to the coupling membrane. Furthermore, the definition of the physical species involved in the transfer (proton, hydronium ion or proton currents) is still an unresolved issue, even though the latest acquisitions support the idea that protonic currents, difficult to measure, are involved. Look at the figure given below:

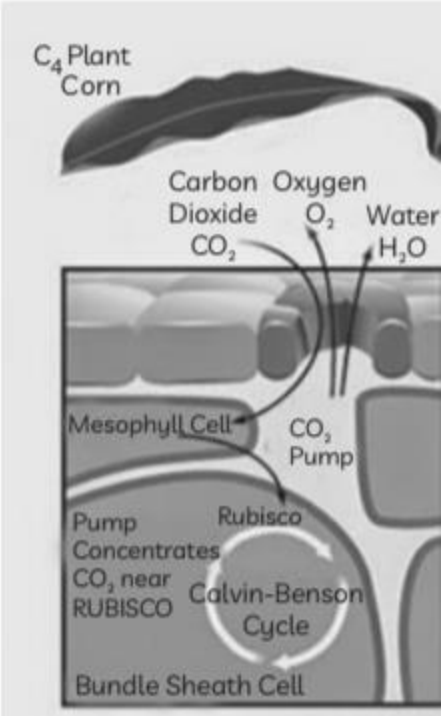


(A) Where does the splitting of water molecules take place?
(B) What kind of potential gradient formed inside thylakoid membrane in the lumen of thylakoid?
(C) (i) Where does the low concentration of proton gradient form?
(ii) Plastoquinone acts.....

Ans. (A) Splitting of water occurs on the inner side of the thylakoid membrane.
(B) High potential gradient is formed inside the thylakoid membrane in the lumen of thylakoid.
(C) (1) Low concentration of proton gradient is formed in the stroma, outer side of thylakoid membrane.
(ii) Plastoquinone acts as a Proton and electron carrier.

3. Photosynthesis is the process that plants use to turn light, carbon dioxide, and water into sugars that fuel plant growth, using the primary photosynthetic enzyme Rubisco. The majority of plant species on Earth uses C_3 photosynthesis, in which the first carbon compound produced contains three carbon atoms. C_3 plants do not have the anatomic structure (no bundle sheath cells) nor the abundance of PEP carboxylase to avoid photorespiration like C_4 plants. One focus of the RIPE project is to create a more efficient pathway for photorespiration to improve the productivity of C_3 crops. The RIPE project is working to improve photosynthesis in C3 crops to ensure greater food security under future climate scenarios. C_3 plants are limited by carbon dioxide and may benefit from increasing levels of atmospheric carbon dioxide resulting from the climate crisis. However, this benefit may be offset by a simultaneous increase in temperature that may cause stomatal stress.





(A) What is the first stable product in this pathway?
(B) Where do photosynthetic functions take place in this pathway?
(C) (1) How many times the carbon dioxide fixation occurs in this cycle? Name the enzymes used to fix carbon dioxide in this pathway.
(ii) Name any two C4 plants.

Ans. (A) Oxaloacetate.
(B) Mesophyll cells and bundle sheath cells.
(C) (i) Two times. PEP carboxylase and RuBisCO.
(ii) Sugar cane and maize.

4. Photosynthesis occurs in two phases- light reaction (photochemical phase) and dark reaction. In dark reactions where products of light reactions are used to incorporate carbon from carbon dioxide to carbohydrates. The reaction does not require light. It takes place in the stroma of chloroplasts. There are two main pathways of this phase, Calvin cycle and C4 cycle. The assimilatory power is generated in thylakoids and used in the synthesis of carbohydrates in the dark reaction. Light reaction of photosynthesis involves the participation of two separate pigment systems or photosystems, i.e. PSI and PS II.

(A) Photosynthesis is a process in which:

(a) Carbon dioxide is reduced to carbohydrates.
(b) NADH is reduced to NAD.
(c) ATP is generated.
(d) None of the above

(B) In photosynthesis, the light reaction occurs in:

(a) Thylakoids
(c) Stroma
(b) Fret channel
(d) All of these

(C) During light reaction, the molecules formed are:

(a) C_4 acid
(b) ATP and NADPH
(c) C_3 acid
(d) None of these

(D) Dark reactions occur in:

(a) only in light
(b) only in the absence of light
(c) independent of light
(d) all of the above

(E) Assertion (A): When a molecule of
Reason (R): chlorophyll b absorbs light it sends its energy to a molecule of chlorophyll a. Chlorophyll b absorbs light of similar wave- lengths which cannot be directly used for photo- synthesis.
(a) Both A and R are true and R is the correct explanation of A.
(b) Both A and R are true and R is not the correct explanation of A.
(c) A is true but R is false.
(d) A is false but R is true.

Ans. (A) (a) Carbon dioxide is reduced to carbohydrates.
Explanation: During photosynthesis, the carbon dioxide is reduced to glucose and water is oxidized and NAD is reduced to NADH due to which ATP is not generated.
(B) (a) Thylakoids
Explanation: Light reaction occurs in the thylakoid membrane whereas the dark reaction occurs in the stroma of chloroplast.

(C) (b) ATP and NADPH

Explanation: Light reaction is the process in which the generation of energy rich molecules such as ATP and NADPH occurs. These are also known as assimilatory powers.

(D) (c) Independent of light

Explanation: Dark reaction is also called light-independent reaction. It does not require light and occurs in the stroma of chloroplasts where the products of light reaction (ATP and NADPH) are used to incorporate carbon from carbon dioxide to carbohydrate.

(E) (c) A is true but R is false.

Explanation: When a chlorophyll b molecule absorbs light, it transfers its energy to a chlorophyll a molecule. Chlorophyll b absorbs light at various wavelengths that cannot be used for photosynthesis directly.