Life Sciences - I

Q. 1: Do as directed (any 15) **15**

Fill in the blank

1. PEPA
2. Thylakoid membrane
3. Dark reaction
4. Auxins
5. dicarboxylic acid cycle /Hatch and Slack cycle / Cooperative photosynthesis
6. Ethylene
7. Artificial ecosystem

Define:

8. Photosynthesis is the process by which green plants and some other organisms use sunlight to synthesize nutrients from carbon dioxide and water.

9. Enzymes: a substance produced by a living organism which acts as a catalyst to bring about a specific biochemical reaction.

10. The absorbed food materials are transported by blood and lymph. Lymph is finally transferred to the blood circulation. The blood transports absorbed food materials to different body cells where food materials become integral component of the living protoplasm and are used for energy, growth and repair. This is called assimilation of food.

11. An agent that is used to prevent the formation of blood clots.

12. The force of circulating blood on the walls of the arteries.

13. Decomposers: they are micro consumers, they bring about the decomposition of dead organic matter of both producers as well as macro consumers (animals) to simple forms.

14. Food chain: the patterns of eating and being eaten forms a liner chain.

15. Water cycle: Living organisms, atmosphere and earth maintain between them a circulation of water and moisture, which is referred to as water cycle or hydrologic cycle.

16. Primary productivity: is define as the rate at which radiant energy is stored by photosynthetic and chemosynthetic activity of producers.

Answer:

17. The efferent arterioles form from a convergence of the capillaries of the glomerulus, and carry blood away from the glomerulus that has already been filtered. They play an important role in maintaining the glomerular filtration rate despite fluctuations in blood pressure.

18. The pulmonary veins are the veins that transfer oxygenated blood from the lungs to the heart. The largest pulmonary veins are the four main pulmonary veins, two from each lung that drain into the left atrium of the heart.

19. The ability to bind calcium ions (Ca^{2+}) is required for the activation of the several *vitamin K*-dependent *clotting* factors, or proteins, in the *coagulation* (*clotting*) cascade

20. Amylase is a digestive enzyme that acts on starch in food, breaking it down into smaller carbohydrate molecules.

Q. 2:

a) Write the Interrelationships between Light and Dark Reaction **8**

Light reaction is commonly called *photostage* and dark reaction synthesis stage. The two phases may also be called hydrogen transfer phase (light reaction) and carbon assimilation phase (dark reaction).

Levitt (1969) proposed a scheme showing interrelationships between the two phases. It explains that the reduction of each molecule of CO_2. 3 molecules of ATP and 2 molecules of NADPH + H^+ (for C_3 plants) are utilised. Both ATP and NADPH; act as assimilatory powers to provide sufficient energy to carry out the process. Twelve molecules of ATP are utilised for uplifting the twelve molecules of NADPH; because the redox potential of NADPH; is much lower (E'_0 = -0.32V) than required (E'_0 = -0.4V) to act as hydrogen donor during the process. Another six molecules of ATP are utilised during the phosphorylation of ribulosc-5-pbospbate to regenerate ribulose1.5-diphosphatc. Similarly twelve molecules of $NADPH_2$ are utilised because for the reduction of each molecule of CO_2 four electrons (hydrogen atoms) are required.

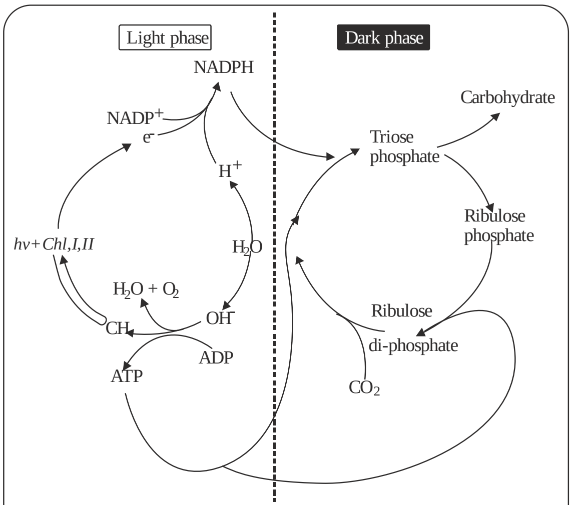


Fig.4: Schematic representation of interrelations between two phases of photosynthesis.

Thus, in all 18 ATP molecules and 12 NADPH molecules are required for the synthesis of each molecule of glucose from CO_2.

$$CO_2 + 2NADPH + H^+ \longrightarrow CH_2O + H_2O + 2NADP$$ OR

$$6CO_2 + 2NADPH + H^+ + 18\,ATP \longrightarrow C_6H_{12}O_6 + 6H_2O + 2NADP + 18ADP + 18Pi$$

b) Write short note on C_4 cycle **7**

The C_4 cycle may also be referred to as the dicarboxylic acid cycle or the p-carboxylation pathway or Hatch and Slack cycle or Cooperative photosynthesis (Karpilov, 1970). While using $C^{14}O_2$ in their experimental studies, they found the initial labeling in oxaloacetic acid followed by malic acid and aspartic acids. Here the characteristic point has been the primary carboxylation reaction and the phosphoenolpyruvic acid (PEP) was found to be the CO_2 acceptor molecule.

In the chloroplast of mesophyll cells, CO_2 is reduced by the carboxylation of *phosphoenol pyruvate* to form oxaloacetate. This step requires a molecule of water and releases a molecule of phosphoric acid as by-product. Enzyme phosphoenol pyruvic carboxylase is needed in the reaction.

The oxaloacetate is readily converted into malate or aspartate depending upon species. Malate is derived from oxaloacetate by reduction with $NADPH+H^+$ in the presence of malic dehydrogenase. Malate is then transported to the chloroplasts of bundle sheath cells where it is decarboxylated by NADP specific malate enzyme to produce pyruvate and carbon dioxide. The released CO2 is used in the carboxylation of ribulose-1, 5-diphosphate in the presence of enzyme carboxydismutase to produce phosphoglycerate, the first stable product of Calvin cycle of photosynthesis. It follows Calvin cycle in further steps to produce starch and to regenerate ribulose-1, 5-diphosphate.

Simultaneously, the pyruvate is transported back to the chloroplast of mesophyll cells where it is reconverted into the phosphoenolpyruvate by utilizing energy of ATP of light phase in the presence of enzyme pyruvate phosphate dikinase. ATP is converted to AMP in the process. Since, the conversion results in the form of AMP, the requirement to regenerate ATP from AMP is 2 ATP. This is how 12 additional ATP are needed in the C_4 pathway.

OR

c) Write short note on Photorespiration **8**

Photorespiration is marked as one of the new discoveries of plant physiology. Krotkov (1963) introduced the term photorespiration to refer "the release of carbon dioxide in respiration in presence of light". The process is carried on only in presence of light. It has been reported only in green cells such as in case of Beta, Phaseolus, Gossypium, Pisum, Capsicum, Petunia, Antirrhinum, Glycine, Helianlhus, Chlorella, Nitella, Oryza etc.

Photorespiration- has been rarely reported in tropical grasses. In photorespiration, temperature plays a very vital role, its rate being very high in between 25 to 35°C. The process also depends upon concentration of oxygen and it goes on increasing with higher concentration of oxygen even up to 100 per cent. The normal respiration (which now may be called dark respiration) is relatively independent of oxygen concentration. Recent investigations have indicated that dark respiration may be inhibited in the light and may be replaced by photorespiration in green leaves and algae.

In dark respiration, the respiratory substrate usually considered is the sucrose while in photorespiration, the recently formed glycolic acid (2-C compound) serves as substrate. Several speculations were made over how glycolic acid is synthesized in the plants and it was in 1971 when Bowes, Ogren and Hageman unraveled the double role of enzyme RuDP (ribulose-1, 5-diphosphate) carboxylase (Rubisco).

Under normal conditions, it catalyses the fixation of CO_2 as a result of which two molecules of phosphoglyceric acid are formed from one molecule of RuDP. But under conditions such as:

(i) Rise in temperature and

(ii) High O_2/CO_2, ratio (high 0_2, low CO_2), it is unable to catalyse CO_2 fixation; instead, O_2 successfully competes with CO_2 and the RuDP carboxylase switches to oxygenase activity. As a result, a 2-carbon phosphoglycolic acid and a 3-carbon phosphoglyceric acid arc formed. The two reactions may be explained as follows:

(a) Carboxylase activity (leading to photosynthesis)

(b) Oxygenase activity (leading to photorespiration)

In the process, phosphoglycolic acid is easily converted into glycolic acid in a subsequent dephosphorylation reaction which acts as substrate for photorespiration. Glycolic acid is transported to peroxisome.

Glycolic acid is converted into glyoxylic acid in presence of enzyme glycolate oxidase as suggested by Zelitch (1966). In the reaction hydrogen peroxide is also formed which is destroyed by enzyme catalase into oxygen and water. The reactions may be represented as follows:

In the next step, glyoxylic acid is converted into glycine in the presence of enzyme glutamate glyoxylate aminotransferase.

d) Write the important roles of Abscissic acid **7**

(i) Bud dormancy. Wareing (1965) demonstrated that in birch, sycamore (*A. pseudoplatanus*) and black currant (woody trees) ABA induces dormancy. It is believed that bud dormancy is controlled through changes in the levels of endogenous growth inhibitors (ABA) which is influenced by day length and chilling effects.

(ii) Senescence. Senescence of leaf is promoted by ABA. Wareing and Hillman (1967) reported that the senescence of isolated excised leaf discs of *Acer pseudoplatanus* is promoted by ABA. However, it remains yet to establish dial natural leaf senescence is in any way determined by endogenous ABA.

(iii) Abscission. Addicott and his coworkers (1964) observed ABA accelerated leaf abscission in cotton plants. Since then it is believed that cause of abscission is the presence of growth inhibiting hormone (ABA), but its universal role for abscission is yet to be established.

(iv) Flower initiation. In certain short day plants such as *Ribes nigrufn Phorbitis and Fragaria*, ABA induces flowering during long days. However it is ineffective in typical short day plant like *Xanthium*. But in general, ABA induces flowering in short day plants and inhibits flowering in long day plants.

(v) Stomatal physiology. ABA alters the plasma membrane by affecting a change in a bioelectrical potential across them and an efflux of K ions.

(iv) Release of ethylene. It's now well established that ABA stimulates release of ethylene.

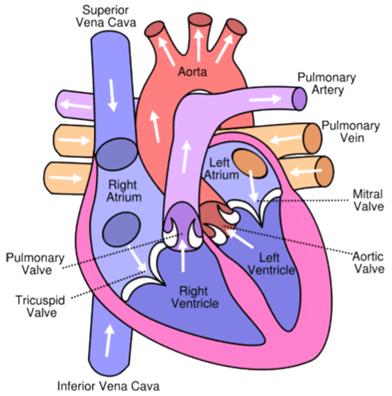
(vii) Counteract GA. ABA counteracts many effects of GA such as induction of hydrolases and α-amylases in barley seedlings. It is believed that this effect is due to inhibition of DNA dependent RNA synthesis which might have been accelerated by GA,

The increase in ABA concentration is an indication of senescence, characterized by loss of chlorophyll, decreased rate of photosynthesis and changes in nucleic acid and protein metabolism. In this way, ABA -can be considered as a chemical indicating the beginning of senescence in plants.

Q. 3:

a) Describe the internal structure of a mammalian heart with a neat labelled diagram **8**

Internally, the heart is made up of four main cavities: two Atria (singular: atrium) and two Ventricles. The atria hold blood briefly, then allow it to fall into the ventricles, which provide the actual 'pump'.



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- The vena cava supplies de-oxygenated blood from the body, which then flows into the right atrium then the right ventricle. This gets pumped through the pulmonary artery to the lungswhere it gets oxygenated, before returning to the heart via the pulmonary vein. This flows through the left atrium into the left ventricle, and then gets pumped to the body via the aorta. It finally returns to the heart through the vena cava, and the process repeats. This is happening inside you right now, about once a second!

- The atria are separated from the ventricles by Atrioventricular Valves (specifically called Tricuspid Valves - right; and Bicuspid/Mitral Valves - left). These valves allow blood to flow downwards when the atria and ventricles relax, but close to prevent blood from flowing back up to the atria when the ventricles are contracting.

- The ventricles are separated from the aorta and the pulmonary artery by the Semilunar Valves (specifically called, respectively, the Aortic and Pulmonary Valves). These prevent bloodfrom flowing in the wrong direction back into the heart.

- The atrial walls are thin; they don't need to withstand much pressure. The ventricles walls on the other hand are much thicker. When the ventricles contract, the blood pressure inside becomes very high, and they need to be able to withstand this.

- Also, the walls of the left ventricle are thicker than those of the right ventricle. This is because the left side of the heart controls the systemic circuit (blood to the whole body) while the right side controls the pulmonary circuit (blood to the lungs).

- Blood in the systemic circuit needs to be at a high pressure in order to make its way around the whole body and back again. In contrast, the lungs are very close to the heart, and contain very delicate capillaries which would break if subjected to too great a pressure. Hence the systemic circuit requires a greater blood pressure than the pulmonary circuit, and thus the walls of the left ventricle must be thicker than those of the right ventricle

b) Give an account of structure of haemoglobin and its polymorphism 7

is a globular heme protein in vertebrate red blood cells and in the plasma of many invertebrates that *carries oxygen and carbon dioxide*; heme group binds oxygen and carbon dioxide and as well as imparts red color to the blood; also spelt as *hemoglobin.*

- Heme is iron porphyrin compound. Porphyrin is a tetrapyrrole structure.
- Ferrous iron occupies the center of the porphyrin ring and establishes linkages with all the four nitrogens of all the pyrrole rings.
- It is also linked to nitrogen of imidazole ring of histidine present in globin part.
- Globin part is made of four polypeptide chains, to identical α-chains and two identical β-chains in normal adult hemoglobin.
- Each chain contains a "heme" in the so called 'heme pocket'. So one Hb molecule possess four heme units.
- Hb molecule contains hydrophobic amino acids inside and hydrophilic ones on the surface.
- Heme pockets of α-subunits are of just adequate size to give entry to an O2 molecule. Entry of O2 into heme pockets of β-subunits is blocked by a valine residue.
- Varieties of normal human Hb are
  - Hb-A1 (two α-chains and β-chains)
  - HbF (two α-chains and ¥-chains)

- Hb-A2 (two α-chains and delta-chains)
- Embyonic Hb (two α-chains and €-chains)
- Hb-A3 (Altered from Hb-A found in old red cells)
- HbA1C (Glycosylated Hb, present in concentration of 3-5% of total Hb). In diabetes mellitus it is increased to 6 to 15%.

OR

c) Define and explain aerobic and anaerobic respiration **8**

Living organisms use energy released by respiration for their life processes. There are two types of respiration – aerobic (which needs oxygen) and anaerobic (which doesn't need oxygen).

Aerobic respiration

Mammals and birds need energy to maintain a constant body temperature. Energy is also needed for the following life processes:

- growth
- cell division
- muscle contraction
- protein synthesis
- active transport
- nerve impulses

Respiration involves chemical reactions that break down nutrient molecules in living cells to release energy.

Aerobic respiration needs oxygen. It is the release of a relatively large amount of energy in cells by the breakdown of food substances in the presence of oxygen:

glucose + oxygen → carbon dioxide + water

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

Mitochondria are tiny organelles found in the cell cytoplasm

Aerobic respiration happens all the time in animals and plants. Note that respiration is different to breathing (ventilation). Most of the reactions in aerobic respiration happen inside mitochondria in cells.

Anaerobic respiration

Unlike aerobic respiration, anaerobic respiration does not need oxygen. It is the release of a relatively small amount of energy in cells by the breakdown of food substances in the absence of oxygen.

Anaerobic respiration in muscles

Anaerobic respiration happens in muscles during hard exercise:

glucose → lactic acid

$C_6H_{12}O_6 \rightarrow 2C_3H_6O_3$

Glucose is not completely broken down, so much less energy is released than during aerobic respiration.

There is a build-up of lactic acid in the muscles during vigorous exercise. The lactic acid needs to be oxidised to carbon dioxide and water later.

This causes an oxygen debt - known as excess post-exercise oxygen consumption (EPOC) - that needs to be ‘repaid’ after the exercise stops. This is why we keep on breathing deeply for a few minutes after we have finished exercising.

d) Describe the structure and function of Nephron **7**

Nephrons are the basic filtering units of kidneys. Each kidney possesses large number of nephrons, approximately 1-1.5 million. The main components of the nephron are glomerulus, Bowman’s capsule, and a long renal tubule. Functioning of a nephron:
a. The blood enters the kidney through the renal artery, which branches into many capillaries associated with glomerulus.
b. The water and solute are transferred to the nephron at Bowman’s capsule.
c. In the proximal tubule, some substances such as amino acids, glucose, and salts are selectively reabsorbed and unwanted molecules are added in the urine.

d. The filtrate then moves down into the loop of Henle, where more water is absorbed.
e. From here, the filtrate moves upwards into the distal tubule and finally to the collecting duct. Collecting duct collects urine from many nephrons.
f. The urine formed in each kidney enters a long tube called ureter. From ureter, it gets transported to the urinary bladder and then into the urethra.

Q. 4:

a) Elaborate on non-living and living components of an ecosystem. **8**

- Definition (2M)
- Types of components (4M)
  Abiotic components
  Biotic components
- Functions of each (2M)

b) Explain in detail about any one type of ecological pyramid. **7**

- Definition (2M)
- Any one type of pyramid (4M)
- Diagram (1M)

OR

c) Explain in detail about parasitism with suitable examples **8**

- Definition(2M)
- Any three examples (each 2M)

d) Describe carbon cycle in detail. **7**

- Definition (1M)
- Explanation (6M)
  Diagram

Q. 5: Write short notes on (any three) **15**

1. Secondary Metabolites

Secondary metabolites perform non-vital functions. They do not take part in plant metabolism directly. They are accessory plant metabolites and are not involved in the biosynthesis of primary plant metabolites. However, certain secondary metabolites such as chlorophylls, carotenoids, phytohormones (GA, ABA) play vital roles in metabolism hence they also be considered as primary metabolites.

Secondary metabolites have got diverse functions. Many secondary metabolites are employed commercially as insecticides, fungicides and pharmaceuticals while others are used as fragrances, flavourings, medicinal drugs and industrial materials.

On the basis of chemistry, secondary metabolites are categorized into following three groups:

(i) Terpenes or Terpenoids

(ii) Phenolic compounds

(iii) N-containing secondary products.

2. Auxins

Auxin stimulates cell divisions, cell enlargement and cell elongation in-the apical region. The primary physiological effect of auxin is to promote the elongation of cells. Role of auxin in cell elongation has been explained by Strafford (1967). The scheme shows that auxin increases (i) amylase activity, (ii) permeability, (iii) formation of energy rich phosphates (ATP) and (iv) cell wall plasticity while decreases (i) viscosity and (ii) wall pressure.

Auxin promotes growth of shoots at a relatively higher concentration and that of root at a very low concentration.

The phenomenon of auxin promoting xylem element differentiation is now well established and is now taken as a measure of auxin bioassays. It is because of tills property, auxins have been commonly used in bud grafting into a callus.

Auxin promotes activities in growth. IAA increases total RNA synthesis particularly a messenger type of RNA and the synthesis of specific enzymes. It is just believed that role of auxin is to release DNA template from nucleo-histone for m RNA synthesis.

Auxins affect a life of a plant in manifold ways. Besides the various processes explained earlier, auxins also play specific roles in seed germination, growth, rooting, flowering (reproductive processes), abscission, parthenocarpy, tissue culture etc.

3. Gastric digestion

Movements of the stomach slowly mix the food with gastric juice. This is a clear, colorless fluid, strongly acid in reaction and possessing a characteristic odor. It is secreted by about five million microscopic glands situated in the walls of the stomach, and contains an enzyme known as pepsin which acts upon proteins and acts only in an acid medium. Besides pepsin, it contains two other enzymes--renin, which coagulates the casein of milk, and gastric lipase, a fat-splitting enzyme. It also contains mineral matters and hydrochloric acid (commonly known as muriatic acid and used as a soldering acid) which is very powerful and literally eats to pieces the food it permeates. It would soon destroy the stomach except for the fact that its walls are continually protected by an alkaline secretion. This alkaline bath in which the stomach is kept is analogous to the water bath some furnaces have to be kept in to prevent them from melting.

4. RBC

Red blood cell, also called erythrocyte, cellular component of blood, millions of which in the circulation of vertebrates give the blood its characteristic colour and carry oxygen from the lungs to the tissues.

The mature human red blood cell is small, round, and biconcave; it appears dumbbell-shaped in profile.

The cell is flexible and assumes a bell shape as it passes through extremely small blood vessels. It is covered with a membrane composed of lipids and proteins, lacks a nucleus, and contains hemoglobin—a red, iron-rich protein that binds oxygen.

5. Function of an ecosystem.

- Explanation of functions (5M)