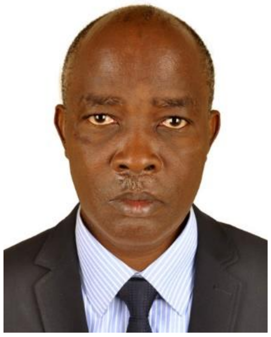


Dr. Bbosa Science

This document is sponsored by
The Science Foundation college Kiwanga-Namanve,
Uganda East Africa
Senior one to Senior six,
+256 778 633 682, +256 753 802709
Based on sciences, Best for Sciences
Obtain free notes, tests, making guides from: digitalteachers.co.ug

Autotrophic Nutrition

This is the synthesis of organic compounds from inorganic sources.
There are two types autotrophic nutrition.

(a) Chemosynthesis: is the synthesis of organic compounds from carbon dioxide and water using energy from oxidation of inorganic materials such as hydrogen sulphide, ammonia and iron II.

(b) Photosynthesis is the synthesis of organic compounds from carbon dioxide and water using energy from light.

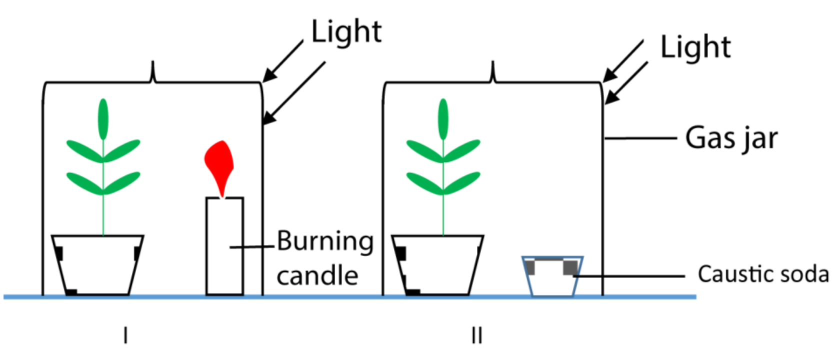
Importance of Autotrophic nutrition

1. Sugars resulting from autotrophic nutrition constitute structures of plants and animals
2. Sugars obtained from autotrophic nutrition are source of energy
3. Hyman depend on photosynthesis for energy containing fuel, which have developed over millions of years
4. Photosynthesis maintains a constant concentration of carbon dioxide and oxygen in atmosphere. Oxygen is added to atmosphere as a result of photosynthesis while carbon dioxide is removed.

Conditions necessary for photosynthesis

(a) Carbon dioxide: is obtained from the atmosphere and water in case of aquatic plants. It is the source of carbon in carbohydrates.

Experiment to show that carbon dioxide is necessary for photosynthesis



The experiment is set up as shown above

1. Two younger seedling growing in pots are kept in the dark for 3 days (to remove starch) and a leaf from each plant is tested to confirm absence of starch.
2. In experiment I the burning candle supplies carbon dioxide while in experiment II carbon dioxide is absorbed by caustic soda.

3. After 3 hours, a leaf is take from each plant and tested for the presence of starch. Starch is found in the leaf of experiment I which had carbon dioxide.

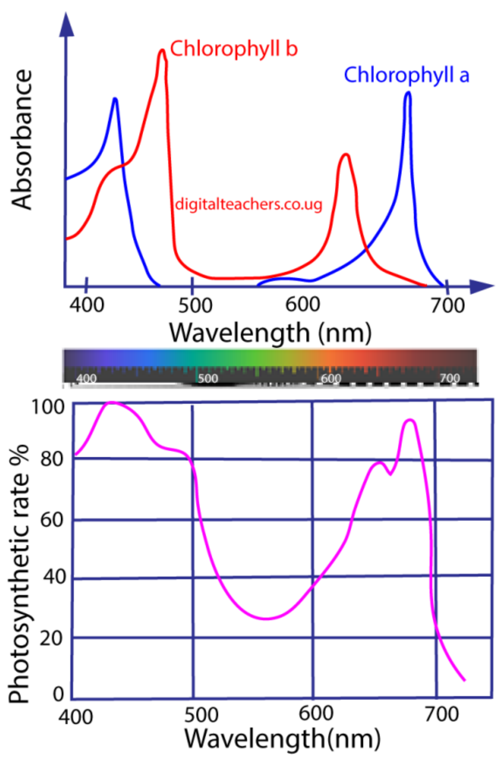
(b) Water provides hydrogen for the carbohydrates

(c) Light usually from the sun is the source of energy for photosynthesising tissues.

Wave length of light for photosynthesis

An action spectrum is the rate of a physiological activity plotted against wavelength of light. It shows which wavelength of light is most effectively used in a specific chemical reaction. Some reactants are able to use specific wavelengths of light more effectively to complete their reactions.

The action spectrum of chlorophyll is shown in the graph below



From the graph of action spectrum of chlorophyll, it observed that chlorophyll is much more efficient at using blue-violet light (wave length (550-400nm) and orange (600-700nm).

However, Bacteriochlorophyll of purple sulphur bacteria absorb ultraviolet (350nm) and infrared (750nm) part of the spectrum. The difference in wavelengths optimum for photosynthesis both in plants and bacteria enables bacteria to survive under water weeds in the pond. i.e. bacteria find the spectrum useful after the plants have filtered out light for photosynthesis.

(d) Chlorophyll: this is a green pigment which helps to trap light energy for photosynthesis.

Experiment to show that chlorophyll is necessary for photosynthesis
When a variegated leaf is picked from a plant on a sunny day and tested for starch. Starch is found only in parts that originally contained chlorophyll.

(e) A suitable temperature: photosynthesis proceed by a series of chemical reactions controlled by enzymes which are sensitive to temperature. By comparing the rates of photosynthesis, at different temperatures, optimum temperatures for various plants are obtained.

Limiting factors

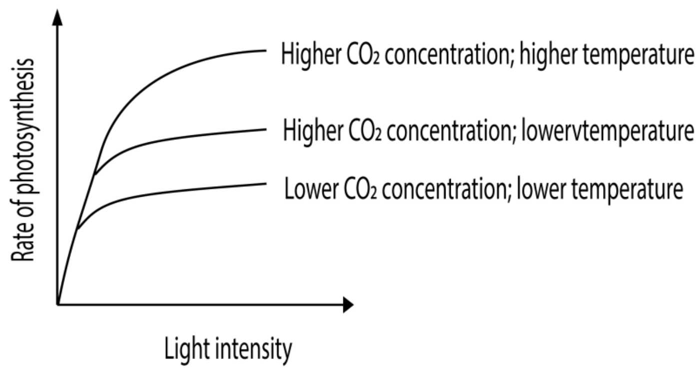
The main **factors** affecting rate of **photosynthesis** are light intensity, carbon dioxide concentration and temperature. In any given situation any one of these may become a **limiting factor**, in other words the **factors** that is in short supply.

In 1905, when investigating the factors affecting the rate of photosynthesis, Blackmann formulated the Law of limiting factors.

This states that the rate of a physiological process will be limited by the factor which is in shortest supply. Any change in the level of a limiting factor will affect the rate of reaction.

For example, the amount of light will affect the rate of photosynthesis. If there is no light, there will be no photosynthesis. As light intensity increases, the rate of photosynthesis will increase as long as other factors are in adequate supply. As the rate increases, eventually another factor will come into short supply.

The graph below shows the effect of low carbon dioxide concentration. It will eventually be insufficient to support a higher rate of photosynthesis, and increasing light intensity will have no effect, so the rate plateaus.



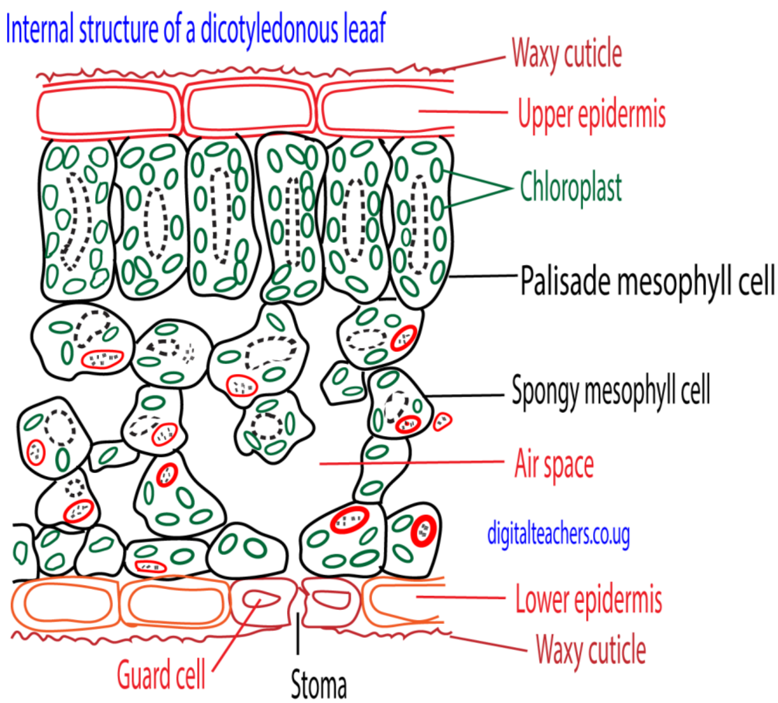
If a higher concentration of carbon dioxide is supplied, light is again a limiting factor and a higher rate can be reached before the rate again plateaus. If carbon dioxide and light levels are high, but temperature is low, increasing temperature will have the greatest effect on reaching a higher rate of photosynthesis.

The leaf

In higher plant the major photo synthetic organ is the leaf.

Functions of the leaves

1. Carry out photosynthesis with subsequent production of organic materials
2. Carry out gaseous exchange through the stomata
3. Transpiration takes place mainly through the leaves resulting in the cooling of plant and absorption of mineral salts and water
4. Some leaves such as those of peas are modified by tendrils for support.
5. Some leaves suck those bryophyllum are modified for storage
6. Some leaves such as for bryophyllum are modified for vegetative reproduction
7. Some leaves possess itching hairs, thorns, spikes and poisonous substances for protection of plant.
8. Some leaves e.g. Venus fly trap are modified for capturing and extracting nitrogen from animals
9. Some produce substances that kill parasites.



Functions of tissues in dicotyledonous leaves

Tissue	Structure	Function
1. Upper and lower epidermis	One cell thick External walls covered with cutin (waxy substance) Contain stomata (pores surrounded by guard cells)	- Protective - Cutin is water proof and reduce water loss from the leaves - Allow gaseous exchange
2. Palisade mesophyll	Column-shaped cells with numerous chlorophyll in thin layer of cytoplasm	- Main photosynthetic tissue. Chloroplast may move towards light
3. Spongy mesophyll	Irregular shaped cells fitting loosely to leave large air space	- Photosynthetic, but fewer chloroplast than palisade cells. Gaseous exchange can occur through the large air space via stomata.
4. Vascular tissue	Extensive finely branching network through leaf	- Conduct water and mineral salts to the leaf in xylem - Remove photosynthetic products through phloem - Provide a supporting skeleton to the lamina, aided by turgidity

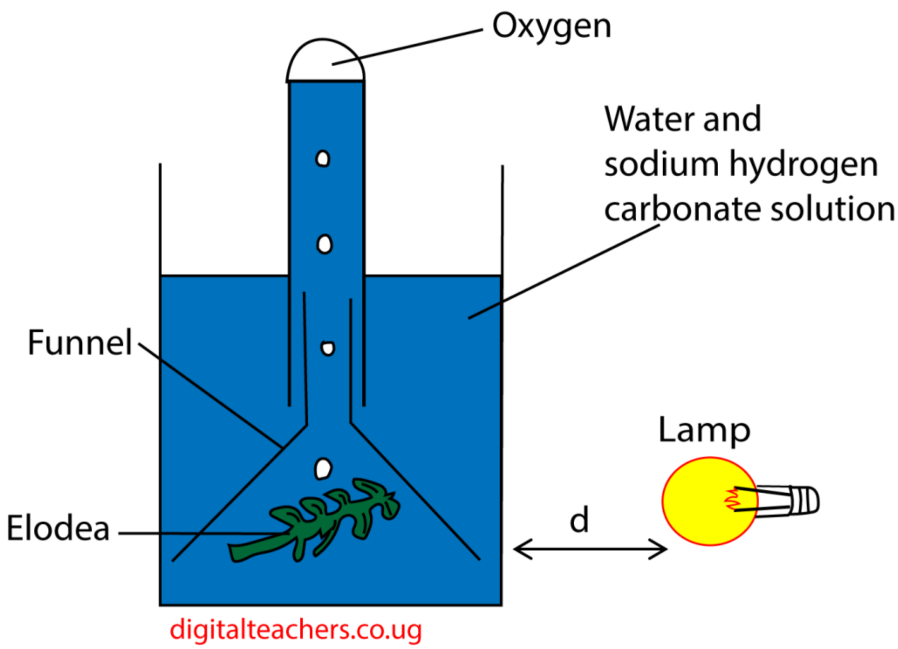
Adaptation of leaves to photosynthesis

1. The leaf is only a few cells thick for easy penetration of light and gases.
2. Wax cuticle prevent excessive water loss
3. The palisade cells that contain numerous chloroplasts are well positioned to receive light.
4. Presence of xylem that supply the leaf with water for photosynthesis
5. The spongy mesophyll has many air space. Gases can readily diffuse to all photosynthetic cells
6. They are broad and flat to offer a large surface area exposed to light and air
7. Stomata control passage of gases
8. The arrangement of leaves to the plant is such way that each leaf receives light.

Modification of leaves to their functions

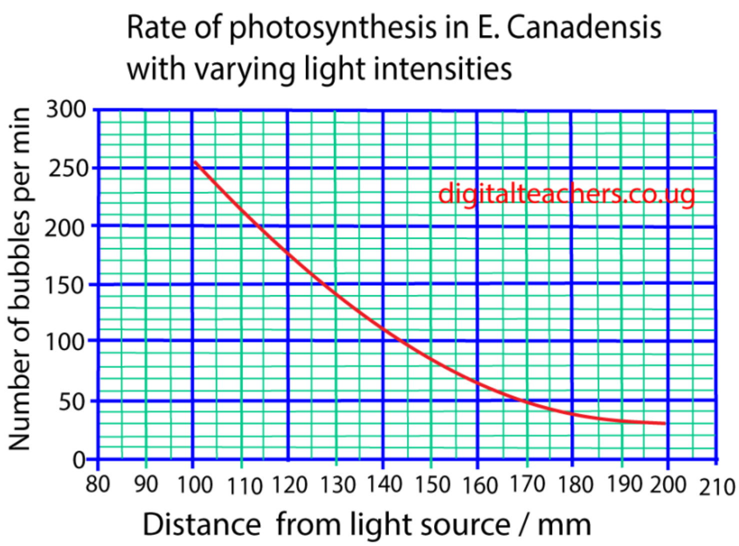
(i) Flattened surface to reduce diffusion distance
(ii) Shiny waxy cuticle to reduce water loss
(iii) Mosaic arrangement to increase light absoption
(iv) modified into tendrils to support weak climbing stems e.g. Gloriosa, peas
(v) Some leaves are modified into spine in order to reduce water loss. Spines also protect the plant from herbivorous animals
(vi) Some leaves are modified into scale leaves (thin, membranous, dry colorless structures) for protection. E.g. onion outer leaves
(vii) **Phyllode :** It is a green, expanded structure formed by the modification of petiole or rachis of leaf. Many xerophytes reduce the size of their leaves to minimize water loss. Such plant develop phyllodes to carry out photosynthesis e.g., *Acacia*, *Melanoxylon* and *Parkinsonia*.
(viii) Some leaves are flesh to store water and food
(ix) Some leaves develop vegetative bud for reproduction, e.g. bryophyllum
(x) In some rootless, aquatic plants, the submerged leaves are modified into root like structure to absorb water and mineral salts. Such modified leaves are called absorbing leaves. e.g., *Utricularia*.
(xi) Some leaves are brightly colored to attract insect pollinator, e.g. Bougainville
(xii) Some leaves are modified to trap insects.

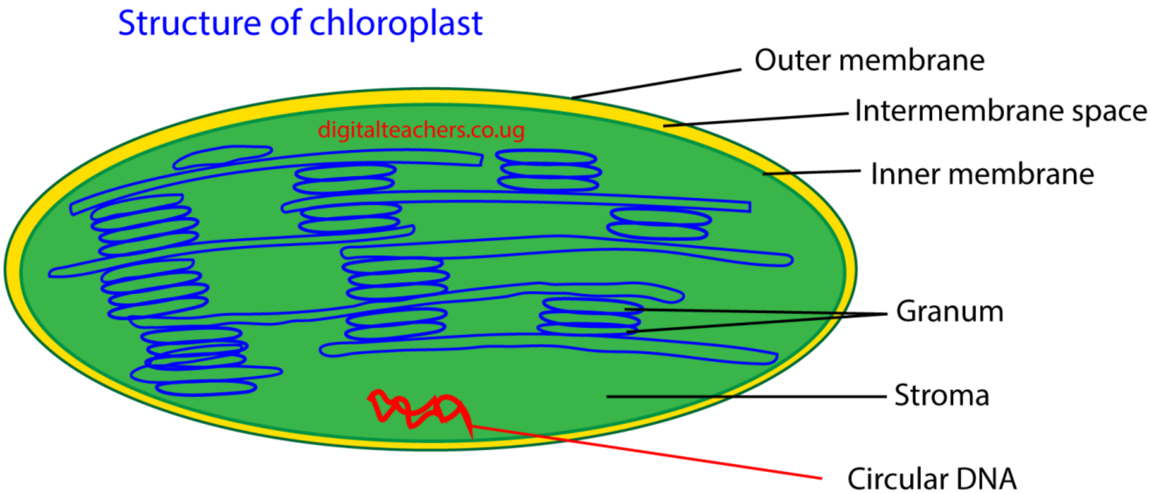
Measuring the rat of photosynthesis



Method

a. The apparatus is filled with carbonated water to enrich it with carbon dioxide.
b. The setup is allowed to adjust to light intensity for 2-3 minutes. The rate of bubbling should be adequate such as 10 bubbles per minute.
c. Light intensity is varied by increasing the distance, d, between the light source and the apparatus such as 10, 15, 20, 40 and 45cm. the bigger the distance, d, the lower the light intensity.
d. The rate of formation of bubbles per minute at different distances, d, is an empirical measure of photosynthesis at a given light intensity.
e. Temperature change is buffered by using a beaker of bigger capacity.





Chloroplast is biconcave (to increase the surface area for absorption of light) It is bound by a double membrane within which are numerous structures called thylakoids. Each thylakoid consists of a pair of membrane close to each other with narrow spaces between them. In places, the thylakoid is arranged in a neat stack, rather like a pile of coin called granum (pl. grana). The grana are connected to each other by a less regular arrangement of the inter grana thylakoids. The thylakoid system is embedded in a protein rich matrix called stoma

Adaptations of chloroplast to their functions

a. Outer membrane is semi- permeable to regulate entry and exit of substances for maintaining internal chloroplast environment.
b. Contains chlorophyll to trap light for photosynthesis
c. Abundant enzymes catalyse photosynthetic reactions in the stroma.
d. Many grana, large surface area for photosynthetic pigments, electron carriers and ATP synthase enzymes.
e. Grana surrounded by the stroma so the products from the light dependent reaction (which occur across the thylakoid membrane which make up the grana) can readily pass into the stroma for the light independent reaction.
f. Narrow intermembrane space enables H^+ ion concentration gradient to be rapidly established for chemiosmosis to occur
g. Inner membrane contains molecules for electron transport pathway
h. DNA presence codes for protein synthesis, including enzymes.
i. Many ribosomes for protein synthesis to reduce on importing proteins from cytoplasm
j. Outer membrane is permeable to gases like carbon dioxide which is a raw material for photosynthesis

Cellular Respiration versus Photosynthesis comparison chart		
	Cellular Respiration	**Photosynthesis**
Production of ATP	Yes; theoretical yield is 38 ATP molecules per glucose but actual yield is only about 30-32.	Yes

Reactants	$C_6H_{12}O_6$ and $6O_2$	$6CO_2$ and $12H_2O$ and light energy
Requirement of sunlight	Sunlight not required; cellular respiration occurs at all times.	Can occur only in presence of sunlight
Chemical Equation (formula)	$6O_2 + C_6H_{12}O_6 \rightarrow 6CO_2 + 6H_2O$ + ATP (energy)	$6CO_2 + 12H_2O$ + light $\rightarrow C_6H1_2O_6 + 6O_2 + 6H_2O$
Process	Production of ATP via oxidation of organic sugar compounds. Glycolysis: breaking down of sugars; occurs in cytoplasm Krebs Cycle: occurs in mitochondria; requires energy. Electron Transport Chain proteins in mitochondria; converts O_2 to water.	The production of organic carbon (glucose and starch) from inorganic carbon (carbon dioxide) with the use of ATP and NADPH produced in the light dependent reaction
Fate of oxygen and carbon dioxide	Oxygen is absorbed and carbon dioxide is released.	Carbon dioxide is absorbed and oxygen is released.
Energy required or released?	Releases energy in a step wise manner as ATP molecules	Requires energy
Main function	Breakdown of food. Energy release.	Production of food. Energy Capture.
Chemical reaction	Glucose is broken down into water and carbon dioxide (and energy).	Carbon dioxide and water combine in presence of sunlight to produce glucose and oxygen.

Stages	4 stages: Glycolysis, Linking Reaction (pyruvate oxidation), Krebs cycle, Electron Transport Chain (oxidative phosphorylation).	2 stages: The light dependent reaction, light independent reaction. (also called light cycle & Calvin cycle)
What powers ATP synthase	H+ proton gradient across the inner mitochondria membrane into matrix. High H^+ concentration in the intermembrane space.	H+ gradient across thylakoid membrane into stroma. High H^+ concentration in the thylakoid lumen
Products	$6CO_2$ and $6H_2O$ and energy(ATP)	$C_6H_{12}O_6$ (or G_3P) and $6O_2$ and $6H_2O$
What pumps protons across the membrane	Electron transport chain. Electrochemical gradient creates energy that the protons use to flow passively synthesizing ATP.	Electron transport chain
Occurs in which organelle?	Mitochondria	Chloroplasts
Final electron receptor	O_2 (Oxygen gas)	$NADP^+$ (forms NADPH)
Occurs in which organisms?	Occurs in all living organisms (plants and animals).	Occurs in plants, protista (algae), and some bacteria.
Electron source	Glucose, NADH + , $FADH_2$	Oxidation H_2O at PSII
Catalyst - A substance that increases the rate of a chemical reaction	No catalyst is required for respiration reaction.	Reaction takes places in presence of chlorophyll.
High electron potential energy	From breaking bonds	From light photons.

Chemistry of photosynthesis

In the process of photosynthesis obtain energy from sunlight is trapped by chlorophyll and used for the manufacture of carbohydrates from carbon dioxide and water.

The process is summarised by the following equation

Carbon dioxide + water $\xrightarrow{\text{chlorophyll}}$ Carbohydrates + oxygen

CO_2 H_2O CH_2O O_2

Photosynthesis takes place in 3 stages

- Light harvesting
- Electron transport
- Reduction of carbon dioxide

1. **Stage 1: Light harvesting**
   Pigment molecules in thylakoid membrane absorb and collect solar energy and funnel it to special molecules of chlorophyll **a** known as the **reaction centre chlorophyll molecule**. On striking this molecule an electron in its orbit is raised to a higher energy level, and picked by electron acceptor.

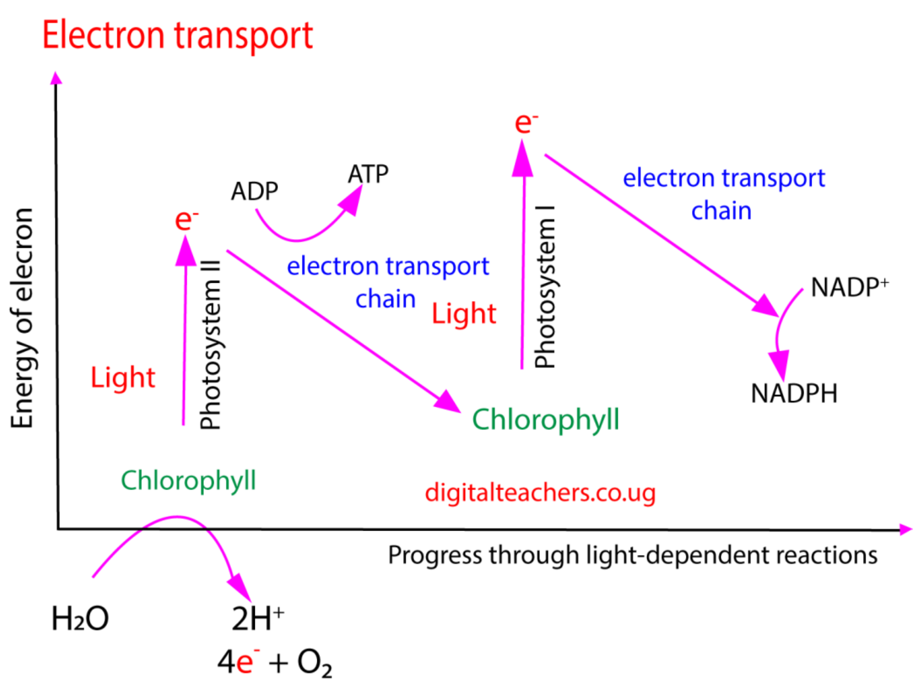
   There are **two kinds of reaction centres** in plants called photosystem I (PSI) and photosystem II (PS II) that differ in structure and function. PSI absorbs light at 700nm and PSII at 690nm. Whereas many chlorophyll molecules are involved in collecting energy, only a few make up the reaction centres.

   The transport of electron through the two centres comprise the second state of photosynthesis.

2. **Stage 2: electron transport**

   This stage occurs in thylakoid of the chloroplast and produces **ATP** and reduced nicotinamide adenine phosphate, **(NADPH)** to be used in the reduction of carbon dioxide in the third stage.

   The events of electron transport are described in the figure below



(i) Formation of NADPH
When light is absorbed by a chlorophyll molecule PSI an electron is displaced and transferred to an electron acceptor which donates it to a protein ferredoxin. Ferredoxin then passes the electron to NADP which is reduced to NADPH.

The electron lost by PSI is restored from PSII. When PSII absorbs light energy, an electron is displaced from it and passes through electron carrier system which includes cytochromes.

The electron lost from PSII is then restored through photolytic splitting of water (Hill reaction)

(ii) ATP formation

(i) Non cyclic photophosphorylation
The flow of electrons from PSII to PSI in thylakoid membrane causes accumulation of H^+ inside the thylakoid space creating a gradient. The passage of H^+ out of the thylakoid provides energy to synthesise ATP.

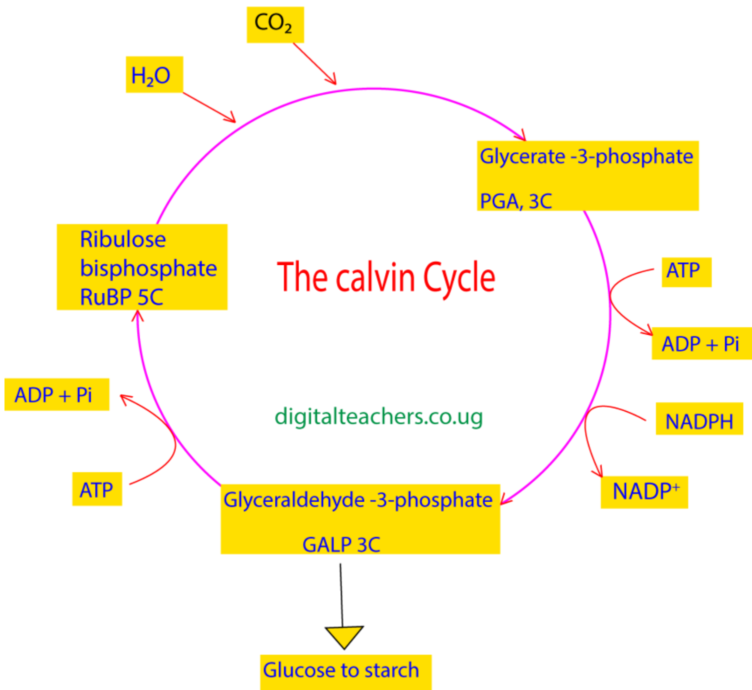
(ii) Cyclic photophosphorylation
Here when PSI is struck by light, electron is excited, passes through electron carrier system and then returned to PSI; that is PSI is the electron donor and acceptor. H^+ builds up in the thylakoid space creating a gradient. Then the passage of H^+ out of the thylakoid provides energy for synthesising ATP. It is useful to synthesise ATP when synthesis of $NADPH_2$ is not necessary.

Differences between cyclic and non-cyclic photophosphorylation

	Cyclic photophosphorylation	Non-cyclic photophosphorylation
1	It occurs only in PS I	It occurs only in PS I and PS II
2	It involves synthesis of ATP	It involves synthesis of ATP and $NADPH_2$
3	Photolysis of water does not occur	Photolysis occurs and oxygen is liberated
4	Electron motion is cyclic	Electron motion is non cyclic

3. Reduction of carbon dioxide

This involves a cyclic chain reaction called Calvin cycle. It occurs in the stroma of chloroplast where NADPH and ATP from stage 2 provide reducing power and energy for synthesis of sugars.



1. In the first step, carbon dioxide combines with a 5-carbon organics compound called **ribulose bisphosphate** (RUBP) with the aid of an **enzyme ribulose bisphosphate carboxylase** giving unstable 6-carbon compound.
2. The unstable 6-carbon compound immediately splits into two molecules of 3-carbon compound **glycerate-3-phosphate**, (GP)
3. The GP is reduced to form a 3-carbon sugar, glyceraldehyde-3-phosphate (GALP). The hydrogen for reduction comes from NADPH which also supplies most of the energy, the rest coming from ATP.

4. The 3-carbon sugar is built into a 6-carbon sugar which may be converted into starch for storage.

5. Some of the 3-carbon sugar is used to regenerate ribulose bisphosphate to be used in the Calvin cycle.

ADAPTATIONS TO PHOTOSYNTHESIZE IN SUN AND SHADE

Shade plant	Sun plant
1. Abundant chlorophyll b (low chlorophyll a to chlorophyll b ratio) which gives leaves dark green colour to increase light absorption in the dark;	1. Abundant chlorophyll a (high chlorophyll a to chlorophyll b ratio) to increase light absorption;
2. Palisade/ spongy mesophyll ratio low to allow maximum light penetration;	2. Palisade/ spongy mesophyll ratio high to minimise light penetration;
3. Mesophyll cell surface / leaf area ratio low to maximise light trapping;	3. Mesophyll cell surface / leaf area ratio high to minimize excessive light and transpiration;
4. Leaf orientation horizontal to maximize light trapping;	4. Leaf orientation erect to minimize light trapping;
5. Reddish leaf undersides to enhance reflectance back up through the photosynthetic tissue; giving the plant a second chance to utilize the light.	5. Stomatal density high to avoid over heating;
6. Stomatal density low to avoid over cooling;	6. Much carotenoids to prevent damage to chlorophyll from very bright light.
7. Thin leaves to maximise light penetration;	7. Thick leaves to minimise light penetration;
8. Stomatal size large to allow loss of excess water;	8. Stomatal size small to minimise water loss;
9. Elongated internodes for increased access to light;	Other features (i) RuBISCO and soluble protein content /mass higher (ii) Chlorophyll / soluble protein ratio high (iii) Chloroplast size small

C3 and C4 plants

In C3 plant such as tomato, and rice, carbon dioxide is fixed by ribulose bisphosphate and the first stable intermediate in production of sugar is a 3-carbon compound**, glycerate-3-phosphate**. However, the C4 plants such as sugar cane and maize fix carbon dioxide using **phosphorenol pyruvic acid (PEP)** and the immediate products of CO_2 fixation is a 4-carbon compound **oxaloacetic** acid.

The oxaloacetic acid formed in C4 plants is subsequently converted into maleic acid from which CO_2 is fed into the Calvin cycle to form carbohydrates.

Advantages of C4 plants over C3 plants

1. C4 plants ably photosynthesize at very low CO_2 concentration (e.g. in dense tropical vegetation) because PEP carboxylase enzyme has a very high affinity for carbon dioxide.

2. Concentric arrangement of mesophyll cell produces a smaller area in relation to volume for better utilization of available water and reduces the intensity of solar radiations.

3. Photorespiration, which inhibits growth in C3 plants is avoided / reduced in C4 because
   (i) the CO_2 fixing enzyme PEP carboxylase does not accept oxygen
   (ii) RuBISCO enzyme inside the bundle sheath cells is shielded from high oxygen concentration by the ring of palisade cells.

4. The CO_2 fixing enzymes in C4 plants are more active at hot temperature and high illumination, therefore photosynthesis occurs rapidly at low altitude, hot and brightly lit tropical conditions than in C3 plants.

5. The productivity of C4 almost four times greater than in C3 because:
   (i) of the increased rate of CO_2 uptake caused by
   (ii) large internal leaf surface area
   (iii) short CO_2 diffusion distance
   (iv) CO_2 steep diffusion gradients

6. The bundle sheath cells in which dark reactions occur have
   (i) a large photosynthetic surface area enabled by un-usually large chloroplasts
   (ii) lack of grana on which O_2 would be produced, so no photorespiration.

7. The palisade cells in which light reactions occur have large grana to increase the photosynthetic surface area.

Disadvantage of C4 plants over C3 plants

The CO_2 fixing enzymes in C4 plants are less active at cool, moist and low illumination conditions, therefore photosynthesis occurs slowly at high altitude with cool temperature and in low light intensity of temperate conditions.

NB: C4 plants grow better under hot, dry conditions when plants must close their stomata to conserve water – with stomata closed, CO_2 levels in the interior of the leaf fall, and O_2 levels rise

CAM Plant e.g. pineapple

These are C4 plants that live especially in arid environment. Because they are at risk of severe water loss, they have accustomed by opening their stomata at night. Thus as opposed to other C4 plants, in CAM plants, the initial fixation of CO_2 by PEP and the conventional Calvin cycle are separated in time. The stomata are generally closed during the day so there is little loss of water; the CO_2 is fixed during the night when the stomata are open.

Photorespiration

Photorespiration refers to the process whereby oxygen is added to ribulose bisphosphate (RuBP) thereby breaking it down into carbon dioxide and water.
The process thus uses up oxygen, leads to loss of carbon, as carbon dioxide, and energy. However, no carbon dioxide is used up, it is instead produced.

Photorespiration occurs only in C3 plants due to high oxygen and low carbon dioxide partial pressure and / or high temperature. In such conditions, oxygen out competes carbon dioxide for the enzyme RuBP carboxylase, which then takes up the oxygen and releases the fixed carbon dioxide.

Difference between C3, and C4 plant

	C3 pathway	C4 pathway
1	Photosynthesis occurs in mesophyll cells	Photosynthesis occurs in mesophyll cells and bundle sheath cells
2	The CO_2 molecule acceptor is RuBP	The CO_2 acceptor molecule is phosphenol pyruvate
3	The first stable product is a 3C compound Called Glycerate-3-phosphate (PGA)	The first stable product is a 4C compound **oxaloacetic** acid (OAA)
4	Photorespiration rate is high and leads to loss of fixed CO_2. Decrease CO_2 fixation rate	Photorespiration is negligible and is almost absent. Hence high CO_2 fixation rate
5	Optimum temperature is 20^0C to 25^0C	Optimum temperature is 30 to 45^0C.
6	Photosynthetic rate is low	Photosynthetic rate is high
7.	Examples of C3 plants are rice, wheat and tomato	Examples of C4 plants are maize, sugar cane

Definition

Photorespiration (also known as the **oxidative photosynthetic carbon cycle**, or **C_2 photosynthesis**) refers to a process in plant metabolism where the enzyme RuBisCO oxygenates RuBP, causing some of the energy produced by photosynthesis to be wasted. This process reduces the efficiency of photosynthesis, potentially reducing photosynthetic output by 25% in C_3 plants

Nutrition in bacteria

Bacteria are classified into 2 two groups

No.	Nutritional type	Source of energy	Source of carbon	Source of hydrogen	examples
1	Autotrophic bacteria are classified according to source energy, carbon and hydrogen				
(a)	Photoautotrophs	Sunlight	CO_2	H_2S	Green sulphurbacteria
(b)	Photoautotrophs	sunlight	CO_2	H_2O	cyanobacteria
(c)	photoheterotroph	Light	Organic compounds	Organic compounds	Purple non sulpur bacteria
(d)	Chemoautotrophs	Inorganic compounds such as NH_3, NO_2, H_2, H_2S	CO_2	H_2O	Nitrifying bacteria, nirobacter
2	heterotrophs	Organic compound	Organic compounds		Most bacteria

Importance of bacteria

(1) Harmful effects
  (a) Bacteria are agents of disease of animals and plants such as syphilis, cholera, tetanus
  (b) Bacteria cause milk and food deteriorate
  (c) Denitrifying bacteria such as Thiobacillus lead to deterioration of soil fertility.

(2) Useful effects
  (i) Saprotrophic bacteria cause decay of waste materials and lead to formation of humus and recycling of minerals. E.g. Bacteria (Nitrosomonas and nitrobacter) convert organically combined nitrogen (e.g. protein) to nitrate which are absorbed by plants.
  (ii) Nitrogen fixing bacteria e.g. Azobacter fix nitrogen into the soil.
  (iii) Aerobic and anaerobic bacteria are useful in digestion of sewage into harmless substances. Methane gas given off is sometimes used for fuel.
  (iv) Mutualistic bacteria in ruminants' assist ruminants to digest cellulose, and synthesis of vitamin K and B group.
  (v) Some bacteria on the skin of humans enable it to obtain protection again inversion of pathogenic organism
  (vi) Bacteria and fungi are useful for making of cheese.
  (vii) Used for production of useful chemicals in genetic Engineering such as insulin

Effects of Light on organisms

1. **Effect of light on protoplasm**: sun rays may penetrate such covers and cause excitation, activation, ionization and heating of protoplasm of different body cells. Ultraviolet rays are known to cause mutational changes in the DNA of various organisms.

2. **Effect of light on metabolism:**
   The metabolic rate of different animals is greatly influenced by light. The increased intensity of light results in an increase in enzyme activity, general metabolic rate and solubility of salts and minerals in the protoplasm. Solubility of gases however, decreases at high light intensity. Cave dwelling animals are found to be sluggish in their habits and to contain slow rate of metabolism.

3. **Effect of light on pigmentation:**
   Light influences pigmentation in animals. Cave animals lack skin pigments. If they are kept out of darkness for a long time, they regain skin pigmentation. The darkly pigmented skin of human inhabitants of the tropics also indicate the effect of sunlight on skin pigmentation. The skin pigment's synthesis is dependent on the sunlight.

   Light also determines the characteristic patterns of pigments of different animals which serve the animals in sexual dimorphism and protective colouration. Animals that dwell in the depths of the ocean where the environment is monotone, though pigmented do not show patterns in their colouration.

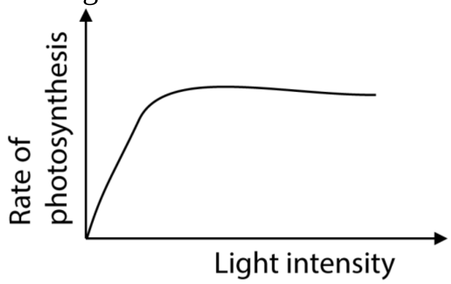
4. **Ef**fect **of light on animal movements:**
   Some animals move in response to light light called phototaxis. Positively phototactic animals such as Euglena, move towards the source of light, while negatively phototactic animals such as planarians, earthworms, slugs move away from the source of light.

5. Growth response such as phototropism

6. **Photoperiodism and biological clocks:**
   Regularly occurring daily cycles of Light (day; and darkness (night) have been known to exert a profound influence on the behavior and metabolism of many organisms. Underlying such environmental rhythms of light and darkness are the movements of the earth relative to the sun and the moon.

Exercise

1. The figure below shows the rate of photosynthesis against light intensity



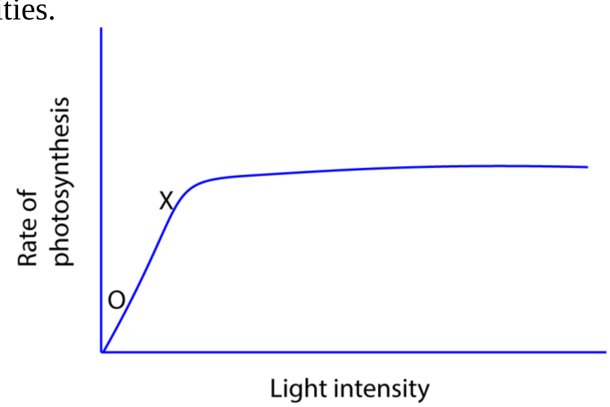
Which one of the following statement is the cause of the flattening of the curve?

A Photosynthetic pigments are saturated
B Too much carbon dioxide is available
C The plant has attained its maximum rate of photosynthesis
D There is a factor other than light which is limiting photosynthesis

2. Which of the following does not occur during photorespiration?

A Oxygen is used up
B Wasteful loss of carbon as carbon dioxide
C Carbon dioxide is used up
D Wasteful loss of energy

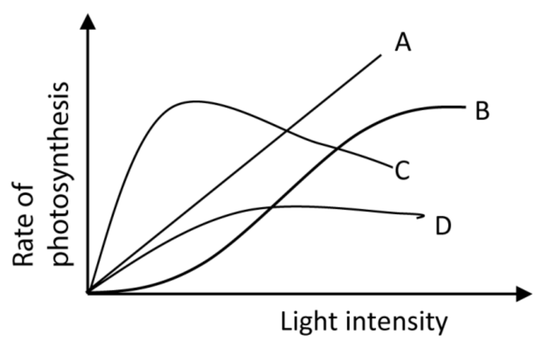
3. The graph below shows the rate of photosynthesis at different light intensities.



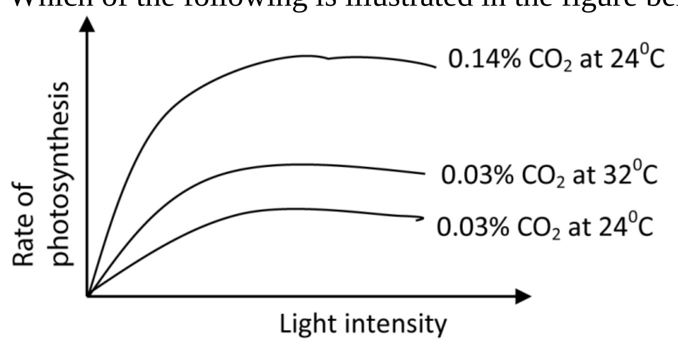
The factor limiting the rate of photosynthesis between O and X is

A Light intensity
B Carbon dioxide.
C Temperature
D oxygen

4. C3 are less efficient than C4 plants in fixing carbon dioxide at low carbon dioxide and high oxygen partial pressure because
   A. C3 plants use more energy
   B In C3 plants, energy is lost
   C RuBP carboxylase is inactivated by high oxygen partial pressure
   D PEP carboxylase has high affinity for oxygen.
5. Photorespiration does not occur in C4 plants because they
   A Use phosphenol pyruvic acid for fixing carbon dioxide
   B Mainly grow at high altitudes
   C Are more abundant in cold region
   D Have succulent leaves which lower the internal temperature
6. Photosynthetic bacterial differ from green plants in that
   A They lack chlorophyll
   B Their source of energy is through oxidation of hydrogen sulphide
   C Their source of energy is through oxidation of iron salts
   D Their source of hydrogen is hydrogen sulphide
7. Net primary productivity in C4 plants is higher than in C3 plants because
   A C4 plants have a higher turn-over rate
   B Energy accumulates at a higher rate in C4 plants
   C Photophosphorylation occurs in C3 plants
   D The rate of respiration is higher in C3 plants
8. Which one of the following curves in the figure below correctly represents plants adapted for low light intensity?



9. Which of the following is illustrated in the figure below?



A With increase in light intensity, the rate of photosynthesis increase until temperature becomes a limiting factor.
B Rate of photosynthesis increases with an increase in the carbon dioxide concentration
C With increase in light intensity, the rate of photosynthesis increases indefinitely
D. Rate of photosynthesis increases with an increase in light intensity until carbon dioxide becomes a limiting factor.

10. Which of the following is likely to occur if a photosynthesizing plant was suddenly removed from light?
A Reduction in PGA
B Accumulation of PGAL
C Accumulation of PGA
D. No change in amount of PGAL

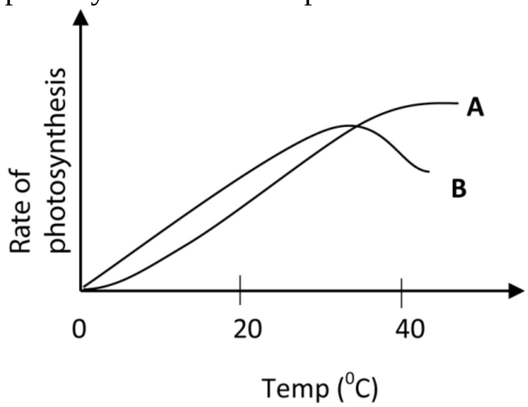
11 In which part of the following parts of a chloroplast are water splitting enzymes mostly located?
A Stroma
B. Intergrana
C Cytoplasm
D Grana

12. Etiolation in plants is usually a response to
A Insufficient nutrients
B Low temperature
C Insufficient light
D. Too much water.

13. In photosynthesis, the major advantage of the C4 pathway is to
A Fix carbon dioxide in the Calvin cycle
B Concentrate carbon dioxide in the cells of leaves
C Fix carbon dioxide from the atmosphere into the leaves
D Store carbon dioxide in form of organic acids

14 During the light stage of photosynthesis, water is important in that it
A Gives of oxygen
B Provides hydrogen that reduce NAD
C Reduces carbon dioxide to carbohydrates
D Provides electrons

15. Figure below shows the relationship between temperature and rate of photosynthesis in two species A and B.



Which one of the following is correct conclusion from the results?

A B is a shade plant while A is a sun plant

B **A** has a lower compensation point than **B**

C **A** has a higher optimum temperature for photosynthesis than B

D Photorespiration does not occur in A but occurs in B

16 Which of the minerals nutrient are constituents of chlorophyll?

A Potassium and sulphur

B Nitrogen and magnesium

C Calcium and phosphorus

D Zinc and copper

17. Photosynthetic bacteria differ from plants in their nutrition in that the bacteria

A Derive their energy from oxidation of ammonia

B Obtain hydrogen for reduction of carbon dioxide from hydrogen sulphide

C Possess chlorophyll **b** to trap sunlight

D Oxidise hydrogen sulphide to obtain energy

18. Which one of the following is the role of reduced NADP in the dark stage of photosynthesis?

A Combines with carbon dioxide

B Provide energy

C Provides hydrogen

D Acts as an electron acceptor

19. Which one of the following colours of light are most effective in photosynthesis?

A Green and red

B Blue and red

C Blue and yellow

D Blue and green

20. Which wavelength from light spectrum is mostly absorbed by green plants?

A Red

B Green

C Blue

D Yellow

21. Where in the cell dos the reduction of carbon dioxide occur during photosynthesis?

A Lamella

B Stroma

C Quatasome

D Grana membrane

22. During what stage of the dark reaction is $NADPH_2$ used? Conversion of

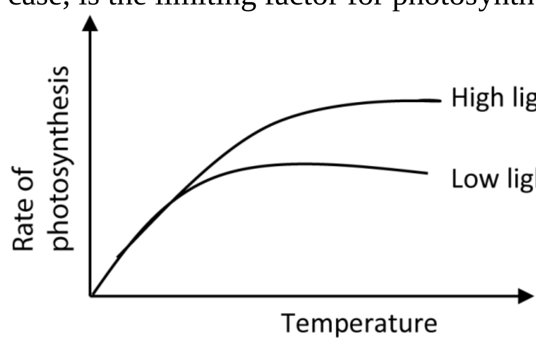
A Ribulose diphosphate to phosphoglyceric acid

B Phosphoglyceraldehyde to hexose sugar

C Hexose sugar to starch

D. Phosphoglyceric acid to Phosphoglyceraldehyde

23. The figure blow illustrates the phenomenon of limiting factors. What, in this case, is the limiting factor for photosynthesis?



A Chlorophyll content

B Temperature

C Carbon dioxide

D light

24. Which of the following occurs during the light dependent stage of photosynthesis?

A Formation of ADP

B Formation of $NADPH_2$

C Formation PGAL

D Production of $NAGP^+$

25. Which of the following pairs of reactants is not required for the light-independent reaction of photosynthesis?
A NADPH and ATP
B ATP and carotenoid
C RuBP and free oxygen
D Carbon dioxide and enzymes

26. The first carbohydrate made in photosynthesis is
A Ribose sugar
B Ribulose
C Phosphoglyceric acid
D Phosphoglyceraldehyde

27. In photosynthesis, the major advantage of the C4 pathway is to
A Fix carbon dioxide in the Calvin cycle
B Concentrate carbon dioxide in the cell of leaves
C Fix carbon dioxide from atmosphere into the leaves
D Store carbon dioxide in form of organic acid

28. During the light stage of photosynthesis, water is an important raw material in that it
A gives off oxygen
B Provide hydrogen that reduces NAD
C Reduce carbon dioxide to carbohydrate
D Provides electron

29. During water stress, photosynthesis reduces in plant mainly due to shortage of
A carbon dioxide
B mineral salts
C Water
D Sunlight

30. A close relationship between the action spectrum for photosynthesis and absorption spectrum of the chlorophylls indicate that
A All the light absorbed by the chlorophylls is used in photosynthesis
B Chlorophylls are responsible for absorption of light in photosynthesis
C Photosynthesis proceeds after light absorption
D Light energy is trapped in chlorophylls.

31. The products of light reaction in photosynthesis are
A NADH2, ATP and O2
B NADP, ATP and O2
C NADPH2, ADP and O2
D NADPH2, ATP and O2

32. Which one of the following stages of photosynthesis uses light energy directly?
A Regeneration of ribulose diphosphate
B Production of energy in the form ATP
C Reduction of carbon dioxide
D Formation of phosphoglyceric acid

33. Which one of the following is the main form of photosynthetic product transported by the phloem?

A Starch
B Amino acids
C Sucrose
D Glucose

34. The difference between a green plant and the iron bacteria in synthesis of organic compound is that

A Bacteria derive their energy for synthesis from oxidation of inorganic compounds
B Source of hydrogen for the bacteria is not water
C Bacterial have a different kind of chlorophyll
D Bacteria lack enzymes for fixing of carbon dioxide

35. Which of the following stages of photosynthesis use light energy?

A Regeneration of ribulose diphosphate
B Production of energy in form of ATP
C Reduction of carbon dioxide
D Formation of phosphoglyceric acid

36. The organism that require only inorganic raw materials from the environment is

A Virus
B Amoeba
C Euglena
D Plasma

37 If carbon containing radioactive carbon was added to a suspension of photosynthesising algae, in which one of the following compound would the radioactive carbon show first?

A Glucose
B Phosphoglyceric acid
C Ribulose bisphosphate
D Triose phosphate

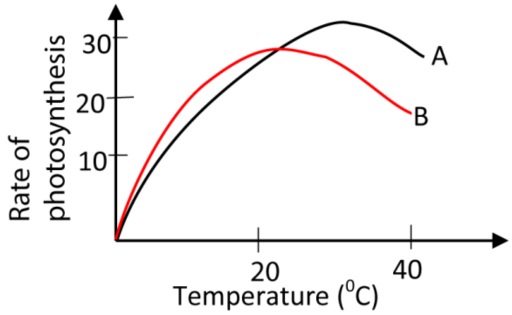
38. The table shows the effect of temperature on the rate of apparent photosynthesis and respiration in plants

Temperature (^0C)	7	10	15	19	22	28
Rate of apparent photosynthesis ($mgCO_2g^{-1}h^{-1}$)	1.3	2.3	2.8	3.1	2.8	2.5
Rate of respiration ($mgCO_2g^{-1}h^{-1}$)	0.3	0.6	0.7	1.2	1.8	2.1

The temperature in ^0C, at which the plant is least efficient photosynthetically is

A 7
B 10
C 22
D 28

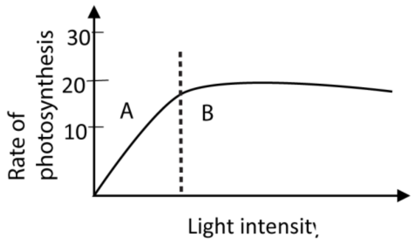
39. The figure below shows the relationship between temperature and the rate of photosynthesis in two plant species A and B.



Which one of the following is the correct conclusion from the result?

A B is a shade plant while A is a sun plant
B A has a lower compensation point than B
C A has a higher optimum temperature for photosynthesis than A
D Photorespiration does not occur in A but occurs in B

40 The figure below shows the variation of rate of photosynthesis with light intensity



The factor limiting the rate of photosynthesis in region A is

A Light intensity
B Carbon dioxide concentration
C Water
D Temperature

41 Which of the following action is most affected by low temperature?

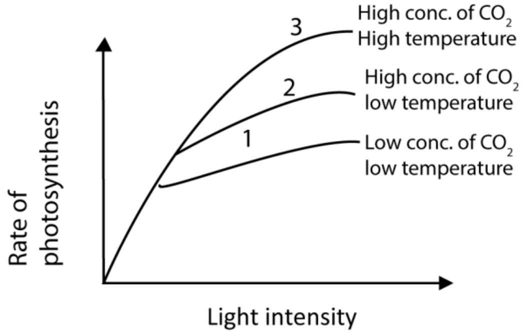
A Absorption of light

B Splitting of water

C. Fixation of carbon dioxide

D Formation of ATP

42 The figure below shows the rate of photosynthesis of a plant at varying conditions.



Which factor is limiting photosynthesis in curve 2

A Carbon dioxide concentration

B pH

C Light

D Temperature

43 Which one of the following if increased to an Eldea plant in water at 30^0Cwould lead to a rise in number of bubbles released from the plant

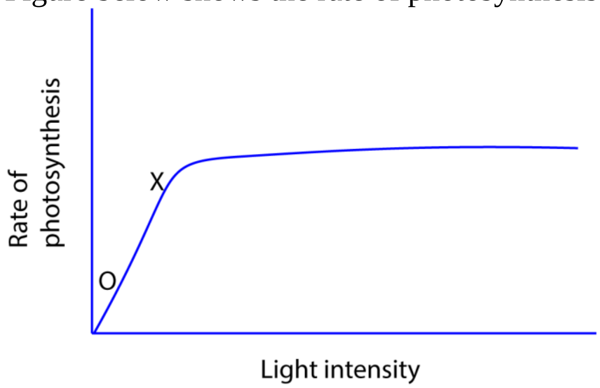
A Light

B Temperature

C Wind velocity

D. Humidity

44 Figure below shows the rate of photosynthesis against light



Which one of the following statements is the cause of flattening of the curve?

A Photosynthetic pigments are saturated with light

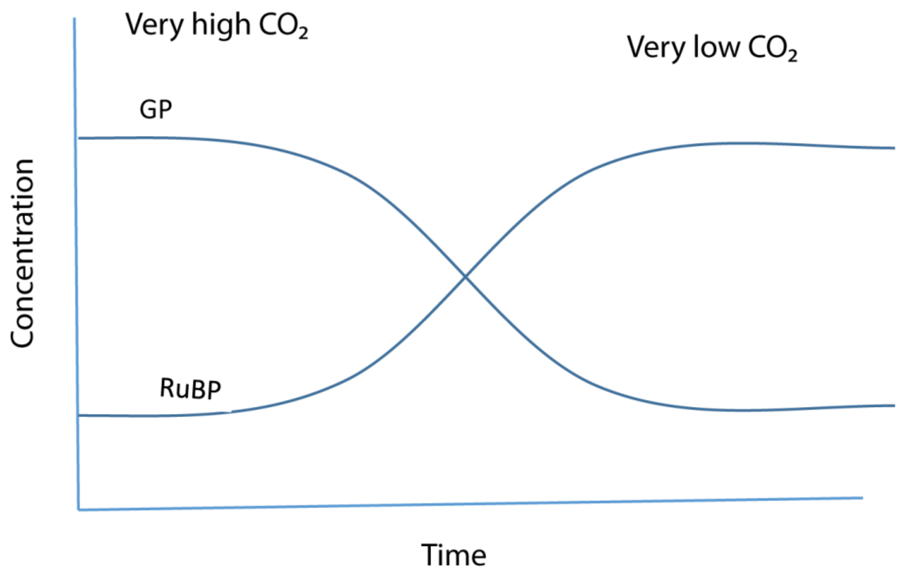
B To much carbon dioxide is available

C Plant has attained maximum rate of photosynthesis

D There is a factor other than light which is limiting the rate of photosynthesis

Structured questions

45. Figure 7 show the concentration -3 phosphate (GP) and ribulose bisphosphate (RuBP) during an investigation in which a sample of chlorella was allowed to photosynthesis at very low and very high carbon dioxide levels.

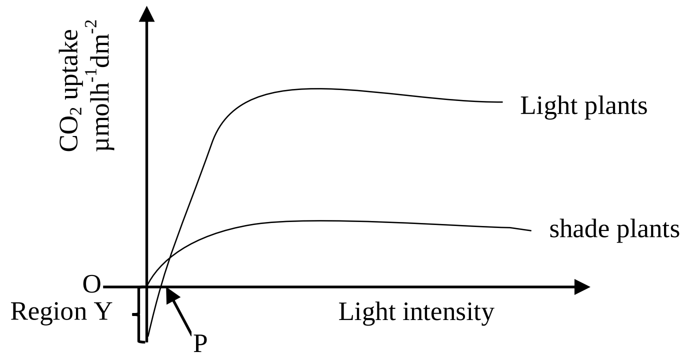


(a) Explain the change in concentration of RuBP at
(i) High carbon dioxide levels
(ii) Very low carbon dioxide levels
(b) Suggest why the concentration of GP falls when the levels of carbon dioxide is reduced
(c) Name two factors which must have been kept constant in the investigation
(d) Give **four** difference between cyclic and noncyclic photophosphorylation

46. (a) What is chemosynthesis? (1mark)

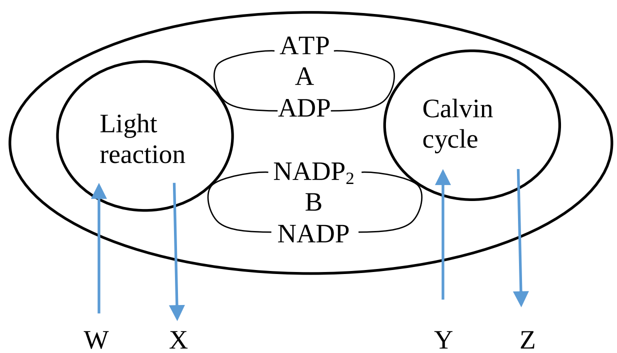
(a) Outline three ways in which photosynthesis in purple sulphur bacteria differs from that of higher plants (3marks)
(b) Explain why it is possible for photosynthetic and chemosynthetic bacteria to co-exist in an oxygen free environment? (3marks)
(c) State the importance of chemosynthetic bacteria in nature. (3marks)

47. The figure below shows light saturation curves of photosynthesis for plants of the same species growing under different light intensities.



(a) Compare the effect of intensity on the carbon dioxide uptake in the two types of plants. (4marks)
(b) Describe the state of the light plants at point P. (2marks)
(c) Explain what happens to the plant biomass in region Y. (2marks)
(d) State an environmental factor that affects the shape of the graph other than carbon dioxide (2marks)

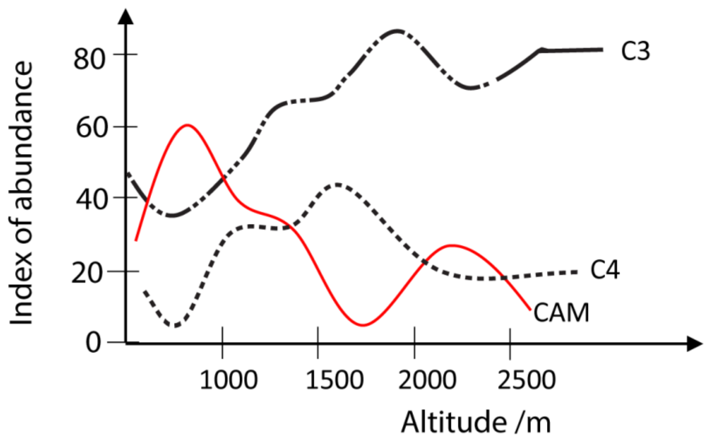
48. (a) How does the synthesis of organic compounds in photosynthetic bacterial differ from that in
   (i) Green plants (2marks)
   (ii) Chemosynthetic bacterial? (2marks)
(b) The figure below shows a scheme of reactions occurring in a chroplast during photosynthesis.



(i) Name the chemical substances represented by letters W, X, Y and Z (2marks)
W……………………………………………………………
X…………………………………………………………….
Y…………………………………………………………….
Z …………………………………………………………….
(ii) Indicate by means of arrows on the diagram, the direction of transfer of substances occurring in cycles A and B (1mark)

(c) State **three** adaptations of a chloroplast for photosynthesis. (3marks)

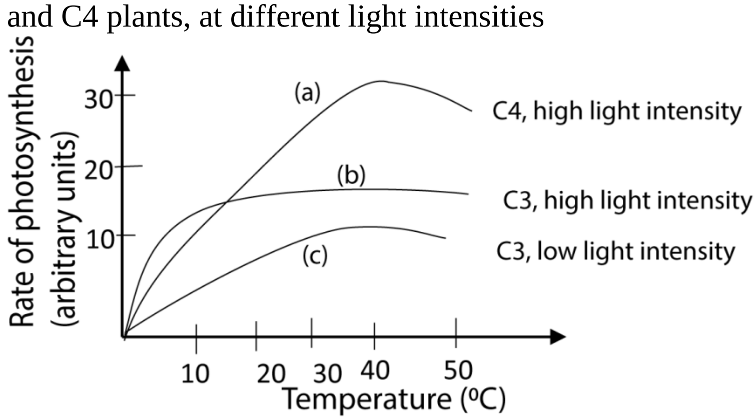
49. Figure below shows the distribution of C3, C4 and CAM plants at altitudes



(a) Suggest reasons for the trends in the distribution of each of the plants
   (i) C3 plants (2marks)
   (ii) C4 plants (2marks)
   (iii) CAM plants (2marks)

(b) State **four** physiologic differences between C3 and C4 plants (4marks)

50. The figure below shows the variation of the rate of photosynthesis with temperature in C3 and C4 plants, at different light intensities



(a) Using the figure, state how different temperatures affect the rate of photosynthesis in C3 plants from C4 plants at high light intensity. (3marks)

(b) Explain the differences in the effect of temperature on the rate of photosynthesis in C3 and C4 plants at high light intensities stated in (a) (03marks)

(c) Explain the pattern of curve C in the figure above. (04marks)

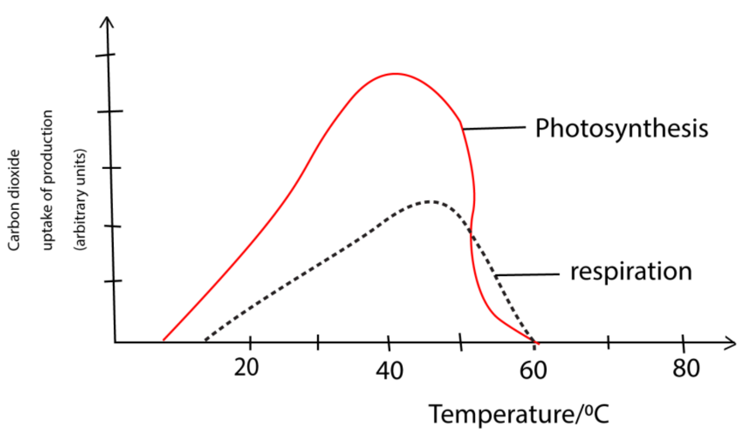
51. (a) Giving examples, differentiate between photosynthetic and chemosynthetic bacteria.
(b) Explain how certain bacteria which require light for photosynthesis, survive under weeds in ponds and rocks

52. (a) Name the two stages of photosynthesis indicating where, in the chloroplast, they occur.
(c) By means of a flow diagram, show the sequence of electron flow during noncyclic photophosphorylation.

53. (a) What is photophosphorylation? (2marks)
(b) Where in the plants cell does cyclic photophosphorylation occur (2mark)
(c) Describe the process of cyclic photophosphorylation (5marks)
(d) Importance of cyclic photophosphorylation in photosynthesis. (2marks)

54. (a) Name the organelle most important in photosynthesis and respiration
(i) Photosynthesis ……………………………………………..
(ii) Respiration …………………………………………………
(b) Give four differences and five similarities between the two organelles
(i) Differences
(ii) Similarities

55. The figure below shows the effect of temperature on the rates of photosynthesis and respiration in well illuminated leaves



(a) Compare the effect of temperature on the rates of photosynthesis and respiration. (04marks)
(b) Explain the shapes of the curves (06marks)

Paper 2

56. (a) Giving examples in each case, explain what is meant by each of the following
    - (i) Saprophytes (2½ marks)
    - (ii) Chemoautotrophs (2½ marks)

(b) Compare saprophytes and parasites (10marks)

(c) Explain the importance of saprophytism to human life (5marks)

57. (a) How is the chloroplast suited for its function? (08 marks)

(b) Describe the modification of the parenchyma tissue in different parts of a plant, to suit its function. (05marks)

(c) Explain the distribution of mechanical tissue in plants. (7marks)

58. (a) Explain how plants living under the canopy of forest trees are able to survive (15marks)

(b) Describe how herbaceous plants are supported of the ground. (5marks)

59. (a) Compare photosynthesis and aerobic respiration. (9marks)

(b) Explain the effect of low oxygen tension on

(i) C3 plants (3marks)

(ii) C4 plants (2marks)

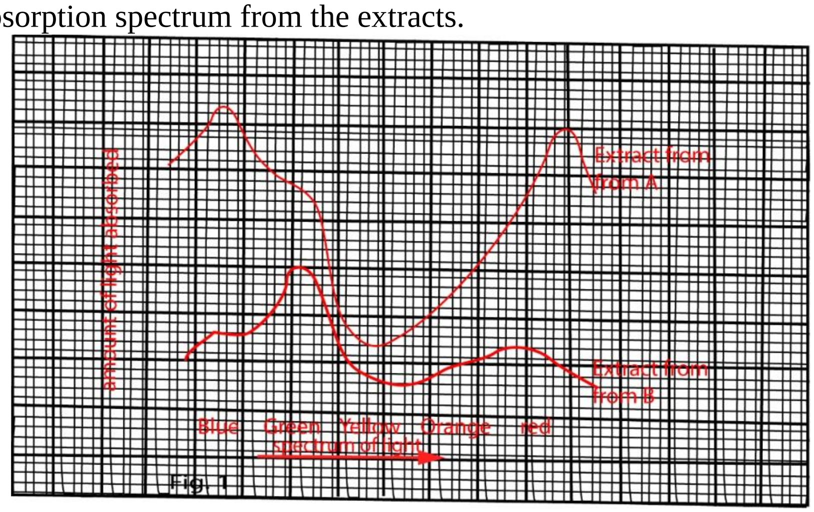
(d) Explain why c4 plants are more efficient in photosynthesis than C3 plants. (06marks)

60. (a) (i) What are chemotrophic bacteria? (1marks)

(ii) Give three groups of bacterial in (a) (i) (3marks)

(b) Using examples, explain the ecological importance of each of the groups in (a) (ii) in an ecosystem

61. (2007/2/1) Two groups of maize seed were germinated and grown in different culture solution. Group A were provided with a complete nutrient solution while group B were provided with a solution lacking magnesium. An extract of photosynthetic pigment was made from leaves of each group of seedlings at the end of three weeks. Fig 1 is the absorption spectrum from the extracts.



In another experiment, six identical shoot of pond weed were placed in separate test tube of pond water in which a dilute solution of sodium hydrogen carbonate had been added. Each test tube was exposed to light which had passed through different coloured filter. The light in all cases was from a 40 watt bulb, placed 40cm from each test tube. The time taken for 20 bubbles to leave the cut end of each shoot was recorded three times and average results were recorded in table 1

Table 1

Colour filter	Average time taken to release 20 bubbles in seconds	Number of bubbles released per minute
Violet	58	
Blue	40	
Blue-green	62	
Green	132	
Yellow	96	
Orange-red	70	

Use the information to answer the questions that follow

(a) Compare the light absorption by extracts from Group A and that of Group B across the light spectrum. (8marks)

(b) Explain the light absorption across the light spectrum for each extract. (9marks)

(c) How does a coloured filter affect light passing through it? (1mark)

(d) (i) Copy and complete Table 1, by calculating the number of bubbles released by each shoot per minute. (3marks)

(ii) Plot a graph to show the relationship between the colour of the filter and the rate at which bubbles are released. (6marks)

(e) (i) compare your graph with that in figure 1, and state the relationship between the two;

(ii) What conclusion can you draw from the relationship? (2marks)

(f) State what would be observed if the distance between the bulb and the test tubes was gradually reduced. Explain your answer. (4marks)

(g) Explain why

(i) the type of bulb and the distance of the bulb from the test tube were kept constant (1mark)

(ii) a dilute solution of sodium hydrogen carbonate was added to pond water in the test tubes. (2marks)

(iii) There were three measurements made on each shoot rather than a single one (1mark)

(iv) Measuring the rate of photosynthesis by counting bubbles in not accurate Method. (1marks)

62. In an experiment to determine the factors affecting photosynthesis, seedlings of a plant were divided into two groups and grown at a constant high light intensity (25 arbitrary units), another group grown at a constant low light intensity (3 arbitrary units). When the plants were mature, their apparent rates of photosynthesis in milligrams of oxygen released per unit leaf are per hour, were measured over a range of different light intensities

Figure 1 shows the results of the experiment. In addition, some characteristics of the two groups of plants were recorded on table 1

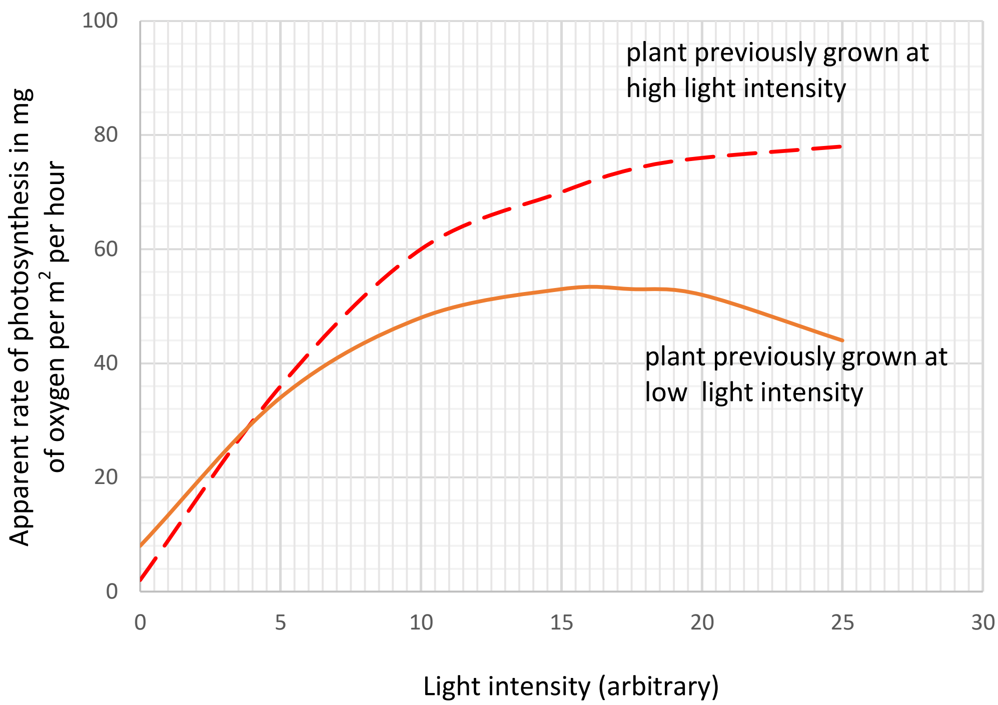


Table 1

Groups of plants	Characteristics
Plants grown at high light intensity	Big, dark green leaves with short internodes
Plants grown at low light intensity	Small, pale yellow leaves with long internodes

(a) From the graph, state
  (i) differences in the effect of light intensity on the groups of plants (8marks)
  (ii) similarities in the effect of light intensity on the two groups of plants. (3marks)
(b) Suggest explanation for the differences you have stated in (a) (i). (8marks)
(c) Explain the pattern of the curve for plants grown in low light intensity. (6marks)
(d) Explain the observed characteristics of the two groups of plants as indicated in table 1. (9marls)
(e) Suggest why:
  (i) Seedlings of the same plant were used in the experiment. (2marks)

(ii) The rate of release of oxygen was used to measure the rate of photosynthesis. (2marks)

(f) Name two factors that may limit the rate of photosynthesis of plants previously grown in high light intensity, if subjected to light intensity above 25 arbitrary units. (2mark)

63. (a) How does a bacteria cell differ from that of a higher plant? (5marks)
(b) Giving Examples, describe the different nutritional groups of bacteria. (5marks)
(c) Discus the importance of bacterial in nature. (10marks)

64. (2014/2/6)
(a) Distinguish between a bacterium and a plant (6marks)
(b) Explain the ecological significance of different nutritional types of bacteria (07marks)
(c) Explain how a leguminous plant and bacteria in nodules benefit from the relationship. (07marks)

65. (a) How are leaves modified to perform its function?

(b) Describe the importance of leaves to the plants.

66. (a) Compare photosynthesis and aerobic respiration (9marks)
(b) Explain the effect of low oxygen tension on
(i) C3 plants (3marks)
(ii) C4 plants (2marks)
(c) Explain why C4 plants are more efficient in photosynthesis than C3 plants (6marks)

67. (a) what is chemosynthesis?

(b) Outline three ways in which photosynthesis in purple sulphur bacteria differs from that of higher plants.

(c) Explain why it is possible for photosynthetic and chemosynthetic bacteria to co-exist in oxygen free environment.

(d) State the importance of chemosynthetic bacteria in nature

Answer to objective type questions

1	D	11	D	21	B	31	C
2	C	12	C	22	D	32	B
3	B	13	C	23	D	33	C
4	B	14	D	24	B	34	A
5	A	15	C	25	B	35	B
6	D	16	B	26	D	36	C
7	A	17	B	27	B	37	B
8	C	18	C	28	D	38	
9	D	19	B	29	A	39	
10	B	20	C	30	B	40	

45. **Solution**

(a) (i) The concentration of RuBP is low. This is because RuBP combines with carbon dioxide and water to form glycerate- 3 phosphate (GP).

Note:

$$RuBP + CO_2 + H_2O \xrightarrow{\text{RuBP carboxylase}} 2GP$$

(ii). The concentration of RuBP is high. This is because RUBP is being regenerated from triose phosphate, but since carbon dioxide concentration is low, RuBP is not being used hence it accumulates

(b) Carbon dioxide combine with RuBP in the presence of RuBP carboxylase to generate GP. Hence low carbon dioxide levels lead rate of formation of GP

(c). Temperature

Light intensity

(d)

Cyclic photophosphorylation	Non – cyclic photophosphorylation
• Involves cyclic pathway of electrons. • Photo system 1 is the first electron donor. • Photo system 1 is the last electron acceptor • Product is ATP only Others • Only photo system 1 is involved	• Involves non –cyclic pathway of elections. • Water is the first electron donor • NADP is the last electron acceptor • Products are ATP, reduced NADP and oxygen. • Bothe photo system 1 and 11 are involved.

Note: phosphorylation is the process by which ATP is synthesized from ADP and an inorganic phosphate using energy.

In photosynthesis the energy is supplied by light, hence the process is called photophosphorylation. It can be cyclic or non- cyclic

The ATP is formed is formed in the light-dependent stage is used to transfer energy to the light independent stage.

46. Solution

(a) Chemosynthesis is the process by which organic compounds are synthesized from inorganic raw material using energy from oxidation of inorganic compounds.

(b).

Purple sulphur bacteria	Higher plants
Source of hydrogen (reducing power) is hydrogen sulphide.	Source of hydrogen (reducing power) is water
Produce solid globules of sulphur as bi-product.	Do not produce any solid bi-product
Do not give off oxygen during photosynthesis	Give off oxygen during photosynthesis
Use bacteriochlorophyll as the pigment	Use chlorophyll as the pigment

(c) Photosynthetic bacteria release oxygen during photosynthesis, which they both use in respiration. They also produce organic compounds which are used by the chemosynthetic bacteria for metabolism.
Chemosynthetic bacteria produce inorganic substrate like hydrogen sulphide which are used by the photosynthetic bacteria in their metabolism.

(a) Chemosynthetic bacteria are important in the decomposition of nitrogenous waste in the environment and thus enrich the soil and water with nutrients.

They release energy in their metabolism that is used by other organism in synthesis of organic compounds.

They are producers manufacturing organic compounds that can be utilized by other organism.

47. **Solution:**

(a) Similarities

Carbon dioxide uptake increase initially at low light intensities and the decreases gradually at higher intensities, to reach constant valves.

Differences

Light plants	Shade plants
- Initial rate of carbon dioxide uptake is high at low light intensities - Carbon dioxide uptake starts below zero. - reach a constant at a higher light intensity. - higher saturation value	- Initial rate of uptake carbon dioxide is high at low light intensities - Carbon dioxide uptake starts at zero - reach a constant at a lower light intensity. - lower saturation value

(b) The plant is in a state of compensation point at point P. Here is no net uptake of carbon dioxide because the rate of photosynthesis equals the rate of respiration.

(c) In region Y the plant biomass decrease

Explanation

The rate of respiration of the plants is higher than photosynthesis. There is more food breakdown than synthesis.

(d) Temperature

48. **Solution**

(a) (i) The hydrogen for reducing carbon dioxide comes from hydrogen sulphide while in green plants, the hydrogen come from water.

Oxygen is not given off during the synthesis of organic compounds in photosynthetic bacteria as it is in green plants

(i) They obtain energy from sunlight while chemosynthetic bacteria obtain the necessary energy from oxidation of inorganic compounds other than sugar.

They do not give off any gaseous product during the processes while some chemosynthetic bacteria give off methane gas.

(b) (i)

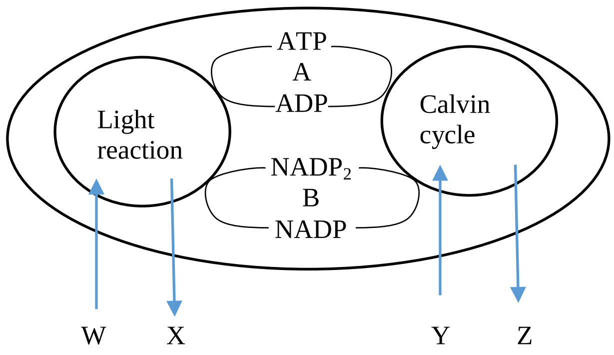
W-water

X- oxygen

Y – Carbon dioxide

Z- phosphoglyceradehyde (PGAL)

OR: carbohydrate.



[NB: The candidates should indicate the arrow on the diagram in the question.

(c) adaptation of the chloroplast for photosynthesis include

- it contains chlorophyll molecules which trap sunlight energy for use in the process of photosynthesis.
- it contains thylakoid membranes arranged into coin-like stacks called grana to increase surface area for packaging of chlorophyll molecules
- it contains enzymes necessary for fixation of carbon dioxide.

49. **Solution**

(a) (i) C_3 plants

Are more abundant at high altitude.

Reason (s)

At high altitude, the partial pressure of oxygen is lower. This reduces competition between carbon dioxide and oxygen for RUBP carboxylase enzyme and enhance carbon dioxide fixation. Thus, C3 plants are more abundant at high altitude where they can photosynthesis more efficiently at low temperature.

(ii) C_4 plant.

Are more abundant at mid-altitude levels.

Reason (s)

Since PEP carboxylase is not affect by oxygen concentration, temperature is the major limiting factor of photosynthesis in C_4 plants.

At low altitudes, temperatures are very high than at high altitude. Only moderate temperature of mid- altitude levels favour efficient photosynthesis in C_4 plant, making them more abundant there.

(iii).CAM plants.

Are more abundant at low attitudes

Reason (S)

CAM plants adapted to photosynthesizing more efficiently at higher temperatures.

Such temperature can only be experienced at low altitudes, explaining their more abundance there.

C_3 plants	C_4 plants
Carbon dioxide acceptor is RUBP First stable product is PGA Photorespiration occurs	Carbon dioxide acceptor is PEP First stable product is Oxaloacetic acid (OAA). Photorespiration does not occur.

Requires 18 ATP for the synthesis of one glucose molecule	Require 30 ATP for the synthesis of one glucose molecule.

50. **Solution**

(a) Maximum rate of photosynthesis is higher for C_4 plants than C_3 plants.

- At temperature below 10^0 C, C_3 plants have a higher rate of photosynthesis
- At temperature above 20^0 C, the rate of photosynthesis in C_3 plants is lower than that in C_4 plants.
- In C_4 plants, rate of photosynthesis is increase rapidly with temperature up to a maximum at 40^0 . for C_3 plans, rate of photosynthesis increases gradually at a decreasing rate with temperature, to a maximum about 35^0 C.

(b) In C_3 plants, plants, increase in temperature reduces the affinity of RUBP carboxylase for carbon dioxide but increase its affinity for oxygen. As a result, more CO_2 is lost and less is fixed photosynthesis.

- PEP- carboxylase's affinity for carbon dioxide in C_4 is not affected by temperature. Instead, temperature increases the rate of the enzyme action by increasing the kinetic energy of the reacting molecules and enhances the process of photosynthesis.

(c) Pattern

- Rate of photosynthesis increases gradually, until a maximum at about 35^0 C and then decreases rapidly at higher temperature.

  Explanation

- At high temperature, RUBP carboxylases gives up CO_2 and pick up O_2. CO_2 then lost in photorespiration.
- However, temperature increases kinetic energy of reactants leading to the initial gradual increase in photosynthetic rate. The rate soon reaches a maximum as the enzyme becomes denatured by high temperatures, and drops rapidly.

51. **Solution**

(a) Photosynthetic bacteria manufacture carbohydrates from hydrogen sulphide, carbon dioxide using light energy. Example is cyanobacteria

(H_2S) as electron donor instead of water

$$CO_2 + 2H_2S \longrightarrow C(H_2O) + 2S$$

They do not give off oxygen

Chemosynthetic bacteria manufacture carbohydrates from water and carbon dioxide using energy from oxidation of chemicals such as ammonia. Example is nitosomonas, iron bacteria, hydrogen bacteria

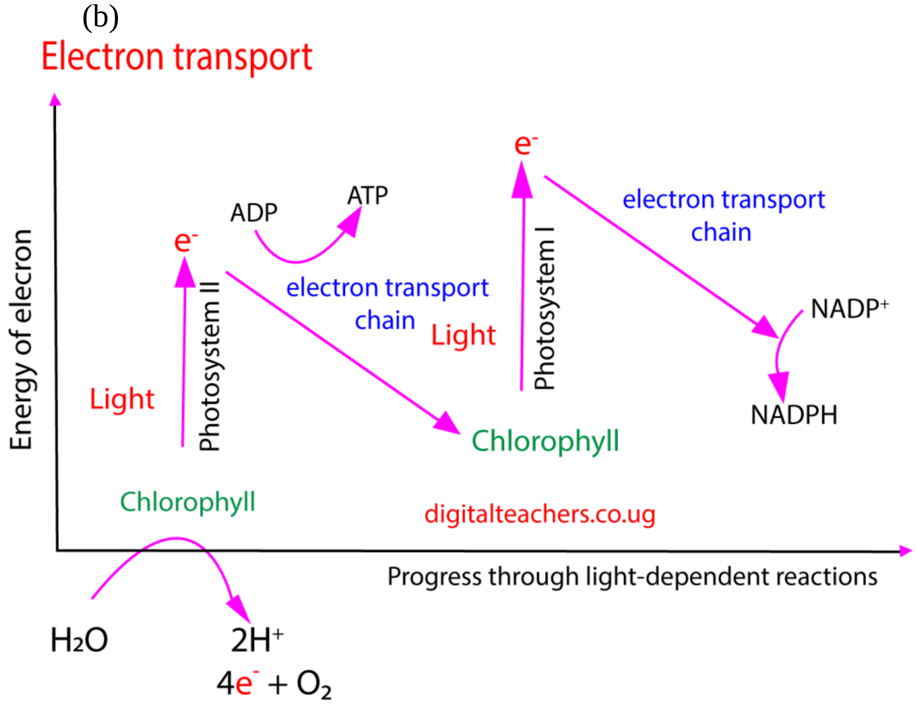
(b) The bacteria chlorophyll absorb light of different wavelengths optimum for photosynthesis from that used by the plants thus, bacteria find the spectrum useful after the plants have filtered out light for photosynthesis. Secondary, the rocks supply hydrogen sulphide.

52 **Solution**

(a)(i) light stage occurs in thylakoid membranes

(ii) dark stage occur I stroma

(b)



Non cyclic photophosphorylation

Chlorophyll molecule PSII is struck by light, an electron is excited and captured by an electron acceptor, passes through an electron carrier system and handed to chlorophyll molecule PSI

The flow of electrons from PSII to PSI in thylakoid membrane causes accumulation of H^+ inside the thylakoid space creating a gradient. The passage of H^+ out of the thylakoid provides energy to synthesise ATP.

53 **Solution**

(a) Photophosphorylation is the formation of ATP from ADP and inorganic phosphate using sunlight as the source of energy.

(b) Cyclic photophosphorylation occurs in thylakoid membranes in chloroplast.

(c) (i) Light strikes chlorophyll molecule PSI

(ii) an electron is excited, passes through electron carrier system and return to PSI

(iii) in the process, H^+ builds up in the thylakoid space creating a gradient. Then the passage of H^+ out of the thylakoid provides energy for synthesising ATP.

54. **Solution**

(a) (i) chloroplast

(ii) mitochondria

(b) (i) differences between mitochondria and chloroplast

Mitochondria	chloroplast
Has no chlorophyll	Has chlorophyll
Break down sugars	Synthesise sugars
Inner folding called cristae	Inner folding called thylakoid membranes
colourless	Green
Bean shaped	Disc shaped
Present in plants and animal	Present in plants

(ii) Similarities between chloroplast and mitochondria

- Both have circular DNA
- Both have a double membrane

- Both have extensive membrane system
- Both have a matrix
- Both produce ATP
- Both reproduce by cell division

55. (a) similarities
- In both photosynthesis and respiration, the rates increase to the maximum and then drop to zero.
- Both have equal CO_2 uptake/production at 50^0C and 60^0C.

Differences
- The rate of photosynthesis starts to rise at a lower temperature than in respiration
- The rate of photosynthesis reaches a maximum at a lower temperature (40^0C) than that of respiration (45^0C).

(b) Explanation
- In both, the rate of photosynthesis and respiration increase with temperature to the maximum because the enzymes become more active as temperature increases.
- After the maximum the rates decrease because the enzymes are denatured by high temperature.
- The maximum rate of photosynthesis are reached at lower temperature because the enzymes for photosynthesis have lower optimum temperature.
- Photosynthesis consume more carbon dioxide than produced by respiration because some sugars are stored and not respired.

56. **Solution**

(a) (i) Saprophytes are organisms which feed on dead/decaying organic matter. Examples include bacteria, fungi and protists.

(ii) Chemoautotrophs are organisms which synthesis organic matter using energy obtained from oxidation of inorganic materials such as ammonia. For example, nitrosomonas and nitrobacter

(b) Similarities

- Both are heterotrophic
- Both produce large number of offspring.
- Both have sexual and asexual phases in their reproductive cycle.
- Both have digestive enzymes.

Differences

Saprophytes	Parasites
• Derive energy from decaying organic matter • Involve a single adult stage and spores in life cycle. • Use a variety of food sources • Have simple method of nutrition • Almost totally bacteria and fungi • There are aerobic and anaerobic forms.	• Derive energy from living organisms • Involve many stages in their life cycle • Are very specific to their hosts • Have a complex method of feeding • Most plant and animal groups have representatives • Most are aerobic

(c). Saprophytism is important to human life in the following ways;

- Recycling of materials by feeding on decaying organic matter, the saprophytes unlock and recycle nutrients which would otherwise have been lost with the dead organisms.
- Decomposition of sewage or waste; saprophytes aid the decomposition of waste produced by human activities. By this the bulk of the waste is reduced and nutrients made available to crops.
- Some saprophytes, especially fungi are used as food by man.
- Physiological processes of saprophytism and as fermentation are useful in brewing and baking.
- The production of yoghurt and cheese from milk also employs saprophytic mechanisms.
- Some saprophytes are used in the production of antibiotics.
- Industrial processes such as leather tanning and production of some vitamins make use of saprophytic organisms.

57. **Solution**

(a) Adaptations of the chloroplast for photosynthesis include;

- It contains chlorophyll molecules which trap sunlight energy to be used in of photosynthesis.
- It contains thylakoid membranes arranged into coin-like stacks called grana to increased surface area for packaging of chlorophyll molecules.
- It contains enzymes necessary for fixation of carbon dioxide.
- Contain thin membrane for diffusion of gases

(b) Modification of parenchyma tissue to suit its functions.

- It forms irregular cells with storage granules and wide triangular intercellular spaces in the central pith of stems and outer cortex of stems and roots; here it functions as packaging and storage tissue.
- Due to presence of storage granules and intercellular spaces, they absorb water, become turgid and tightly packed and so provide support for the organs in which they form the main means of support.
- Parenchyma cells may have large air spaces and vacuoles to form parenchyma which is important in providing buoyancy to certain water plants.
- A system of air spaces runs from the external environment where they open as stoma (in leaves) or lenticel (in stems). These air spaces run between cells and allow gaseous exchange to take place between living cells and the external environment.

- Parenchyma cells may be flattened to form a one-cell thick layer that covers most parts of the plant as epidermis. This is usually covered with wax and helps to protect the plant from desiccation.
- Photosynthetic parenchyma, also called collenchyma, contains chlorophyll that traps light energy for the process of photosynthesis. It is usually found in the palisade layer of leaves exposed to sunlight.
- Companion cells are specialized parenchyma cells found adjacent to sieve tubes and are vital for the functioning of the latter. They are very active metabolically and how the denser cytoplasm, larger nucleus and smaller vacuoles than normal parenchyma cells denser exposed to sunlight.
-

(c) Mechanical tissues in plants constitute the tissues that are responsible for supporting the plant above the ground.

- In the non-woody herbaceous plants, parenchyma serves as the mechanical tissue. It is distributed in the cortex, pith and packing tissue in xylem and phloem. In this position they offer support to the stem when turgid and keep it above the ground.
- In woody plants, mechanical tissue consists of collenchyma and sclerenchyma which has more mechanical strength than parenchyma is located in the cortex, pith, phloem and xylem at this position, they provide enough tensile and compressional strength that allows the woody plants to withstand the stresses of the atmosphere.
- Sclerenchyma and collenchyma tissue also form mechanical tissue around the vascular bundles. This allows the vascular bundles to remain open in order to continually transport material within the plant.

58. **Solution**

(a) In this question, you should identify the problems of plants living under the canopy of the forest tress and indicate how they get round these problems in order to survive plants living under canopy of forest trees are in a light shadow and usually live in water logged soils of the forest which have less aeration**.** The following make these plants to survive successfully;

- Some have adopted a parasitic mode of life and are found developing from the stems of tall forest trees as epiphytic feeders.
- Some have climbing stems. This makes them capable of reaching out to light by growing their leaves beyond the forest canopy.
- Some have breathing roots that grow up from the water logged soils to allow for proper gaseous exchange.
- Some plants such as the ferns have tissues that are well adapted to live in the water logged soils of the forest.
- Some plants are well adapted to photosynthesize at low light intensities below the forest canopy.
- Some plants form symbiotic relationships with the forest trees and other saprophytic organisms (such as fungi) in order to obtain enough nourishment.
- Some have adopted C_4 photosynthetic pathway, making them more efficient at photosynthesis.

- Most plants have a higher chloroplast density in their leaves compared to the tall forest tress. This makes them efficient at trapping the low light that reaches them below the forest canopy.
- Some plants are more efficient at trapping and utilizing light of different wavelength from that trapped by the tall trees. Thus, they can still be able to receive this after the tall trees have trapped the rest from the light spectrum.
- Some of the plants such as the insectivorous plants are heterotrophic feeders and so require a minimum amount of light which they can sufficiently receive even below the forest canopy.
- Most plants possess an extensive surface root system in order to obtain enough aeration in the water logged forest soils.
- Most plants are seasonal, growing only when conditions are favorable.

(b) In this question you should describe support in a non-woody plant

- After the absorption of water, the cells in the plant become turgid because of the relatively inelastic cellulose cell wall. This results in a firm tissue which provides mechanical support to the plant. This is supplemented by smaller quantities of mechanical tissues (collenchyma, sclerenchyma and xylem)

59**. Solution**

(a) This question requires that you give both differences and similarities between photosynthesis and aerobic respiration.

Similarities

- Both are energy converting processes.
- Both require mechanisms for exchange of carbon dioxide and oxygen.
- Both processes have a reaction pathway in which ATP is formed i.e. photo phosphorylation and oxidation phosphorylation in photosynthesis and respiration respectively.
- Bother processes involve enzyme-controlled reactions.
- Both require special organelles in eukaryotes, chloroplasts for photosynthesis and mitochondria for respiration.
- Both processes are affected by temperature.

Differences

Aerobic respiration	Photosynthesis
A catabolic process (involves breakdown of carbohydrates into simple of sugar) inorganic compounds.	An anabolic process which results in synthesis of carbohydrate molecules from simple inorganic compounds.
Energy is incorporated into ATP for immediate use	Energy is accumulated and stored in carbohydrates
Oxygen is used up	Oxygen is released
Carbon dioxide and water are released	Carbon dioxide and water are used up
Process occurs in decrease in dry mass	Results in increase in dry mass
Process occurs in mitochondria in eukaryotes	Process occurs in chloroplast in eukaryotes
Takes place continuously throughout life and is independent of chlorophyll and light	Occurs only in cells possessing chlorophyll and only in the presence of light.

(b) (i) low oxygen tensions stimulate photosynthesis in C_3 plants

Explanation

There is reduced competition between oxygen and carbon dioxide for the active site of ribulose -1, 5-biphosphate (RUBP) carboxylase enzyme.

(ii) Low oxygen tensions have no effect on the rate of photosynthesis in C_4 plants.

Explanation

The active site of phosphoenol pyruvate (PEP) decarboxylases enzyme does not accept oxygen.

(c). The malate shunt in C_4 plants acts as a carbon dioxide pump and increase carbon dioxide concentration in the bundle sheath cells. This increases the efficiency with which PEP carboxylases reduces carbon dioxide. As a result, C_4 plants maintain high photosynthetic rates even when carbon dioxide concentration is low and stomata are nearly closed.

Since PEP carboxylase I not sensitive to oxygen concentration, photorespiration is negligible.

60. Solution (a)

(i) Chemoheterophic bacteria are bacteria which use externally obtained chemical substances as their source of food and energy. They are not capable of manufacturing their own food

(ii) (ii) examples of groups of chemoheterophic bacteria include;

- Saprophytic bacteria
- Parasitic bacteria
- Symbiotic bacteria.

(b) The importance of bacteria in the ecosystem depends on their activities in the ecosystem;

- Saprophytic bacteria derive organic materials from decomposition of dead and decaying organic matter. Examples include; putrefying bacteria. They decompose dead bodies of plants and animals and covert their complex body building compounds into simpler substances. These are taken up by green plants and used to synthesize new organic compounds. In this way these bacteria help in recycling of materials which would otherwise have been lost from the ecosystem.
- Parasitic bacteria are important in causing disease to organisms in the ecosystem. They include cocci and bacilli. They diseases that may lead to death of non- resistant organisms in ecosystem. This leads to population regulation and reduction in competition for resources in the ecosystem. It may also lead to emergency of new species in the ecosystem.
- Symbiotic bacteria live in association with other organisms, deriving benefit from the and causing no harm to them. For example, a rhizobium bacterium which lives in association with roots of leguminous plants fixes nitrogen from the atmosphere into nitrates in the soil. These can then be utilized by plants and other organisms in the ecosystem. Cellulose

producing bacteria in the gut of wood eating ants derive shelter from the ants but produce cellulose enzyme that helps the ants to utilize cellulose in their diets. They thus help in recycling of nutrients locked in the cellulose of mood.

61. **Solution (a)**

- Light absorption by extracts from both groups A and B is greater in blue, green and red light and least in yellow light across the spectrum.
- Across the spectrum, light absorption by extract from group A is greater than that from group B
- For extract from group A the order of absorption is blue > green > orange >> yellow while for extract from group B, the order of absorption is green > blue > red > orange > yellow.

(b) Extract from group A

- Chlorophyll molecules in extract from the group A are well formed because of the adequate amount of nutrients (including magnesium) and therefore capable of absorbing enough light energy for photosynthesis. Being a green molecule, chlorophyll absorbs most of the other colours of the spectrum but reflects green and yellow.

Extract from group B

- Extract from group B has inadequate amount of magnesium so that chlorophyll molecules formed are incomplete. Such molecules are less efficient in absorbing light energy for photosynthesis. The photosynthetic pigment formed is yellowish and has a poor absorption capacity for the colour of the light spectrum compared with the green pigment of the extract from group A. however it absorbs other colours of the spectrum better than yellow which is reflected.

(c) a light filter usually light of wavelength different from its own and reflects light of its own wavelength.

(d) (i) note

In it’s a shoot release 20 bubble

In $\frac{t}{60}$ min a shoot releases 20 bubbles.

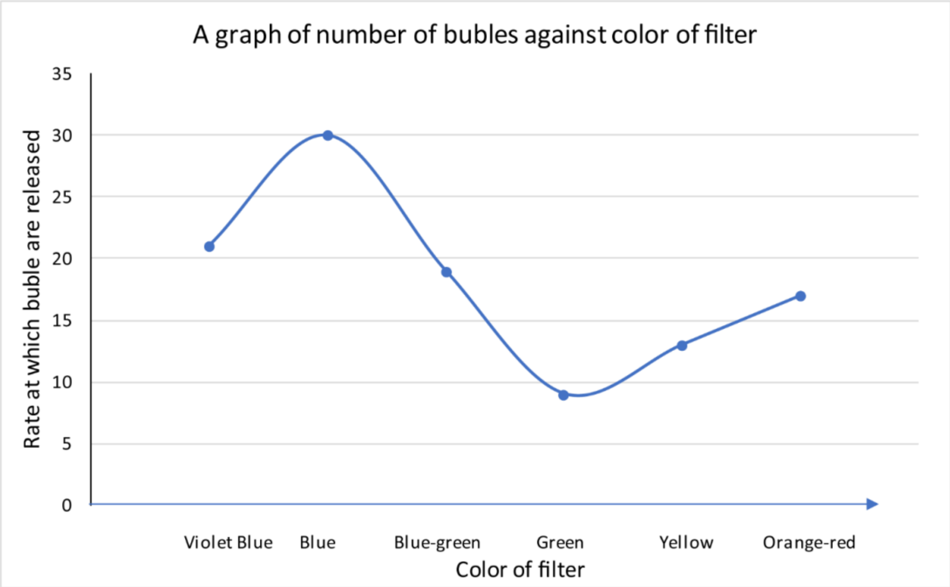
In 1 min a shoot releases 20÷ $\frac{t}{60}$ bubbles.

$\frac{20\times60}{t}$ for a violet filter, for example

No. of bubbles released per minute=$\frac{20\times60}{58} = 20.7 \approx 21$

The other values in the table can be determined in the same way,

Colour of filter	Average time taken to release 20 bubble in seconds	Number of bubbles released per minute
Violet	58	21
Blue	40	30
Blue-green	62	19
Green	132	9
Yellow	96	13
Orange red	70	17



(e) (i) In both graphs, the absorption of light is higher in the violet-blue and orange ranges and minimum in the green-yellow-range of the light spectrum.

Relationship

- Violet-blue and orange-red ranges of the spectrum favour the process being investigated better than the other colours.
- Chlorophyll absorbs light well in the violet and orange red regions of the spectrum which energy is used in photosynthesis.

(f) The number of bubbles produced per minute would increase and then reach a maximum and become constant rate.

(g) (i) to maintain a constant temperature and light intensity received by the test tube.

(ii)To produce carbon dioxide that is used by the plants during photosynthesis.

(iii) Growth of a leaf is not uniform in all dimensions. Therefore, measurement of growth by leaf length would give inaccurate results but an average is quite more representative of overall growth.

Bubbles represent oxygen produced as a bi-product of the process. Since some of the oxygen produced is used up in respiration, the bubbles are not a clear representation of the actual rate of oxygen production

62. **Solution**

(a)(i) Differences

Plants previously grown at low light intensity	Plants grown at high light intensity
Photosynthetic rate is generally lower	Photosynthetic rate is generally high
Photosynthetic rate reduces at high light intensities	Photosynthetic rate increases and peaks at higher light intensities
Optimum light intensity for photosynthesis is lower	Optimum light intensity for photosynthesis is higher
Photosynthetic rate reaches a peak at lower light intensity	Photosynthetic rate reaches a peak at higher light intensity
Peak photosynthetic rate lower	Peak photosynthetic rate higher
Photosynthetic rate is higher at lower light intensities.	Photosynthetic rates are lower at low light intensities
Increase in photosynthetic rates with light intensities is gradual	Increase in photosynthetic rate with light intensities is rapid

(iii) Similarities

a. Increase in light intensities cause increase in photosynthetic rate at lower light intensities in both cases
b. In both there is optimum light intensity at which photosynthetic rates remain constant called the peak photosynthetic rate.
c. In both groups, photosynthetic rate is low at lowlight intensity

(b) Explanation for the differences

a) Plants grown previously at high light intensity generally have high rate of photosynthesis because are well adapted to trapping and utilization of light energy for photosynthesis than those previously grown at low light intensity, i.e.

- They have more chloroplasts for trapping sunlight energy.
- Have high stomata density to increase the rate of gaseous exchange and prevent overheating at higher light intensity
- Has much carotenoid to prevent damage to chlorophyll from very bright light.

Plants previously grown at low light intensity have high photosynthetic rate because

- Its enzyme have low optimum temperature
- Has thin leaves to maximize light penetration
- Long internodes exposes each leave to light
- Low stomata density reduces heat low to avoid over cooling.

(c) Initially the of photosynthesis increase with temperature (0.5 -4 unit light intensity), because increase in light intensity increases the rate excitation of electrons from PSI and PSII leading to production of ATP and NADPH for the dark reaction.

The rate of photosynthesis then slows up because other factors other than light (such as amount of chlorophyll) limit the rate.

The rate of photosynthesis then drops because at very high light intensity, high temperature denatures the photosynthetic enzymes.

(d) Plants previously grown at low light intensity have

- Have pale leaves because they have density of chlorophyll
- Have small leaves are due to low rate of photosynthesis producing less nutrient to build structures
- Long internodes to allow increase in length to search for light.

Plants previously grown at high light intensity

- Have dark leaves due to high density of chloroplast
- Have broad leaves due to available nutrients from photosynthesis
- Broad leaves to provide large surface area to trap light

(e) (i) to minimize errors due to genetic composition

(ii) oxygen is easier to quantify.

(f) – temperature

- Chlorophyll
- Carbon dioxide concentration

63. (a) differences between bacteria cell and higher plant cell

Bacterial cell	Plant cell
Independent single celled organism	Is the structural and function unit of plant
Prokaryotic cell	Eukaryotic cell
Cell wall made of murine	Cell wall made of cellulose
Has no membrane bound nucleus	The nucleus is double membrane
Respiration occurs in mesosome	Respiration occurs in mitochondria
DNA single strand	DNA double strand
Ribosome 70S	Ribosome 80S
Lack chlorophyll	Has chlorophyll
Lacks vacuole	Has permanent vacuole
Sexual reproduction by conjugation	Sexual reproduction by fusion of gametes
Small in size	Big in size

(b) Nutritional groups of bacteria

No.	Nutritional type	Source of energy	Source of carbon	Source of hydrogen	examples
1	Photoautotrophs	Sunlight	CO_2	H_2S	Green sulphurbacteria
2	Photoautotrophs	sunlight	CO_2	H_2O	cyanobacteria
3	photoheterotroph	Light	Organic compounds	Organic compounds	Purple non sulpur bacteria
4	Chemoautotrophs	Inorganic compounds such as NH_3, NO_2, H_2, H_2S	CO_2	H_2O	Nitrifying bacteria, nirobacter
5	heterotrophs	Organic compound	Organic compounds		Most bacteria

(c) Importance of bacteria

(3) Harmful effects

(a) Bacteria are agents of disease of animals and plants such as syphilis, cholera, tetanus
(ii) Bacteria cause milk and food deteriorate
(iii) Denitrifying bacteria such as Thiobacillus lead to deterioration of soil fertility.

(4) Useful effects

(i) Saprotrophic bacteria cause decay of waste materials and lead to formation of humus and recycling of minerals. E.g. Bacteria (Nitrosomonas and nitrobacter) convert organically combined nitrogen (e.g. protein) to nitrate which are absorbed by plants.
(ii) Nitrogen fixing bacteria e.g. Azobacter fix nitrogen into the soil.
(iii) Aerobic and anaerobic bacteria are useful in digestion of sewage into harmless substances. Methane gas given off is sometimes used for fuel.
(iv) Mutualistic bacteria in ruminants' assist ruminants to digest cellulose, and synthesis of vitamin K and B group.

(v) Some bacteria on the skin of humans enable it to obtain protection again inversion of pathogenic organism
(vi) Bacteria and fungi are useful for making of cheese.
(vii) Used for production of useful chemicals in genetic Engineering such as insulin

64. (a) **Solution**

Differences between bacteria and cell

bacterium	Plant
Unicellular organism	Multicellular organism
Nuclear membrane absent	Nuclear membrane present in all cells
DNA is circular and lies free in the cytoplasm	DNA is linear and contained in a nucleus
Membrane bound organelles absent	Membrane bound organelles present
DNA is naked	DNA is associated with proteins to form chromosomes.
Ribosomes are smaller (70S	Ribosomes are larger (80S)
Ribosomes lie free in the cytoplasm	Ribosomes may be attached to endoplasmic reticulum
Mitochondria absent. Respiration carried out by mesosomes	Mitochondria are responsible for aerobic respiration
When present, cell wall is the non-cellulose type, composed of amino sugars and muramic acid.	The cell wall is composed of cellulose

(b) Chemo-heterotrophic bacteria use chemical substance obtained externally as their source of food and energy. They are of vital ecological importance depending on their activities in the ecosystem as illustrated;

- Saprophytic bacteria; these derive organic materials from dead decaying organic matter.

Examples include, putrefying bacteria. These bacteria are the main organisms to decay. They decompose dead bodies of plants and animals and covert their complex compounds into simpler substances which are taken up by green plants for the synthesis of new complex organic compounds, in this way, these bacteria help in the cycling of matter which would otherwise have been lost from the ecosystem.

- Symbiotic bacteria; several bacteria are found in nature in symbiotic relationship with man and other animals. Cellulose-producing bacteria in the gut of wood-eating ants offer the best example. In exchange for shelter provided by the ants, these bacteria help to produce cellulose enzyme that helps these organisms to utilize cellulose in their diet. As a result, they help in recycling of nutrients locked in the cellulose of wood. Also the bacterium, rhizobium, fixes nitrogen in a symbiotic association with roots of leguminous plants such as peas and beans. This increases the nitrate content of the soil and can be utilized by organisms in the ecosystem.
- Parasitic bacteria; these are important in causing disease to organisms in the ecosystem. Examples include; cocci and bacilli. By causing disease, they may lead to death of some non-resistant organisms in the ecosystem leading to population regulation and reducing competition for resources in the ecosystem.

Chemo autotrophic bacteria are more commonly known as chemosynthetic bacteria. They use carbon dioxide as the source of carbon but obtain their energy from chemical reactions. Examples include nitrifying bacteria (nitrosomonas, nitrococcus and nitrobacter), iron bacteria, hydrogen bacteria etc. they enrich the soil with nitrogen through their oxidative reactions.

Photo autotrophic bacteria are also referred to as photosynthetic bacteria. They use sun light energy as their source of energy and carbon dioxide as the source of carbon. They are important in introducing oxygen to the atmosphere and also providing organic materials for heterotrophic micro-organisms in the environment.

(c) The roots of leguminous plants often have nodules in which are numerous rhizobium bacteria. The two organisms live together in mutualistic relations, i.e, both organisms benefit and none is harmed.

- The leguminous plant provides water, shelter, protection and nutrients (organic and inorganic) to the bacteria.
- The rhizobium bacteria have the ability of fixing nitrogen, in the form of nitrates into the soil from the atmosphere. The nitrates are absorbed and utilized by the leguminous plant.

65 (a) Modification of leaves to their functions

(i) Flattened surface to reduce diffusion distance
(ii) Shiny waxy cuticle to reduce water loss
(iii) Mosaic arrangement to increase light absoption
(iv) modified into tendrils to support weak climbing stems e.g. Gloriosa, peas
(v) Some leaves are modified into spine in order to reduce water loss. Spines also protect the plant from herbivorous animals
(vi) Some leaves are modified into scale leaves (thin, membranous, dry colorless structures) for protection. E.g. onion outer leaves
(vii) **Phyllode :** It is a green, expanded structure formed by the modification of petiole or rachis of leaf. Many xerophytes reduce the size of their leaves to minimize water loss. Such plant develop phyllodes to carry out photosynthesis e.g., *Acacia*, *Melanoxylon* and *Parkinsonia*.
(viii) Some leaves are flesh to store water and food
(ix) Some leaves develop vegetative bud for reproduction, e.g. bryophyllum
(x) In some rootless, aquatic plants, the submerged leaves are modified into root like structure to absorb water and mineral salts. Such modified leaves are called absorbing leaves. e.g., *Utricularia*.
(xi) Some leaves are brightly colored to attract insect pollinator, e.g. Bougainville
(xii) Some leaves are modified to trap insects.

(b) **Functions of the leaves**

(i) Carry out photosynthesis with subsequent production of organic materials
(ii) Carry out gaseous exchange through the stomata
(iii) Transpiration takes place mainly through the leaves resulting in the cooling of plant and absorption of mineral salts and water
(iv) Some leaves such as those of peas are modified by tendrils for support.
(v) Some leaves suck those bryophyllum are modified for storage
(vi) Some leaves such as for bryophyllum are modified for vegetative reproduction
(vii) Some leaves possess itching hairs, thorns, spikes and poisonous substances for protection of plant.
(viii) Some leaves e.g. Venus fly trap are modified for capturing and extracting nitrogen from animals
(ix) Some produce substances that kill parasites.

66. Solution

(a) This question requires that you give both differences and similarities between photosynthesis and aerobic respiration.

Similarities

- Both are energy converting processes.
- Both require mechanisms for exchange of carbon dioxide and oxygen.
- Both processes have a reaction pathway in which ATP is formed i.e. photo phosphorylation and oxidation phosphorylation in photosynthesis and respiration respectively.
- Bother processes involve enzyme-controlled reactions.
- Both require special organelles in eukaryotes, chloroplasts for photosynthesis and mitochondria for respiration.
- Both processes are affected by temperature.

Differences

Aerobic respiration	Photosynthesis
A catabolic process (involves breakdown of carbohydrates into simple of sugar) inorganic compounds.	An anabolic process which results in synthesis of carbohydrate molecules from simple inorganic compounds.
Energy is incorporated into ATP for immediate use	Energy is accumulated and stored in carbohydrates
Oxygen is used up	Oxygen is released
Carbon dioxide and water are released	Carbon dioxide and water are used up
Process occurs in decrease in dry mass	Results in increase in dry mass
Process occurs in mitochondria in eukaryotes	Process occurs in chloroplast in eukaryotes
Takes place continuously throughout life and is independent of chlorophyll and light	Occurs only in cells possessing chlorophyll and only in the presence of light.

(b) (i) low oxygen tensions stimulate photosynthesis in C_3 plants

Explanation

There is reduced competition between oxygen and carbon dioxide for the active site of ribulose -1, 5-biphosphate (RUBP) carboxylase enzyme.

(ii) Low oxygen tensions have no effect on the rate of photosynthesis in C_4 plants.

Explanation

The active site of phosphoenol pyruvate (PEP) decarboxylases enzyme does not accept oxygen.

(c). The malate shunt in C_4 plants acts as a carbon dioxide pump and increase carbon dioxide concentration in the bundle sheath cells. This increases the efficiency with which PEP carboxylases reduces carbon dioxide. As a result, C_4 plants maintain high photosynthetic rates even when carbon dioxide concentration is low and stomata are nearly closed.

Since PEP carboxylase I not sensitive to oxygen concentration, photorespiration is negligible.

67 Solution

Chemosynthesis is the process by which organic compounds are synthesized from inorganic raw material using energy from oxidation of inorganic compounds.

(b).

Purple sulphur bacteria	Higher plants
Source of hydrogen (reducing power) is hydrogen sulphide.	Source of hydrogen (reducing power) is water
Produce solid globules of sulphur as bi-product.	Do not produce any solid bi-product
Do not give off oxygen during photosynthesis	Give off oxygen during photosynthesis
Use bacteriochlorophyll as the pigment	Use chlorophyll as the pigment

(c) Photosynthetic bacteria release oxygen during photosynthesis, which they both use in respiration. They also produce organic compounds which are used by the chemosynthetic bacteria for metabolism.

Chemosynthetic bacteria produce inorganic substrate like hydrogen sulphide which are used by the photosynthetic bacteria in their metabolism.

(e) Chemosynthetic bacteria are important in the decomposition of nitrogenous waste in the environment and thus enrich the soil and water with nutrients.

They release energy in their metabolism that is used by other organism in synthesis of organic compounds.

They are producers manufacturing organic compounds that can be utilized by other organism.