PROPOSED ANSWERS TO THE GRAND ANNUAL UMSSN A'LEVEL BIOLOGY SEMINAR QUESTIONS 2023

HEARTFELT SUCCESS

1. a) **Gross primary productivity** refers to the total amount of energy that primary producers capture through photosynthesis **per unit area per year**. It refers to the rate at which primary producers convert inorganic substances into organic substances using solar energy. It is expressed in **kcal/m^2/year**.

Net primary productivity refers to the amount of energy or biomass that remains available to primary producers and for growth and development after accounting for or subtracting the energy used during cellular respiration/it is the rate of organic matter accumulation minus the amount of energy expended in own metabolic processes.

b) i) Increase in leaf area index from 1cm^2/cm^2 to 3cm^2/cm^2 caused/led/resulted into a rapid increase in gross primary productivity. Further increase in leaf area index from 3cm^2/cm^2 to 7cm^2/cm^2 then caused a gradual increase in GPP. Increase in leaf area index from 7cm^2/cm^2 to 10 cm^2/cm^2 then caused GPP to remain almost constant to the maximum.

ii) Increase in leaf area index from 1cm^2/cm^2 to 5cm^2/cm^2 caused a rapid increase in NPP. Increase in leaf area index from 5cm^2/cm^2 to 6cm^2/cm^2 then caused a gradual increase in the GPP to a peak. Further increase in leaf area index from 6cm^2/cm^2 to 10cm^2/cm^2 then caused a gradual decrease in NPP.

c) (i) From 1cm^2/cm^2 to 3cm^2/cm^2, GPP increased rapidly while NPP increased gradually. This is due to leaf area being significantly limiting, so an increase causes a significant increase in surface area over which light is captured increasing greatly photosynthesis and NPP increases at a slower rate because less energy is used during cellular respiration which respiratory costs increase with leaf area so as to maintain the metabolic demands of more leaf tissues.

(ii) GPP increases gradually as NPP decreases gradually partly due to **self-shading** or **intra-plant competition for light** which reduces rate of photosynthesis for the shaded leaves in relation to respiration which increases more due to more metabolizing tissues not corresponding to their demand by the more leaf tissues not corresponding to their supply hence restricting photosynthesis rate and decreasing NPP.

As the GPP gradually increases further with increase in leaf area index, NPP gradually decreases due to **water supply and temperature limitations** due to shading (of lower leaves) which reduces rate of photosynthesis despite the increasing respiratory demands of more formed leaf tissues.

d) (i) Pests feeding on crops have to be controlled to prevent reduction in leaf area index which is associated with lower NPP which implies **less energy available for the consumers** and poor plant growth and dev't. The feeding pests also damage the leaves and cause infections both of which **increases respiratory demands** to effect repair, regeneration and healing which reduces NPP hence available energy for the consumers, growth and dev't of the plants/crops;

(ii) Herbivores consume some leaves keeping the leaf area index at **optimum** to prevent leaf shading and to reduce respiratory demands, which maintains a **high** GPP and NPP of the plant; once the herbivores are not regulated, they can over consume the leaves, which further reduces the leaf area index and reduce both NPP and GPP;

(iii) When pruning, it is important to **remove old less productive leaves and branches**; which increase respiratory demands without increasing photosynthesis so as to redirect respiratory energy to productive parts; it is also important **to remove the excess shading leaves**; to reduce the leaf area index which limits NPP; During pruning, it is also important to reduce stress on the plant so as to reduce respiratory energy expenditure in repair which reduces NPP;

It is also important **not to over reduce the overall leaf area index** since it is associated with low NPP hence poor growth, development and food storage for consumers; pruning timing should also be synchronized with seasons whose conditions favor photosynthesis for increased NPP, growth, development and food storage;

Damage to plant parts and use of clean tools to prevent infections should also be considered to reduce respiratory metabolism demands and subsequent NPP reductions;

Also the plant species being pruned as a key consideration since not all of them regenerate/repair to enhance NPP;

(e) Plants grown in green houses **experience controlled environments** which maximize photosynthesis and generally control respiratory demands; **the temperature in the green house is maintained at optimum range**

throughout the year to effect maximum photosynthesis and maintain high NPP; **the greenhouses humidity is also always at optimum** to reduce water stress and promote NPP; being an enclosure, **green houses are protected from pests and diseases** which minimizes respiratory energy expenditure for repair and healing hence increases NPP; **greenhouses use transparent covers and artificial light to avail the plants with constant reliable light supply** needed for high NPP; the reliable nutrients supply, water management and low O2 supply to minimize photorespiration and nourish plants increases NPP; **greenhouses are associated with enhanced CO2 supply** needed to be fixed into organic matter hence increased NPP.

2. a) Species diversity is a measure of biodiversity; using **two components of species richness** which is the number of different species in an area, and **Species abundance/ species evenness** which is the proportion of individuals of each species in a community.
b) A study area is selected ensuring that it represents the larger population or ecosystem of interest. Appropriate size of quadrat frame is chosen; usually a 1m x1m square frame. Random locations within study area are selected to place quadrats. The quadrats are placed at each of these appropriate locations within the study area. The number of individuals of a species, or species within each quadrat is counted and recorded. This count represents the abundance or density of the species or organisms within that specific area. The average abundance or density of the species across all the quadrats is calculated by summing the counts from all quadrats and dividing by the total number of quadrats.
c) The proportion of marked to unmarked individual in the second sample is the same as the proportion of marked to unmarked in the whole population; The marked individuals released from the first sample distribute themselves evenly among the remaining population and have sufficient time to do so; The population has a definite boundary such that there are no migrations; There are few deaths and births if any within the population. The method of marking is not toxic to the individual nor does it make the individual more conspicuous and therefore more liable to predation; The mark or label is not rubbed off or lost during the investigation.

3. a) Genetic code refers to instructions contained in a gene that guide a cell on how to make a specific protein. The genetic code is held in sequence of bases along the DNA molecule. Sections of DNA called citrons contain the information needed to make a polypeptide chain and is transmitted through messenger RNA.
b) The genetic code consists of the sequence of nitrogenous bases i.e. adenine, guanine, cytosine and uracil on the messenger RNA molecule. The four bases make up the letters of the genetic code ie A, G, U and C. Messenger RNA is translated in from the cytoplasm of a cell during which transfer RNA reads its nitrogenous bases as triplets.
The genetic code is universal whereby all known living organisms use the same genetic code. It is punctuated with a start and a stop. Polypeptide synthesis is usually initiated by the codon AUG specifying methionine which is usually the first amino acid in the polypeptide chain being synthesized. Synthesis ends when the ribosome reaches the stop codons UAA, UAG or UGA which do not specify any amino acid.
During translation, the genetic code is non- overlapping, where each base is part of only one triplet codon.
The genetic code is also degenerate; there are more codons than amino acids and therefore most amino acids are coded for by more than one codon.
The code is non-ambiguous whereby a given triplet code/codon only specifies a single kind of amino acid.

c) ER captures the selected protein from the cytosol, translocated into ER lumen where chain undergoes part of the posttranslational modification; involving enzymatic cleavage of peptide bonds/ proteolytic cleavage to remove some portion, and covalent additions of particular chemical groups e.g. phosphorylation, acetylation, methylation, carbohydrate addition/ glycosylation, lipidation,
Golgi apparatus receives chains from ER via a transport vesicle, further sorting and processing them for transport to their eventual destinations/lysosomes/ plasm membrane/ secretion via vesicles that bud off them.
Proteins are received in clusters of fused vesicles at the cis-cisternae/cis face/side of dictyosome closest to ER, by these vesicles fusing with cis-cisterna membrane delivering their contents into its lumen where they are

partly modified. The proteins progress to the golgi stack/ median-cisternae, where enzymes further modify the proteins into functional molecules modifying/folding the chain into a specific 3-D configuration/3^{o} structure; or coiling it into a 2^{o} structure. Coated vesicles then pinch off the medial-cisternae and fuse with the membrane of trans-cisterna/ part of dictyosome furthest from ER where sorting / tagging/ marking of the molecules occurs into different transport vesicles to their destination such as lysosome, cell membrane or for exocytosis/secretion

4. a) (i) The close similarity between the two curves shows that the wavelengths absorbed by the pigments lead to the most efficient rates of photosynthesis by the bean leaves.
(ii) The leaf is green because wavelengths in this region of the spectrum, about 540-560 nm, are least strongly absorbed by the leaf; implying that these light wavelengths are (mostly) reflected.
b) The absorption spectrum at 490 nm in graph B shows that **carotene is the pigment absorbing light**. The action spectrum in graph A shows that photosynthetic efficiency is relatively lower here than at any point in the spectrum. **Carotene is, therefore, not so efficient at using this light energy for photosynthesis**. It, in fact, passes the energy on to chlorophyll.
c. (ii) The graph shows that the compensation point for species A is reached at a light intensity of 1%, whereas the compensation point for species B occurs at a corresponding value of 6%. This indicates that species A is able to **carry out photosynthesis faster at lower light intensities than species B** (i.e. up to a light intensity of 30% of mean noon sunlight). Beyond light intensities of 30% mean noon sunlight, species B has a much higher rate of photosynthesis.
From the data given, **species A would appear to be a 'shade species'** and thus be physiologically adapted to make efficient use of low light intensities. **Species B would appear to be a 'sun species'** and adapted to make efficient use of high light intensities. Species A is unable to increase its rate of photosynthesis even if the light intensity increases beyond 30 per cent. The above information suggests that these plants would be entirely capable of growing in the same habitat.
However, competition for light may act as a limiting factor. If the leaves of species A are situated above those of species B this would present problems for growth of species B, which depends upon higher light intensities. This would not be a problem if the leaves of species *B were* situated above those of species A.

d. (i) A limiting factor is the factor, **in a chemical reaction involving several factors**, which prevents the reaction rate from increasing because it is **present at its minimum value**.
(ii) **Low temperature:** This influences the rate of the enzyme-catalysed reactions of the light- independent stages of photosynthesis. At low temperatures, the low activity of RUBISCO limits the uptake of carbon dioxide by ribulose bisphosphate. Thus, the rate of formation of phosphoglyceric acid and triose phosphate is reduced.

Low light intensity: This limits the initial light-requiring reactions of photosynthesis. Inadequate light intensity provides insufficient energy to excite electrons in the magnesium atoms of the chlorophyll molecules to higher energy levels. No electrons flow along the electron carrier chain and non-cyclic photophosphorylation fails. No ATP is produced. No photolysis of water occurs to replace the electrons lost from chlorophyll and no $NADPH_2$ is formed.
Low carbon dioxide concentration: If a plant has optimum light intensity and optimum temperature, and the rate of photosynthesis does not increase any further (remains constant), the limiting factor of photosynthesis is low carbon dioxide concentration.
5. a) Somatostatin; glucagon; adrenaline; thyroxine; growth hormone; triiodothyronine; cortisol
b) The rise in insulin level is greater in group Y than in group X; The rise in insulin level is more rapid in group Y than in group X; Insulin level rises in both
c) Blood glucose level decreases in both as it is transported into various cells throughout the body, where it is used as an immediate respiratory substrate to release energy; built into glycogen and fat stores
d) From 1-2hrs concentration of glucose increased slowly as that of insulin increased rapidly. This is because increased level of glucose above normal, stimulates the beta cells of islets of Langerhans; to secrete insulin

hormone into the blood stream; when it reaches the liver. It activates liver cells; to convert excess glucose to glycogen; it increases the rate of respiration; increase the conversion of glucose to fats; decrease conversion of glycogen to glucose; prevent gluconeogenesis. All the above bring the blood glucose level back to normal; consequently.
From 2-4hrs the glucose concentration decreases slightly to normal. As insulin also decreased gradually back to normal; because after its work, insulin is rapidly destroyed in the liver.
e) Blood glucose in group X rises more rapidly, and attains a higher peak; after which it remains high and does not return to the norm as this group of diabetic persons fail to initiate (effectively) corrective mechanisms of secreting (sufficient) insulin which would stimulate the necessary changes to restore the norm; blood glucose rises continuously; and slight fall is only attributed to excretion of glucose in urine and some respiration of glucose; while in group Y; effective corrective mechanisms were initiated such as sufficient insulin secretion to increase homeostatic mechanisms that eventually restored the norm of blood glucose.
f) After 24hrs, the glucose concentration in A would decrease gradually; because much of it will be excreted in urine; and the glycogen stores will nearly be exhausted/depleted; due to high concentration of glucagon; the glucagon keeps converting stored glycogen to glucose.
g) **Complications:** CVDs; hypertension; Neuropathy (nerve damage); Retinopathy (eye complications); kidney damage (nephropathy); Compromised (weakened) immune system;
Risk factors: Increased adoption of sedentary lifestyles (lack of regular exercise) and diets high in processed foods, sugars, and unhealthy fats; Genetics and Family History; Increased obesity risk; Lack of awareness and education; Limited Access to Healthcare;

6. a) The Kranz leaf anatomy forms a structural dimorphism where around the vascular bundles are distinct tight ring of bundle sheath cells surrounded by tight fitting mesophyll cells. This ensures that the inner bundle sheath cells layer where the light independent stage takes place is **isolated from the air inside the leaf**; preventing photorespiration; by **keeping oxygen away from these cells.** It also prevents carbon dioxide, fixed by PEPCo and from oxidative decarboxylation of organic acids like malate, being lost; which therefore accumulates within the cells; and this **store of CO_2 is used when supplies from outside the leaf are in short supply.** The light dependent stage where oxygen is produced takes place in mesophyll cells and not in bundle sheath cells, which **spatial separation prevents photorespiration by keeping RUBISCO devoid of oxygen.** Presence of numerous plasmodesmata btn the two rings of cells allows more rapid movement of malate and pyruvate between the two.

b) i) **C3 plants** are more abundant at high altitude where there is low light intensity that reduces photorespiration; as little oxygen builds up in cells from the low photolysis; and low temperatures favor activity of C3 photosynthetic enzymes.
(ii) **C4 plants** These are more abundant at moderate altitude because moderate temperature is optimum for the activity of C4 photosynthetic enzymes maximizing photosynthesis. Their abundance is low at high altitude because there are low temperatures hence a low productivity due to few active photosynthetic enzymes. At high altitude they face water stress; as they over lose water thru vaporisation across open stomata.
iii) **CAM plants** These are more abundant at moderate and low altitude; altitude because they prevent photorespiration thru reversed stomatal rhythm and their remarkable ability to conserve water during day when stomata are closed.
6. c) i) **Similarities:** In both, the carbon dioxide uptake decreased during the three days.
In both, day one had the highest carbon dioxide uptake.
Differences: There was **greater** reduction in the carbon dioxide uptake in sorghum than in soybean.
(ii) Sorghum (a C4 plant) has a **relatively high optimum temperature** for effective enzyme catalysis of photosynthetic reactions. Cooling to 10^oC **greatly lowered the temperature below optimum and greatly increased the compactness of membrane proteins/ chloroplasts**; causing **great inactivation of**

photosynthetic enzymes; such that even when returned to 25^{o}C, the **highly inactivated enzymes did not gain sufficient energy for catalysis**, as they would before cooling.

7. a) Lymph vessels are transport channels for tissue fluid. The smallest vessels of the lymphatic system are called lymphatic capillaries and lacteals. These small vessels join up to form bigger vessels called the lymphatics/ lymphatic vessels. The biggest lymphatic vessels are called thoracic ducts. Each thoracic duct drains lymph into a subclavian vein near the junction of the neck and the arm. Lymphatics collect excess tissue fluid (interstitial fluid), filter it, and return it to the bloodstream, helping to maintain fluid balance.

Along lymph vessels are valves keep the lymph flowing in one direction by preventing backflow; and Lymph nodes which are small bean-shaped structures usually in clusters that act as filters for lymph, trapping and removing foreign particles and contain immune cells, like lymphocytes, which help mount immune responses.
A fluid called lymph important in transportation of nutrients, antibodies, oxygen and other important materials around the body.
Glands and organs such as the spleen, adenoids, tonsils, thymus, lymph nodes and appendix. The largest organ of the lymphatic organ is the spleen. The thymus is a gland located on top of the heart is important in the maturation of T lymphocytes (T cells), a type of white blood cell central to the adaptive immune response.
The spleen acts as a blood filter, removing old or damaged red blood cells and platelets, as well as storing platelets and white blood cells.
Tonsils and adenoids help protect against pathogens entering the body through the nose and mouth; contain immune cells and serve as a first line of defense against infections.
Bone marrow is a primary site for the production of white blood cells, including lymphocytes, which are critical for immune responses. It also produces red blood cells and platelets, contributing to overall hematopoiesis.

b) In aqueous solution- A small amount, about 5% of carbon is transported in physical solution in blood plasma. In this way Carbon dioxide from respiring cells diffuses across the membrane and reacts with water in blood plasma. It is then transported to the lungs as carbonic acid.

In combination with haemoglobin-A little carbon dioxide around 10%, will combine with the amino groups in the four polypeptide chains which make up each haemoglobin molecule. It is then transported to the lungs as carbamino haemoglobin.

In the form of hydrogen carbonate-The majority of the carbon dioxide (80%) produced by the tissues combines with water to form carbonic acid. This reaction is catalysed by the zinc-containing enzyme carbonic anhydrase. The carbonic acid dissociates into hydrogen and hydrogen carbonate ions. These reactions take place in red blood cells. The hydrogen ions produced combine with haemoglobin which loses its Oxygen. The oxygen released diffuses out of the red blood cell through the capillary wall and tissue fluid into a respiring tissue cell. The hydrogen carbonate ions diffuse out of the red blood cell into the plasma where they combine with sodium ion from the dissociation of sodium chloride to form sodium hydrogen carbonate. It is largely in this form that the carbon dioxide is carried to the respiratory surface where the processes are reversed, releasing carbon dioxide which diffuses out of the body. The loss of negatively charged hydrogen carbonate ions from the red blood cells is balanced by the inward diffusion of negative chloride ions from the dissociation of the sodium chloride. In this way the electrochemical neutrality of the red blood cell is restored a phenomenon known as the chloride shift.
c) An increase in carbon dioxide concentration reduces the oxygen carrying capacity of blood. This is because it enhances the dissociation of oxyhemoglobin into oxygen and hemoglobin molecules. Carbon dioxide produced by the tissues combines with water to form carbonic acid under the influence of carbonic anhydrase. carbonic acid then dissociates into hydrogen and hydrogen carbonate ions. As pH decreases (becomes more acidic), hemoglobin's affinity for oxygen decreases causing Bohr effect. Oxyhemoglobin dissociates to releases

its oxygen more readily to the tissues that need it. This phenomenon enhances the delivery of oxygen to metabolically active tissues.

A decrease in carbon dioxide concentration decreases chances of formation of carbonic acid hence increases oxygen carrying capacity of blood; as hemoglobin affinity for oxygen increases.

8.a) The trichromatic theory states that human retina contains **three types of color sensitive photoreceptor cells**; the blue, green and red cones; that are **sensitive to different wavelengths of light**. The perception of color arises from the combined responses of these **three types of cones** to different wavelengths of light. When light of various wavelengths enters the eye, it stimulates these cones to varying degrees. The brain then processes the relative activation of these cones to create the perception of color.

Stimulation of **one cone type** results into primary clours of either blue, green or red colour percieved. If two cone types are **equally stimulated**, a secondary colour is percieved, while stimulation of all the three types of cones results into perception of white, whereas if none of the cones is stimulated, then black is perceived by the brain.

b) **Frequency /pitch /highness**: The thickness and stiffness of the basilar membrane determine its resonance frequencies. The region of the basilar membrane that resonates in response to a particular frequency of sound will transmit neural signals to the brain, indicating the presence of that specific pitch. **The basilar membrane is wider at the apex than at its base** between the oval and round window. The base of the cochlea, where the basilar membrane is narrow and stiff, is sensitive to high-frequency sounds, while the apex, where the membrane is wider and more flexible, is sensitive to low-frequency sounds.

Sound of short wave length (high frequency) vibrates relatively a short portion at the base of basilar membrane. Only the hair cells nearest the oval window will be stimulated. The impulses fired from these few cells and arriving at the brain are interpreted as a high-pitched sound.

On the other hand, sound of a longer wave length (low frequency) causes a larger portion of the basilar membrane to vibrate towards its apex therefore the sensory hair cells that are stimulated further along this membrane are stimulated. The impulses fired from these cells when they reach the brain are interpreted as sound of low pitch.

Perception of intensity /loudness: This is related to the amplitude of sound waves impinging (striking) up on the tympanic membrane which in turn determines the amplitude with which the basilar membrane vibrates; and the sensory hair cells of organ of Corti are stimulated by differing vibration thresholds. Loud sound brings about greater displacement of the basilar membrane such that sensory hair cells are stimulated more strongly and numerous impulses are discharged in a larger number of auditory nerves.

Sound waves of smaller amplitude bring about lesser displacement of the basilar membrane, which results in low stimulation of the receptor cells that brings about fewer impulses being discharged in fewer auditory nerves. The human ear can only detect sounds within a certain range of intensities. Sounds above 120dB can be painful and may cause immediate damage to the cochlea receptors. Long term exposure to sounds over 85dB can also damage the receptors leading to partial loss of hearing.

C) Inhibitory synapses	**Excitatory synapses**
Make the post synaptic neuron to be hyperpolarized	Make the post synaptic neuron to be depolarized
A threshold necessary for generation of action potential is not reached	A threshold necessary for generation of action potential is reached
The post synaptic neuron allows inward movement of Cl^- ions; or efflux of K^+ ions	The post synaptic neuron allows inward movement of sodium ions
An impulse does not cross synapse	An impulse crosses the synapse

9. (a) Nitrogenous excretory products result from the breakdown of excess amino acids consumed by animals. As plants can make all their amino adds from basic raw materials ($C0_2$, H_20 and NO_3) they only manufacture them as and when the need arises. Consequently, they have no excess amino acids to breakdown and hence no nitrogenous waste.

(b) (i) Water reabsorbed by proximal tubules plus water in urine (not reabsorbed) = 150 + 1.5 =151.5
Amount of water reabsorbed elsewhere =180-151.5 = 28.5
Percentage of water reabsorbed elsewhere =(28.5/180x100) =15.83%

(ii) The longer the loops of Henle the greater the proportion of water that is reabsorbed. Long loops of Henle are hence common in animals which need to conserve water, e.g. mammals living in hot deserts.
(Juxtamedullary nephrons vs cortical nephrons)
(iii) The vasa recta is a specialized network of blood vessels that runs alongside the nephrons, forming a countercurrent exchange system with the nephrons, meaning that the flow of blood in the vasa recta runs in the opposite direction to the flow of fluid in the nephrons (the loop of Henle). This countercurrent arrangement is essential for maintaining the concentration gradient in the medulla of the kidney.
As blood flows through the vasa recta in the descending limb, it encounters an increasing concentration of solutes in the surrounding interstitial fluid due to the active reabsorption of ions. In the ascending limb of the vasa recta, the blood flows in the opposite direction and encounters decreasing solute concentrations.
As blood flows through the vasa recta, it exchanges ions and water with the surrounding interstitial fluid in the renal medulla in response to the varying osmotic concentrations in the medullary interstitium.
(c) (i) While ammonia is the simplest excretory product it is very toxic. However, freshwater fish are able to dilute this to harmless concentrations using the large volume of water which passes into them osmotically and has to be removed by the kidneys; with minimal energy use as some can easily diffuse out in solution across body epithelial surfaces of fish.
As seawater fish tend to lose water osmotically to saline envt, they cannot afford to dilute the ammonia adequately. They therefore excrete urea which does not require as much water to dilute it to a non-toxic level.

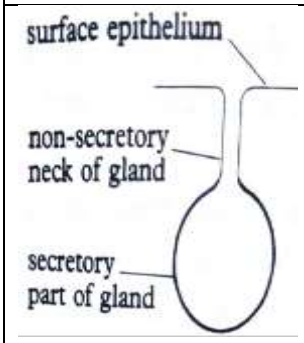
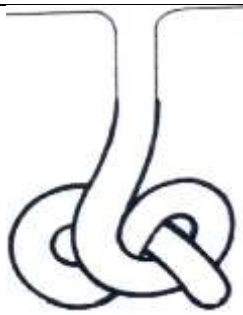
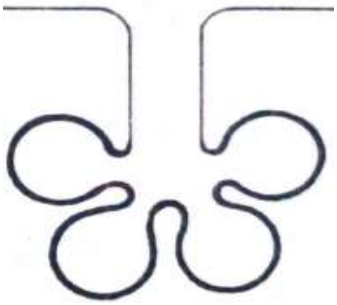
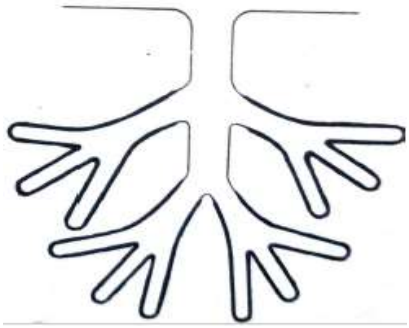
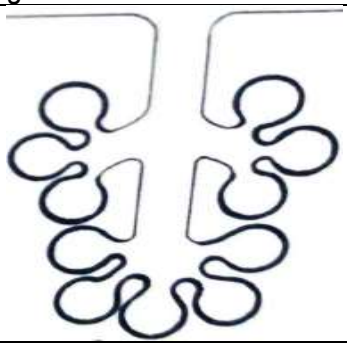
(ii) As eggs are enclosed by shells, excretory products cannot escape. If these products were soluble they would diffuse throughout the egg and poison the embryo. The insoluble uric acid is therefore the only safe form in which excretory pro ducts can be stored. (Being non-toxic)

10. (a) K+ higher in cytoplasm while Na+ higher in extracellular fluid; due to the action of sodium-potassium pumps that actively pump these ions to maintain resting state.
Organic anions only present in cytoplasm since they are resident negatively charged molecules that contribute to the negative resting membrane potential; and the membrane is fully impermeable to them.
Chloride ions are of far higher concentration in extracellular fluid than cytoplasm; since most of the chloride channels are closed; during resting state of axon.
b) i) Cells X, Y and Z are epidermal cells.
ii) During stomata closure, potassium ion concentration increases in cells with guard cells having the lowest concentration followed by X, Y and Z. This is because potassium ions move from the guard cells into the surrounding epidermal cells. This lowers the osmotic potential of guard cells resulting into osmotic movement of water from the guard cells into epidermal cells. Guard cells eventually lose turgidity and the stomata close.
During stomata opening, potassium ion concentration decreases in cells with guard cells having the highest concentration followed by X, Y and Z. This is because potassium ions move from the surrounding epidermal cells into the guard cells. This increases the osmotic potential of guard cells resulting into osmotic movement of water from epidermal cells into guard cells. Guard cells eventually gain turgidity and the stomata open.
(C)

Guttation	**Transpiration**
Water is lost from the plant as droplets	Water is lost from the plant as water vapor
It usually takes place during conditions of low temperature and low light intensity (night time)	It usually takes place during conditions of high temperature and high light intensity (day time)
Water is lost through hydathodes	Water is lost through stomata
Wilting does not result	Can cause wilting

By root pressure	By transpiration pull, capillarity, root pressure

11. a) Epithelial tissue consists of one or many layers of cells thick; the cells are cemented to each other, forming continuous sheets or layers. Specialized cell-to-cell junctions exist: Cells rest to a basement membrane; Tissue is avascular; richly innervated; has a high regenerative capacity through mitosis; cells have variable specializations/modifications

(B) Simple saccular gland e.g. mucus glands in skin of frog (amphibia)	**Simple tubular *gland*** e.g crypts of Lieberkuhn in the wall of ileum	**Coiled tubular gland** e.g. sweat glands in the skin of humans	**Simple branched tubular gland** -Brunner's glands in the walls of ileum & gastric glands in walls of stomach
			
Simple branched saccular gland e.g oil-secreting sebaceous glands in skin	**Compound tubular glands** e.g. Salivary glands	**Compound saccular gland** e.g. part of pancreas that secrets digestive enzymes, & mammary glands	
			

12. (a) 3cm^3 of 0.1 moldm^{-3} sodium hydroxide per 1cm^3 of stomach contents

(b) Addition of food and saliva to the stomach neutralized some of the stomach acidity

(c) The level of acidity in the stomach falls gradually over the first hour from 1.5 hours to 2.5 hours. There is then rapid fall over the next half-hour and then a gradual fall off over the next half-hour to the lowest pH value. This value is then maintained constant for a further half-hour before rising again very gradually.

It is essential that there is an adequate amount of acid in the stomach while food is present. This provides the optimum pH of 1.5 which the enzyme pepsin requires in order to break down proteins into polypeptides.

The graph shows that the rate of secretion rises to a maximum 1.5 hours after eating a meal but then steadily falls off as food begins to leave the stomach.

(d) *There are three* mechanisms involved; the first is a reflex mechanism initiated by swallowing food. Impulses pass via the vagus nerve to the stomach which secretes gastric juice as food enters the stomach.

Secondly, stretch receptors in the stomach wall *respond* to distension by setting up nerve impulses which lead to the secretion of more gastric juice.

Finally, the physical presence of food in the stomach stimulates the gastric *mucosa* to release a hormone called gastrin which stimulates further production of gastric juice.

13. a. (i)

Donors \ Recipients	Group A	Group B	Group AB	Group O
Group A	✓	×	✓	×
Group B	×	✓	✓	×
Group AB	×	×	✓	×
Group O	✓	✓	✓	✓

(ii) **HDN:** If the mother is Rh- (lacks the Rh factor) and the father is Rh-positive, there is a higher chance that the fetus may inherit the Rh-positive gene from the father. During pregnancy or childbirth, small amounts of the baby's Rh-positive red blood cells may enter the mother's bloodstream, sensitizing her immune system to the Rh antigen. This can occur during delivery, miscarriage, abortion, or any event that causes fetal-maternal blood mixing. The mother's immune system produces antibodies against Rh-positive blood cells. These antibodies can cross the placenta and affect the Rh-positive red blood cells of a subsequent Rh-positive fetus. In a subsequent pregnancy with an Rh-positive fetus, the mother's antibodies may cross the placenta and attack the fetal red blood cells. This immune response can lead to hemolysis (destruction of red blood cells) in the fetus, resulting in HDN. Severe cases of HDN can lead to significant fetal anemia, jaundice, neurologic damage or death if left untreated.

Prevention of HDN: Administering anti-rhesus antibodies (anti-D injections) to pregnant mothers around 28 weeks of pregnancy and within 72 hours after childbirth, to prevent immune sensitization against Rh antigen.; Intra-uterine transfusion of compatible blood to the fetus; administering immunosuppressants to the mother; Blood typing;

b. (i) Innate immunity in humans is the first line of defense against pathogens thru; Physical Barriers e.g. keratinised skin; Body secretions e.g. tears, hydrochloric acids, vaginal acids, saliva,; Phagocytic action by neutrophils and macrophages; Inflammatory responses; Natural killer cells; Complement system; Viral interferons; coughing; sneezing; vomiting; cilia action in trachea; etc

(ii) **In active immunization,** the immune system of the individual is stimulated to produce its own immune response by administering a vaccine containing weakened or inactivated forms of the pathogen (antigens). The immune system responds by producing specific antibodies and memory cells, providing long-lasting immunity against antigen administered.

Passive immunization involves the direct transfer of already formed **antibodies or immune cells** from an external source to an individual. This does not stimulate the individual's immune system to produce its own antibodies, and the immunity is temporary.

14.(a) **Similarities**: Both attained peak; Level of blood glucose level was the same at 2 hours;

Differences

Blood glucose levels after carbohydrate meal	**Blood glucose level after a protein meal**
Attained a higher peak/maximum	Attained a lower peak/maximum
Attained a peak earlier	Attained a peak later
From 0 to about 1 hour, it increased very rapidly	It increased very slowly
From 1 hour to 2.30hours, it decreased very rapidly	It increased slowly
From 2.30hours to 3.30hours, it increased slowly	It increased rapidly
From 3.30hours to 6.20hours, it increased slowly	It decreased rapidly
It decreased to a level below norm	It decreased to norm

b) (i) From 0 to 1 hr, the level of blood glucose after a carbohydrate meal, increased very rapidly; because after eating the carbohydrate was hydrolyzed to glucose which was absorbed by diffusion into the blood stream; and increased above norm; this stimulated the beta cells of islets of Langerhans in the pancreas; to secrete insulin

hormone which stimulated the liver cells to convert excess glucose to glycogen; and also increased respiration; formation of non-carbohydrates from glucose; all these decreased the level of blood glucose rapidly to below norm;
(ii) From 2.5 to 4 hours the level of blood glucose increased slowly; because it was below norm; which stimulated the alpha cells of the islets of Langerhans in the pancreas; to secrete glucagon hormone; that stimulate the liver cells to convert glycogen to glucose; this increased level of glucose in blood back to norm; and thereafter remained constant;
c) (i) From 0 to 4 hours the blood glucose level first increased slowly and then rapidly to the peak; because protein is first hydrolyzed to amino acids; which are absorbed into the blood stream and passed to the liver; where they are deaminated to form the carbon skeleton and ammonia; the carbon-skeleton is converted to glucose; from 4 to 6.5 hours it decreased rapidly because of respiration.
(ii) From 0 to 3 hours the level of glucose in blood increased very slowly; lipids are hydrolyzed to fatty acids and glycerol; and only glycerol is converted to glucose; the level of glucose decreased very slowly due to respiration;
d) The blood glucose level after carbohydrate meal attained a higher peak than that after protein meal; because carbohydrates are hydrolyzed directly to glucose while proteins are first hydrolyzed to amino acids that are later deaminated to form glucose;
(e) Glucose is a respiratory substrate for cells e.g. Main metabolite for cells such as brain cells; lack of glucose results into hypoglycemia/ fainting/ ketosis; glucose concentration affects the osmotic relations of cells/ regulation of water; excess glucose would result into breakdown of cells e.g. Brain cells;

15. a. (i) Amino acids cannot be stored in the body. Excess amino acids are deaminated in the liver by the enzymic removal of the amino group. The remainder (keto-carboxyl group) of the molecule is then oxidized to form a carbohydrate which is utilized in respiration. The amino group is immediately reduced to form ammonia. Due to its high toxicity in aqueous solution. ammonia is metabolized within a series of biochemical reactions known as the ornithine cycle. In these reactions ammonia and carbon dioxide combine in a series of reactions to form urea which passes into the blood and is transported to the kidneys.
A number of amino adds which are deficient from the diet are synthesized by the enzymic transfer of the amino group from one amino acid to a keto acid. This is called transamination.
Finally, a number of plasma proteins such as albumins and globulins and blood-clotting factors such as prothrombin and fibrinogen are manufactured in the liver.

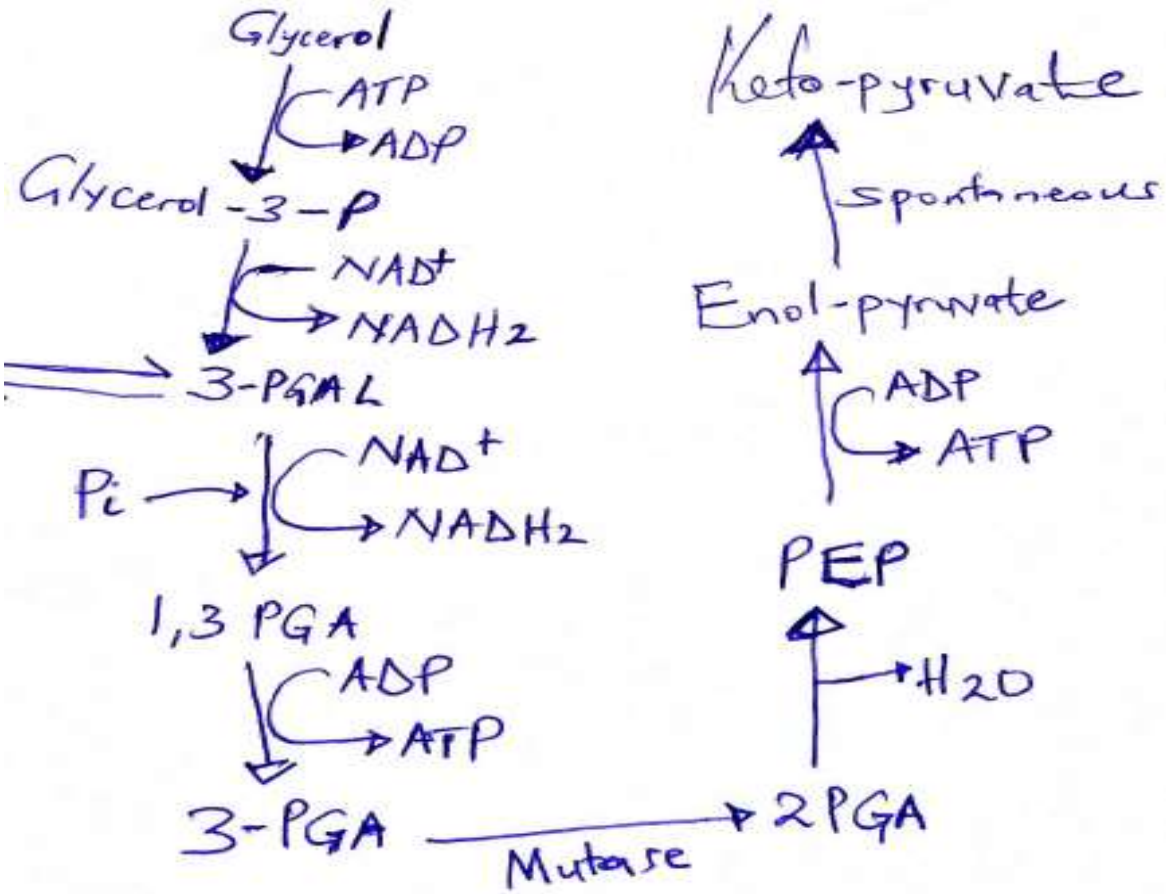
(ii) Removal of bacteria and other pathogens from the blood by phagocytic **Kupffer cells**; Breakdown of chemical substances such as alcohol to carbon dioxide and water; Breakdown of hydrogen peroxide to water and oxygen by catalase; Foreign substances such as drugs are broken down by the liver, as are excess amounts of hormones, in particular sex hormones. Removal of certain metabolites such as lactic acid and heavy metal salts from the blood also occurs in the liver

(iii) All hexose sugars from the gut pass through the liver. Here excess amounts of sugars are removed from the blood and converted to glycogen. This process is called glycogenesis and is stimulated by the presence of insulin. Glycogen, being insoluble, is stored but when the plasma sugar level falls glucagon stimulates the breakdown of glycogen back to glucose. This process is called glycogenolysis. In extreme cases of undernourishment both fats and proteins can be converted into sugars. This is called gluconeogenesis. In cases of overeating excess carbohydrates are converted into fats and stored in the body.

b) In plants the range of tolerance to extreme environments is much greater than animals, their tissues are often much harder and withstand greater physiological adversity than animals. Plant cells can lose a far higher proportion of water than animal cells and recover afterwards. One of the major problems encountered by plants is extreme of temperature. On hot, sunny days many plants show photosynthetic slump. This is a temporary reduction of metabolic activity resulting from change in enzyme structure or the closure of stomata. The main

reason for this may be water loss, although wilting is often seen in well-watered plants on hot days. The rate of water loss from the plant by transpiration is temperature-dependent and the loss of latent heat in this way prevents the plant from overheating. Selective ion uptake allows plants to absorb essential nutrients; Plants maintain a stable internal pH to optimize enzymatic reactions using various mechanisms such as proton pumps in cell membranes.

16. a) Adaptations for finding and catching prey: Well-developed canines and incisors; Sharp pointed teeth; Carnassial teeth; Absence of diastema; Closed roots to teeth; Powerful jaw muscles; Keen Senses especially sight, smell, and hearing; camouflage patterns to help blend into the environment; High speed and agility; Venom and Toxins; Mimicry; special hunting techniques; Claws - cat family; Spiked teeth - Piscivores, e.g. seal; Short elongated snout - Insectivores, e.g. hedgehog; Extremely sticky longue - e.g. ant-eater; etc
Adaptations for ingesting the food: Sharp, pointed canines for tearing prey, Sharp molars and premolars for slicing and shearing meat; Powerful jaws that enable them to exert significant force when biting down their prey; wide gape of the jaws and a flexible neck;
Adaptations for digesting the food: Highly acidic stomachs; Venom and Toxins; less developed caecum and colon; secretion of enzymes
b) **Herbivores**: canines are usually small or absent; Greater dental wear; have diastema; usually fewer number;
c) Insectivorous plants such as Venus fly trap, sundew, pitcher plant and bladderwort that devour prey, which is not a direct energy supply but a source of some necessary mineral, e.g. nitrogen, phosphorus. They lure prey by emitting attractive scents, displaying bright colors; producing sugary nectar on their surfaces; specialized leaves modified into traps; secrete enzymes onto substrate; digest, absorb and assimilate products such as amino acids into the tissues.



17.a) Oxidative decarboxylation refers to removal of hydrogen and carbon atoms; from intermediate compounds/ substrates of respiration. There is conversion of pyruvate produced during glycolysis into acetyl-CoA, a two-carbon molecule that can enter the citric acid cycle of mitochondrion.

Oxidative decarboxylation is essential for the production of reducing equivalents, such as NADH and FADH2, which carry high-energy electrons; playing a pivotal role in the electron transport chain; where they transfer electrons to generate a proton gradient releasing energy that is used to drives the synthesis of ATP, a process known as oxidative phosphorylation.
Carbon dioxide given off can be used as raw material for the Calvin cycle of photosynthesis.

(b)Chemiosmotic theory of energy formation proposes that hydrogen atoms in the mitochondrial matrix are dissociated into protons and electrons using energy produced from the moving electrons down an energy gradient among cytochromes in the inner membrane of the mitochondria. The formed protons are pumped across the inner membrane into the intermembrane space of mitochondrion.
The high concentration of protons in the inter-membrane space reduces the pH and creates a very high electrochemical proton gradient between the matrix and intermembrane space of the mitochondria.
The large electro chemical proton gradient drives protons from the inter membrane space via stalked granules rich in ATPase enzyme in the inner membrane of the mitochondria into the mitochondrial matrix.
As the protons pass thru the stalked granules in the inner membrane, the ATPase enzyme in the granules is activated to catalyse the combination of inorganic phosphate with ADP to form ATP.

18. a. (i) Horse; donkey
(ii) Loss of the 5^{th} digit; Increase in length and prominence of the 3^{rd} digit; Reduction of 2^{nd} and 4^{th} digits; Appearance of a true hoof
(iii) Increased strength of the limb; increased speed of running; Raised the body off the ground; Increased leverage for running
(iv) Radioactive carbon dating of fossil; Dating the age of the rocks in which the fossils are found
((b)(i) Presence of the same bone types and bone arrangement/ same basic plan
(ii) Difference in the; number and length of phalanges, number and arrangement of carpals, distance between ulna and radius and their thickness, length and thickness of humerus
(iii) **Human:** Thumb opposable to allow high eye-hand precision /to write/hold thins
Long humerus to hold the body high during crawling/ reach out for things at a distance/protect its self at a distance
Dog: Phalanges curved and close to each other for easy walking/running/absorb shock during running/walking.
Long humerus to lift the body high enough from the ground during locomotion
Bird: Fewer digits/phalanges to reduce wait during flight; Humerus relatively long to increase wing span/ allow wing to move up and down away from the body during flight.
Whale: Phalanges are thick and spread widely to increase the surface area for acting on water during swimming

19. a) Travel in blood; Effect at target cell, small soluble organic molecule, effective in low concentration, fits precisely into receptor molecules in the target like a key in a lock; Are peptides, steroids or amines; Released by endocrine glands; Highly specific in action; last a short time after release (are degraded by liver cells); Exert a slow but long-lived response
b) **FSH:** From 0-2 days, level of FSH remains low and constant during the menstrual phase during which the endometrium sheds in response to the previous cycle's drop in hormone levels and pituitary gland is still being inhibited from release of FSH; from 2-3 days the FSH level rises gradually to the maximum and then remains constant till day 6 due to the follicular phase setting in as a result of hypothalamus secreting Gonadotrophin releasing hormone that stimulates the pituitary gland to start secreting FSH into blood to ovary to stimulate development of ovarian follicles which now contain immature oocytes; and stimulate follicles further to secrete oestrogen. From 6- 12 days, FSH level drops slightly and is very low due to rising levels of oestrogen inhibiting FSH secretion such that no other ovarian follicles develop.
From 12-14days, FSH rises to peak as its synergy with LH stimulates further follicular growth and ovulation.

From 14-15 days, FSH level falls gradually and then remains low and constant during rest of the cycle during the luteal phase whereby development of corpus luteum secretes high levels of progesterone and oestrogen that have a negative feedback on FSH (and LH) secretion by pituitary gland; since the body recognizes that ovulation has occurred, and there is no further need to stimulate the development of more follicles at this time.

Oestrogen: From 0-7 days, the level of oestrogen remains low and constant due to degenerated corpus luteum such that it dropped oestrogen (and progesterone) secretion; (low oestrogen level at menstrual phase stimulates prostaglandins release which cause the uterus to contract, leading to the shedding of the endometrial tissue and menstrual bleeding).
From 7-13 days, oestrogen level rises gradually and then rapidly to the peak during the follicular phase as FSH release stimulates developing follicles to secrete oestrogen hormone; for stimulating healing/ repair of uterine wall and then stimulate LH secretion towards ovulation period.
From 13-15 days, Oestrogen level falls rapidly to minimum due to high level of LH having a negative feedback on its release, such that developing yellow body begins progesterone secretion in luteal phase.
From 15 to 20 days, Oestrogen level rises rapidly to the peak during luteal phase where corpus luteum secretes oestrogen (and progesterone) that helps to maintain the endometrial lining and support the potential pregnancy.
From 20 to 28 days, Oestrogen level falls gradually for the rest of the cycle due to corpus luteum degenerating such that it reduced oestrogen secretion (No pregnancy occured, no HCG release which would maintain the corpus luteum); in preparation for the next menstrual flow.

LH: The level of LH in blood remains low and almost constant for the first 12 days; since in the early follicular phase, rising estrogen levels have a negative feedback effect on the hypothalamus and the anterior pituitary gland in the brain thus no (low) LH secretion. From 12-14 days, LH level rises due to high level of oestrogen stimulating LH secretion; at the time where LH (in synergy with FSH) stimulate further follicular growth and eventual rupture of follicle to release secondary oocyte; and stimulate the remaining empty follicle develop into yellow body and further stimulate it to secrete ovarian hormones. From 14-16 days, LH level falls rapidly and then remains low and constant thought the rest of the cycle due to the rising levels of ovarian hormones having a negative feedback on LH secretion.

Progesterone: From 0-14 days, progesterone level remains low and constant due to degenerated corpus luteum stopping its secretion. From 14-20 days, progesterone level increases rapidly to the peak due to LH stimulating its secretion from the developing corpus luteum; such that the hormone stimulates preparation of endometrium for pregnancy. From 20-28 days; hormone level falls throughout as corpus luteum degenerates after failure of conception/ implantation such that it reduces progesterone secretion.

c. (i) Negative feedback occurs to correct the deviation from the norm of particular hormones during the cycle. Following end of menstruation; low level of progesterone (and oestrogen) signals the hypothalamus and pituitary gland to secrete FSH. Rise in FSH stimulates Oestrogen secretion, and further rise in oestrogen eventually inhibits FSH secretion and stimulates LH secretion.
Rising level of LH inhibit oestrogen secretion but later stimulates progesterone release; and eventually high level of progesterone inhibits LH secretion.This all happens at different stages of the cycle.
(Generally ovarian hormones have a negative feedback on Pituitary gland hormones and vice versa)
(ii) Negative feedback is important to **correct hormonal imbalance**, by keeping particular hormones at **suitable levels** during the different times; to **ensure correct timing of the series of events during the cycle**.

d) (i). The level of ovarian hormones oestrogen and progesterone would decrease greatly; Due to the lack of negative feedback from estrogen and progesterone, the levels of LH and FSH, which are gonadotropin hormones produced by the anterior pituitary gland, would increase.

(ii) From onset of implantation of blastocyst, the **developing fetal placenta secretes human chorionic gonadotropin hormone** (whose action is similar to LH); stimulating the corpus luteum to continue producing progesterone and, to a lesser extent, estrogen. HCG also suppresses LH and FSH production from the anterior pituitary. Towards parturition; level of other hormones prolactin, human placental lactogen and oxytocin rises.

e) (i) **Contraceptive pills** contain progesterone and oestrogen which inhibit production of FSH and LH. Therefore, the levels of progesterone and oestrogen will increase while that of FSH and LH decreases due to their secretion being inhibited.
(ii) **Fertility drugs are variable in type** and contain a range of hormones e.g gonadotrophins such as synthetic HCG that contain (increase) levels of LH and FSH which stimulate follicle development and ovulation; as a result their levels in blood increase; Other reproductive hormones oestrogen/ progesterone can change depending on the type of synthetic hormone in drug administered.
f) Photoperiod, Temperature, Food availability; breeding system, physiological stage (Hormonal levels); age; Reproductive strategies
g) Multiple births is when a female gives birth to more than one baby at a time. It arises due:
One fertilized egg(ovum) splitting before it implants in the uterine wall result into production of identical babies, or two or more separate ova being fertilized by different sperms at the same time resulting into non-identical (fraternal) babies.
h) Formation of a pair bond – relationship between male and female of same species which means they recognize each other as individuals and avoid aggression; It advertises sexually receptive individuals; Brings both mating partners to reproductive readiness simultaneously; It ensures that members of the same species find each other and mate; Maintain distinct species

20. a) When receptors are stimulated, they are depolarised; the stimulus was very weak/subliminal, the cells were not sufficiently depolarised and thus the sensory neurone not activated to send impulses; the receptor/ generator potential was below firing threshold, the stimulus only caused local depolarisation of the receptor cell. Thus no action potentials initiated in the sensory neurone.
b) Pressure / stimulus, causes deformation of Pacinian corpuscle; increased permeability to sodium ions; sodium channels open; sodium ions move into receptor / axon; causes depolarisation; potential difference becomes less negative;
c) No action potential recorded with low and medium pressure; because these subliminal stimuli caused a low generator potential did not reach threshold; action potential recorded only with high pressure; for higher pressure, the stimulus was strong enough; and firing threshold reached; then the sensory neurone was activated and transmitted impulses to the CNS
Increasing the strength of the stimulus produces an increasing receptor potential. At a low strength, a small increase results in a relatively large increase in receptor potential. At higher strengths, the increase in receptor potential is less; it results in a relatively high level of sensitivity to low-level stimuli as long as they are above the critical threshold. The greater the strength of the stimulus applied, the greater the frequency of action potentials generated.
d) **At unmyelinated axon portion,** ion channels are much distributed along the entire region. Sodium channels are present at regular intervals; when a microelectrode is inserted at an unmyelinated portion, it accesses a **higher density of sodium channels,** making it easier and faster to reach the threshold potential.

At myelinated axon portion, fatty myelin **insulates the axon** and prevents ion flow across the membrane. **The ion channels are clustered at the nodes of Ranvier**, which are the gaps between the myelin sheath. This means that the depolarization occurs only at these nodes, but the ion channels are not as densely distributed along myelinated region; thus, microelectrode accesses a smaller density of sodium channels thus generator potential builds up slowly.

e) **Similarities:** Both are synapses; Both rely on the release of neurotransmitters to transmit signals from the presynaptic cell to the postsynaptic cell; Neurotransmitter released into by exocytosis and move by diffusion; Use sodium-potassium pump to repolarize the axon; In both types of synapses, the neurotransmitters bind to specific receptors on the postsynaptic cell membrane.

Differences:

Interneuronal synapses	**Neuromuscular junctions**
release a range of transmitter substances, including acetylcholine, GABA and dopamine	acetylcholine is the usual neurotransmitter
Membrane of adjacent neurone is the postsynaptic membrane	sarcolemma is postsynaptic membrane
postsynaptic neuronal membranes are not folded	sarcolemma is folded to give a large surface area
action potentials travel across the membrane dendrites and cell bodies of neurones	an action potential passes along the sarcolemma and down T-tubules
Maybe excitatory or inhibitory	Usually excitatory
Motor, sensory and relay neurone may be involved	Only motor neurone involved
Synapse btn two neurons	Synapse btn motor neuron and muscle fibre
Transmit impulses to other neuron	Transmit impulses to muscle fibre
Smaller and less specialised	Larger and more specialised

f.(i) Myelinated neurones transmit impulses much faster than unmyelinated neurones; due to saltatory conduction; stimulation of Pacinian corpuscle might indicate damage to the skin; thus, need to remove the part of the body from danger very quickly;

(ii) If it were to respond to every single hair being touched individually, **it would waste energy** on non-prey stimuli, such as raindrops or when a piece of debris falls into the trap. In the due course the plant receptor cell (hair) **gets adapted** which helps prevent sensory overload by reducing the intensity of the response to continuous unchanging stimulus, allowing the organism to focus on detecting new or significant sensory information.

21. a. (i) Predator-prey relationship is interspecific feeding interaction between two organisms in which the predator hunts, seize and kill the other (prey) for food. The relationship regulates the population of both the predator and prey individuals at equilibrium within the habitat. It also results in better adapted individuals in both populations, since the weaklings are selected against.

(ii) In areas with cane toads, red bellied snakes learned to avoid cane toads and feed on other source of food thus **selective feeding** whereas in cane toad free areas, snake feed on the all available food.

(iii) As the number of years of exposure increased, percentage reduction in snake swimming speed decreased; due to development of resistance to cane toad toxin; rendering it non-poisonous.

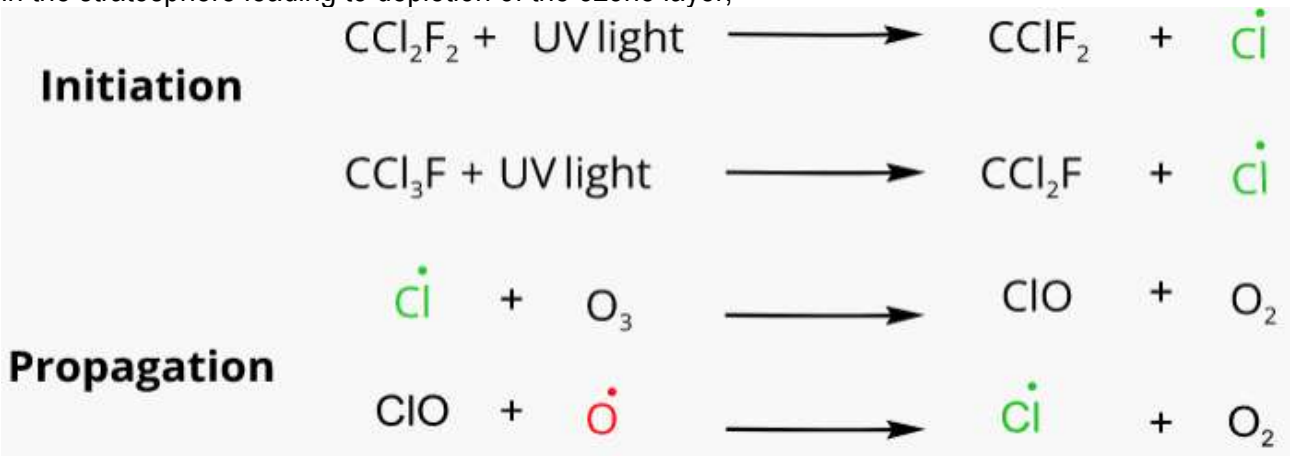
(iv) Random mutations occurred leading to synthesis of enzymes that renders the cane toad toxin harmless; also synthesis of a proteins that deter binding and entry of the cane toad toxin in the epithelial lining of digestive tract; development of protein pumps that remove the cane toad toxin within cells;

b. (i) Possession of defensive/ protective devices such as horns and antlers buffaloes and deer, hard shells in land snails and tortoise(carapace), stings in hymenopterans, sharp spines in porcupines and insects(hind limbs), pouches for carrying their young ones in kangaroo; dorso-laterally positioned eyes for wide field of view; an electric organ that discharge high voltage to shock predators in cat fish and eels, puffing up and spreading wings in pea cocks, well developed limbs for running; Living in groups e.g. herd of buffaloes, shoal of fish; Mimicry where palatable mimics unpalatable species e.g. in some snake species; Warning colourations; camouflage e.g. peppered moth forms blend with tree barks etc

(ii) These are interspecific mutually beneficial relationships;

Nutrient recycling e.g nitrogen fixing bacteria of genus Rhizobium that harbor root nodules of legumes; mycorrhizae;
Coevolution, where species evolve together in response to each other's presence; e.g. pollinators and flowering plants; predator and prey,
Enhance the productivity of ecosystems, e.g nitrogen-fixing bacteria in the root nodules of legumes provide plants with essential nitrogen, increasing their growth and productivity
Human benefits such as agriculture; Oxygen production ie chlorella residing inside the hydra; Pioneer organisms in succession ie lichens; Increased nutrient extraction ie cellulase secreting bacteria in rumen and caeca of ruminants, trychonympha (biflagellate/ protozoa) in wood eating termites; Increased survival ie cleaner shrimps remove and eat parasite that up residence in the gills of fish, in certain acacia trees ants live in large bulbs at the base of tree spines and attack herbivores that threaten the tree; sea anemone and hermit crab; Increased biodiversity as a result of mutual coexistence;

22. a) Stratosphere is the upper layer of the atmosphere; 15-40 kms above the earth surface, with the ozone layer; which absorbs short wavelength radiations like UV rays, X-rays and gamma rays; from the sun and prevent them from reaching the earth surface in large amount. Ozone is destroyed by fluorine and chlorine radicals from the breakdown of CFCs using UV radiations from the sun; the CFCs are used as aerosol sprays or coolants in refrigerators while chloromethane from rotting vegetation and bush burning also react with ozone in the ozone layer; when the fluorine and chlorine radicals react with ozone using energy from UV radiations and sunlight, the ozone is broken down into molecular oxygen at a rate faster than at which it is reformed; bromine also gives off radicals which react and breakdown ozone, it is mainly obtained from methyl bromide used in fungicides; nitrogen monoxide from the reaction of dinitrogen oxide with atomic oxygen using energy from UV radiations also reacts with and destroys the ozone layer; the high flying aircrafts release icy particles in the stratosphere leading to depletion of the ozone layer;



b) (i) This a species of organisms which are highly sensitive to a certain environmental factor where by their presence, absence or relative numbers reflects the level or amount of that factor in the environment; like the lichen are indicator species of the concentration of SO_2 in the atmosphere; because lichens are highly poisoned and killed by SO_2, their large population in an area reflects low levels or absence of SO_2; in the area and its low population reflects high levels of SO_2 in the area;
(ii) the large amounts of short wavelength radiations from the sun reaching the earth surface; the more frequent change in the nucleic acids or mutations which result into genetic diseases and abnormalities e.g. skin cancers; crop damage which is characteristic of absorption of short wavelength radiations; regular destruction of aquatic species of organisms mainly the fish larvae and planktons; reduced carbon dioxide absorption by algae resulting in increased global warming is evidence of algal destruction by short wavelength radiations from the sun;
(c) Encourage industries to adopt environmentally friendly alternatives; Strengthen and enforce regulations on the production, use, and disposal of Ozone Depleting Substances (ODS); Promote and incentivize the development and use of ozone-friendly technologies. This includes encouraging the use of non-ODS

refrigerants, aerosols, and fire extinguishing agents; Continue to monitor the state of the ozone layer through satellite observations and ground-based measurements; Raise public awareness about the importance of protecting the ozone layer and the potential health and environmental risks associated with its depletion; Develop strategies to adapt to increased UV radiation, such as promoting the use of UV-blocking clothing and sunscreen and designing UV-resistant crops; Controlled greenhouse emissions

23. a) (i) Foramen ovale is a small opening in the wall between the right atrium and the left atrium of human heart present before birth. It allows the passage of most of the blood from the right atrium to the left atrium, preventing it from flowing to and spending a lot of time in the capillaries of the non-functional lungs during prenatal development.
(ii) Patent foramen ovale results it it fails to close properly after birth; resulting into **Blue baby condition.**
Signs include Migraine, shortness of breath or shallowness of breath; failure for the baby to breath fast enough when in sitting or standing position; bluish or grayish discoloration of the skin, lips, tongue, or nails.; Excessive sweating; Underweightness; Baby discomfort; fatigue

(b) (i) Placenta **secretes HCG**, which sustains the corpus luteum in the first three months of gestation, which in turn, produces progesterone during the early stages of pregnancy.; **secretes placental oestrogen** which allows fattening and increase the sensitivity of endometrium to oxytocin during partition; **secretes progesterone** which maintains the uterine lining and preventing its shedding, prevents uterine contractions thereby supporting the pregnancy; **secretes Human Placental Lactogen (hPL)** which stimulates the growth of the mammary glands and reduces maternal glucose consumption, sparing it for the foetus and also stimulates the breakdown of maternal fat stores; **secretes relaxin hormone** that stimulates the relaxation of the uterine muscles preventing premature contractions. At full term, the hormone relaxes the cervix and pelvis by loosening the ligaments, easing childbirth.

(ii) Endocrine cells that secrete hormones such as oestrogen and hPL; Numerous microvilli that provide extensive surface area for the exchange of nutrients and wastes between the maternal and feral blood; Extensive and numerous blood capillaries that ease the transportation of material and maintain steep concentration gradient between maternal and fetal blood allowing continued exchange of materials by diffusion; Has pores that allow only the passage of nutrients and prevent the passage of big pathogens, toxins and antigens; Numerous mitochondria that produce a lot of ATP for the active transportation of mineral ions across the placenta to the foetus; Physical barrier to separate maternal blood from fetal blood

(iii) Fetal haemoglobin has got higher affinity for oxygen than adult haemoglobin, the need for higher affinity decreases as the baby starts to breath independently. Adult haemoglobin with lower oxygen affinity develops for better transportation of oxygen in lungs and throughout the body; as it more readily releases its oxygen to respiring cells as compared to fetal hemoglobin; and its lower affinity for oxygen is counteracted by the high partial pressures of oxygen in air dissolving at lung surface such picks up sufficient oxygen.

24. a) (i) All living organisms are composed of cells; The cell is the basic structural and functional unit in living organisms; All cells arise from pre-existing cells;
(ii) Some infectious agents such as viruses are acellular; Multinucleated cells (Syncytia) challenge the idea that cells must be discrete entities with individual nuclei; Mature red blood cells in most mammals lack nucleus while in other organisms such as birds they retain their nucleus; Viruses and their life cycle
(b) **The Cell surface area-to-volume ratio** is the ratio of a cell's outer surface area (cell membrane) to its internal volume (cytoplasm). As a cell grows larger, its volume (the amount of cytoplasm and organelles it contains) increases more rapidly than its surface area (the membrane that surrounds it); This means that the smaller the cell, the higher the surface area-to-volume ratio. Surface area of a cell is essential for exchange of nutrients, gases, and waste products with the external environment. A high surface area-to-volume ratio is

advantageous because it allows for fast & efficient exchange of materials across the cell membrane. In contrast, as a cell becomes larger and its surface area-to-volume ratio decreases, it may face challenges in adequately supplying and removing materials through diffusion alone which can lead to limitations in cell size.

The cell Nucleo-Cytoplasmic Ratio (NCR): refers to the ratio of the size of the cell's nucleus (which contains genetic material) to the size of its cytoplasm. In larger cells, the nucleus must be capable of controlling and coordinating the increased cellular activities and gene expression. If the cell becomes too large without a proportionate increase in the size of the nucleus (a low NCR), the nucleus may struggle to effectively control the cell's functions, leading to inefficient regulation of cellular processes In smaller cells, a relatively larger nucleus (a high NCR) can efficiently regulate the limited cytoplasmic content

25. a) **After-ripening** refers to the period of time given to ripe fruits such that their seeds undergo structural and metabolic changes that enhance their ability of germinating when conditions become favorable. The seed coat becomes more permeable to water and gases, allowing for better exchange of nutrients and gases required for germination. Often involves the breakdown of germination inhibitors; triggers the activation of various metabolic processes within the seed, such as respiration, enzyme synthesis, and mobilization of stored nutrients, which are essential for germination and seedling growth; breaks embryo dormancy; makes embryo more sensitive to light in positively photoblastic seeds; builds up food stores in seed; lowers ABA; rises GBA levels; Increases seed longevity since seeds that have undergone after-ripening more likely to maintain their viability for longer periods, allowing for effective seed banking/storage.

b) **Changes:** Breakdown of cell wall components, such as pectins, hemicelluloses, and cellulose by enzymes like pectinases and cellulases are responsible for degrading these components to softening it;
Breakdown of chlorophyll and the synthesis of pigments such as carotenoids and anthocyanins. Chlorophyll degradation causes the green color to fade, while the accumulation of carotenoids and anthocyanins imparts yellow, orange, red, or purple colour to the pericarp, depending on the fruit type. Increased synthesis of volatile compounds including esters, alcohols, and aldehydes responsible for the characteristic flavors and aromas associated with ripe fruit contributing to the pleasant scent and taste of ripe fruit; Sugar accumulation occurs due to hydrolyssis of starch reserves and the activation of enzymes involved in sugar metabolism; Increased breakdown of organic acids, such as citric acid, malic acid decreasing acidity of fruit contributes to the overall flavor balance of the ripe fruit; Alterations in cell structure, water content, and the composition of cell wall components
Significance: softening of the fruits allowing fruits to become more palatable and facilitates seed dispersal through animals that consume the fruit; Synthesized colour pigments give fruits their characteristic red, orange, or purple hues, attracting animals that aid in seed dispersal; the changes in aroma and flavor profiles enhance the attractiveness of ripe fruits to animals; the sugar accumulation not only contributes to the sweet taste of ripe fruit but also serves as a source of energy for seed development and germination.

b) i) % of corns growing for seeds kept at 6^{o}C far higher; and starter germinating at an earlier time.
ii) The difference is attributed to **prechilling of seeds/ cold stratification** at 6^{o}C unlike those kept at room temperature (25^{o}C) **;** a method used to simulate natural winter conditions for certain seeds, including corn, which improves their germination rates and overall seedling growth ability before they are sown by subjecting them to a long period of cold treatment; **helps overcome barriers such as hard seed coats**, **chemical inhibitors, or inhibitory physiological processes within the seed** by mimicking the cold winter conditions that corn seeds go throu in their natural environment before the warmer spring conditions arrive; also helps synchronize the germination of seeds, ensuring that a large number of plants emerge simultaneously. By artificially inducing cold treatment, seeds that require cold stratification can be successfully grown in areas where such conditions are not naturally present. **Cold temperatures during stratification activate certain enzymes that are involved in the germination** which help the seed convert stored nutrients into energy

required for germination and early seedling growth; **also allows the seed to absorb water more efficiently when it is planted**, which is essential for germination to occur; **breaks embryo dormancy**;

26. (a) RQ Value **can inform biologist the type of respiration going** on and the **nature of substrate being respired**. For example, by measuring the ratio of carbon dioxide (CO2) produced to oxygen (O2) consumed during respiration, biologist can determine whether the body is primarily using carbohydrates (RQ = 1.0), fats (RQ < 0.7) and protein (RQ of 0.8) as an energy source. High anaerobism (RQ>1.0) and aerobism of sugars (RQ=1.0).
Monitoring RQ can help diagnose and manage health conditions. For example, an elevated RQ may be associated with conditions like diabetes or insulin resistance, while a reduced RQ can be seen in conditions like malnutrition.
Predicting state of activity of organism such as hibernating mammal has RQ below 1 as it oxidizes fat stores but the RQ value increases to 1 after arousal from torpor.

(b) From 40 to 80 minutes, RQ reduced rapidly below 1.0 due to the shortage of carbohydrates and the metabolic switch from carbohydrate respiration to mixture of low remaining carbohydrates and the abundant lipids and proteins; which need more oxygen and produce less carbon dioxide on metabolism.
From 80 to 160 minutes, RQ decreased further but gradually to minimum due to increased metabolism of mainly lipid stores to generate much metabolic energy; as possibly the bird was highly active during the fast.
From 160 to 200 mins RQ increased gradually due to reducing rate of oxidation of lipid stores; as the bird was now to rest during the fast.
From 200 to 240 mins, RQ remained constant at 0.7 because the bird respires lipid at a stable rate which required much more oxygen to metabolize but produce little carbon dioxide on oxidation; as it was also in a stable state of low activity.

(c) At 0 days (onset of germination); RQ is high and above 1.0 due to high anaerobism as a result of the high impermeability of seed to air such that respiratory metabolism released far more carbon dioxide that the oxygen consumed in the process.
From 0 to 2 days, RQ drops rapidly due to imbibition of water softening seedcoat increasing permeability of seed to air such that there was increased oxygen uptake by the seedling thus reducing anaerobism; and increasing aerobism.
From day 2 to day 5, RQ is low and remains constant at 0.7 because of aerobic oxidation of stored lipids that uses more oxygen than the carbon dioxide the process evolves.
From day 5 to day 6, RQ reduces very rapidly to a much lower value as some of the carbon dioxide evolved in aerobic oxidation of lipid stores is now being used for photosynthesis.
From day 6 to day 8, RQ remains constant since there is stable rate of conversion lipid stores to carbohydrates (sugars), a process that consumes much oxygen.
From day 8 to day 10 RQ increases rapidly because of the metabolic shift to the respiration of both the low remaining lipid stores and the increasing carbohydrates produced by photosynthesis.

(d) RQ Values are not realistic because they;
Assume that at one particular time, the organism respires only one particular substrate yet in, living organisms can respire a cocktail of substrates.
Assume a steady state in which the metabolic processes are in equilibrium. In reality, metabolic processes in organisms can fluctuate widely in response to changing energy demands, nutrient availability, and other factors but not the substrate being respired.
Assume ideal and complete oxidation of substrates yet in reality, in living organisms not all substrates are completely oxidised. For example, during anaerobic metabolism, incomplete oxidation can occur, leading to the production of lactic acid.

27. (c) Glandular plant tissues include laticiferous (latex-secreting) tissue, trichomes, nectar glands, hydathodes, glandular pitcher, etc

Secrete chemical compounds such as toxins, repellents that deter herbivores, pathogens, or competing plants enhancing their chances of survival and reproduction; Secrete nectar that attracts pollinators facilitating successful reproduction; Certain glandular tissues, such as the glandular trichomes found on the leaves of carnivorous plants like sundews and pitcher plants, secrete sticky substances that trap insects and other small prey to obtain nutrients from trapped prey; Glandular hairs produce substances like mucilage, which can help in cooling the plant by reflecting sunlight and reducing water loss through transpiration; Glandular tissues can be an adaptation to specific environmental conditions. For example, salt glands in halophytic plants help excrete excess salt allowing the plants to thrive in saline habitats.

Laticiferous tissue or latex-producing tissue produces latex that acts as a chemical defense against herbivores and pathogens; Latex also seal cuts or injuries on the plant's surface preventing the entry of pathogens and reducing water loss

Hydathodes exude excess water in hydrophytes thru guttation, while in halophytes excude excess salts

28. (a) Abdominal pumping in insects refers to the rhythmic contraction and expansion of the insect's abdomen to facilitate the flow of air in and out of the insect's respiratory system. This is essential for an insect's respiration to deliver oxygen directly to their cells and driver away carbon dioxide; in large insects where diffusion is inadequate.

(b) (186-42/42) x100 =342.8%

(c) Small insects **have a large surface area to volume ratio**, the distances over which oxygen and carbon dioxide must travel within the tracheal system are relatively short due to their small size. This allows for **efficient passive diffusion of gases,** where gases simply move through the thin tracheal walls by diffusion, driven by concentration gradients.

The size of their tracheae and the reduced space for muscle attachments make it difficult for them to generate the mechanical forces required for abdominal pumping.

(d) (i) **60/10 =6 times per minute**

(ii) Little water is lost so more is retained reducing desiccation chances; Conserve energy during times when resources may be limited due to adverse environmental conditions

(e) Malpighian Tubules remove waste products in form of dry uric acid crystals and excess ions from the hemolymph (insect blood); Rectal glands help insects reabsorb water from their feaces and concentrate their urine. Tracheal system can be used by insect to release excess water thru opened spiracles; Chitinous exoskeleton prevents water loss; Metabolically release water into tissues in times of insufficiency; Use behavioral means e.g. nocturnal lifestyle; Valves of spiracles close to prevent water loss on hot days; etc

29. (a) (i) A represents the rods because of their absence at position 6.3 arbitrary units, the fovea

B represents the cones because their concentration is highest at position 6.3 arbitrary units, the fovea

(ii) position 5 is the blind spot, where nerves from the rods and cones converge to form optic nerve fibres and leave the eye connecting to the brain, hence no rod or cone cells are present

(iiI) Fovea centralis because of the highest number of cone cells present there;

b) (i) This is because position 6.3, the fovea centralis, is in line with the lens hence it receives most of the light rays; at centre of principal axis of eye lens; hence high degree of stimulation of the cone cells by the incident light rays from the given object,hence high visual acuity

(b)(ii) From bright sunlight ,much photo decomposition of rhodopsin had occurred hence much of the retinene is in transform ,thus rod sensitivity is low hence objects in the room at first cannot be seen , the objects gradually become visible due to resynthesis of cis-retinene in adequate amounts, the resynthesize process is a slow enzyme -catalysed reaction, the adequate cis retinene amounts caused the the rod cells to regain sensitivity

hence when they are struck by dim light, they are bleached causing depolarisation, producing generator potentials hence producing action potentials transmitted to the brain.
In bright light, the circular muscles of the iris contract and radial muscles relax to narrow the pupil; and reduce on over-stimulation of the retinal cells by entry of light into the eye. In dim light, radial muscles contract to dilate the pupil slowly to allow entry of light; whose threshold at first is low to stimulate the rods for objects to be seen; but later improves to enable vision as the pupil dilates fully
(b) (iii) Rods are sensitive to light of low intensity, hence only them are bleached in a dimly lit room.
Rods are of one type (one type of visual pigment rhodopsin), and are unable to distinguish between colours hence the brain perceives the objects in black and white only
b(iv) The retina of nocturnal animals is almost entirely composed of rods; with rhodopsin which is particularly sensitive to low levels of light and breaks down so rapidly in bright light; The slit pupil and squinted eyes reduce the amount of light entering the eye to enable rhodopsin form faster than it breaks down for vision to occur;
(v) When looking directly at the faint star, most of the light rays fall onto the fovea which has only the cones, of which cones are insensitive to light of low intensities hence no perception of an image
But when looking slightly to one side of it , most light rays are incident on part of the retina with lot of rods which are sensitive to light of low intensity i hence bleached, producing depolarisation, producing generator potentials which build up producing an action potential transmitted via optic nerves to the brain perceiving a faint star.
(vi) Pressing of eye ball distorts the normal common horizontal eye position such that the two eyes are unable to look directly at an object in the same direction, hence the brain fails to blend together the images from the two eyes, causing double vision to be perceived.
(Vii) Presence of two eyes along the same horizontal plane allows **stereoscopic vision**, which allows for overlap of visual fields of the two eyes, that are focused on the same object, such that the slight difference in two images perceived is resolved into one by the brain to give a precise appearance and location of the object.
(viii) The forearm has a lower density of touch receptors whereby only single receptor is stimulated; unlike the fingertip which has a higher enough density of touch receptors such that both points of dividers each stimulates a touch receptor.
(ix) The many different flavours of food are rather detected the olfactory epithelium in the nose as smell; but not tongue taste buds. A cold blocks nasal passages preventing the chemical vapours from food in the mouth from entering the nose; so they are detected to a lesser extent; so making food appear 'less tasty'.
(x) Staring at a bright red circle for 30seconds over stimulates the red cones to the point where they are no longer capable of transmitting impulses to the brain for interpretation; ie they become adapted. Shifting gaze to white wall would normally result into equal stimulation of the three cone types, but inability of the red cones earlier stimulated by the red circle to transmit information to the brain , means that only blue and green cones in this region send messages to the brain; the brain interprets the information as a blue-green circle-described ass an image of green.
c (i) Presence of numerous cones at the fovea centralis at position 6.3 which cones are of many types that is 3 types blue, green and red cones where most light rays from the object are incident allowing colour vision
(ii) The human eye photoreceptor cells are sensitive to a range of only visible light wavelengths but not ultraviolet light which is beyond the visible spectrum. Bees have the ability to see and distinguish different patterns of ultraviolet light, which is a part of the electromagnetic spectrum that is invisible to humans.

30. (a) **Temperature Similarity**: In both from 11m to 15m depth, temperature remains constant
Differences in temperature: From 0 to 2.5 m depth, temperature increases in winter while remains constant during summer.
From 6m to 10m depth, temperature remains constant in winter while it decreases during summer.
Surface temperature is extremely lower in winter while is higher during summer
From the surface to the deepest bottom of lake, temperature changes slightly while changes greatly during summer.
Temperature remains constant over a bigger change in depth of lake in winter than during summer.

Similarity for oxygen: In both from 0 m to 7m depth oxygen concentration remains constant

Differences for oxygen

From 10m to 15m depth oxygen decreases in winter while remains relatively constant during summer.

From 5m to 10m oxygen concentration remains relatively constant in winter while decrease during summer.

From the surface to the deepest bottom, oxygen change is smaller in winter while change is greater during summer

b. (i) **Winter:** From 0 to 10m oxygen level is high and remains constant because during winter the transparent ice floating at the surface of the water, allows oxygen production from photosynthesis but limits oxygen consumption by aerobes, which would have moved to deeper layers of water where water remains warmer.

From 10m to 15m oxygen decreases slightly because there is reduced oxygen production from low photosynthesis, due to low light intensity yet high aerobic activity consumes oxygen.

(ii) **Summer**: From 0m to 6m oxygen remains moderately high and constant because much as this layer receives much light for production of oxygen from photosynthesis, the warmth of water causes oxygen to dissolve out of the water and also favours habitation by both microscopic and vertebrate aerobes, to balance oxygen consumption with production.

From 5m to 10m dissolved oxygen decreases rapidly because of rapid decrease in photosynthesis caused by the rapid decrease in temperature during the same depth of water

From 10m to 15m, dissolved oxygen remains constant because of reduced photosynthesis due to reduced light intensity, yet high aerobic activity consumes oxygen

(c) (i) Photosynthetic activity, and dissolution from air

(ii) Sun's radiation which heats the top layer of water then waves mix up this water to distribute heat within the top layer of water. Surface ice maintains temperature at the lake bottom constant as it insulates the lake

(d) Increase in temperature decreases dissolved oxygen, because oxygen dissolves out of water

Decomposition of organic matter and metabolism increases, which increases demand for oxygen by aerobes

(e) Nutrient enrichment (eutrophication); Turbidity increases and reduces photosynthesis at the point of discharge; Bacteria decomposition activity releases ammonia, which is oxidised to nitrites and nitrates;

Fertilisers contain nitrogen which increases the nitrate levels in water; increased BOD; Reduced biodiversity;

31.(a) **Similarities**

Both attain a maximum; -Remain constant during the latent period; Increase during initial infection;

Differences

T4 Cells	**HIV particles**
Higher maximum attained	Lower maximum attained
Increase more rapidly during initial infection	Increases less rapidly during initial infection
Initially lower during initial infection	Initially higher during initial infection
Higher during latent period	Lower in the latent period
Lower during development of AIDS stage	Higher during development of AIDS Stage
Decreases rapidly during development of AIDS	Increases rapidly during development of AIDS
Increases towards latency stage	Decreases towards latency stage

iii) **During the initial infection,** number of HIV particles increases more than that of T4 cells; because it is not recognized by T4 cells; as immune system is not yet sensitized; thus on entering the body cell, HIV freely replicates; proliferates faster;

Towards latency stage, number of T4 cells increases while number of HIV particles decreases; because T4 cells recognize antigens presented on body cells; activated; rapidly divide by mitosis; increasing their number more than that of HIV particles; kill the HIV particles; decreasing number of HIV particles;

During the latency stage, the number of HIV particles is low and constant while the number of T4 cells is high and constant, the virus is still active but produces at very low levels.

During the development of AIDS stage, number of HIV particles increases while number of T4 cells decrease because after a period of dormancy/latency in the nucleus of infected T4 cells; suddenly, T4 cells makes copies of viral genes/mRNA; migrating into the T4 cell cytoplasm, and using the cell's proteins synthesis mechanisms; new HIV particles are formed; bursting out of the T4 cell; infecting and killing more T4 cells; decreasing the number of T4 cells; (Reference to Viral lytic cycle)

(iv) Opportunistic infections are infections that **occur in individuals with weakened immune systems.** In later years of the infection, with the lower number of T4 cells than HIV particles; secretion of cytokines by T4 cells stops/decreases; thus, B lymphocytes are not activated to proliferate into antibody producing plasma cells; progressively impairing the cell-mediated and humoral immune response systems; increasing susceptibility of the body to opportunist pathogens;

(v) Frequently change shape of antigens; due to mutations; so that it can no longer be identified by the white blood cells; hence it escapes being removed from the body; -Long latency periods within the infected cells; allows the spread of the viral DNA; without triggering an immune response; and also protects the virus from antiviral agents; -Destroys T helper cells impairing the cell-mediated immune response system as well as production of antibodies by the B –cells -It does not kill its host quickly; this provides more time for its division and spread;

(vi) Absence of metabolic mechanisms/pathways; and cell structures in HIV; for antibiotics to disrupt; as HIV rely on the host cells; to carry out its metabolic activities; HIV have envelope protein rather than murein cell wall; thus do not have sites where antibiotics can work; Antibiotics cannot reach HIV within the host's own cells;
(vii) Mix HIV antigens with sample of patient's blood; look for evidence of agglutination/reaction;
(viii) In the final stage of HIV infection, the T – lymphocytes decrease rapidly because the virus multiplies rapidly; so many T cells destroyed/virus causes T-helper cell/lymphocytes to lyse; T-helper cells would induce B-lymphocytes to secrete antibodies, ; thus antibody formation is impaired (fall on graph); thus the body is more susceptible to infection/ virus causing tumours
(ix) Responsible for cell-mediated response/cellular response; recognize antigens presented on body cells/antigen-presenting cells; activated; rapidly dividing by mitosis into a clone of identical T cells which differentiate into T4 cells/CD4 cells/T-helper cells; secrete cytokines on contact with Antigen-presenting cells; which stimulate B lymphocytes to proliferate into antibody producing plasma cells; and memory B cells that retain information of a particular antigen allowing a rapid secondary response on attack by the same antigen

T8 cells/CD8 cells; which include: (i) Killer T cells/Cytotoxic T cells; attack and kill cancer cells; virus infected body cells; and cells in transplanted organs; by releasing chemicals, perforins; that punch holes in cell surface membrane; water rushes into the cells; cell swells and burst; (ii) Suppressor T cells; Secretes cytokines that suppresses the activities of the plasma cells and macrophage cells; once the pathogen has been eliminated from the body; T memory cells; that retain information of a particular antigen; allowing a rapid secondary response on attack by the same antigen.

32. (a) (i) **Aerofoil** refers to any smooth surface which moves through the air at an angle to the airstream.
(ii) **Lateral drag** in fish refers to the hydrodynamic force that fish experience which tends to push fish body (tail and head) sideways as fish forward thrusts through water.
b. (i) **Birds:** When a wing is held at an angle relative to the flow of the airstream,'the angle of attack', air flows over the wing at faster speed than below the wing, the pressure above the wing reduces compared to the pressure below the wing, due to pressure difference a lift force is generated.

ii) **Dogfish: By action of paired fins,** particularly the pectoral fins and the caudal fin, **the pectoral fins are held at a slight angle to the body** so as the caudal fins propels the fish forward, the pectoral fins are pushed

against water and experience a force which can be resolved into upward and backward components, the upward component provides support which is the lift force.
In addition it uses its **heterocercal tail**'s asymmetrical shape, with the upper lobe (or dorsal lobe) **being larger and extending further than the lower lobe (or ventral lobe)**. This design helps the dogfish maintain buoyancy and stability in the water. The larger dorsal lobe provides lift, similar to the wing of an airplane, which helps the fish stay buoyant and keep its head up while swimming.
iii) Teleost fish: **Air-filled swim bladder provides buoyancy**, to generate a lift a counter current exchange system operates in the closed swim bladder and the gas glands, lactic acid is produced by the epithelial cells of the gas gland, lowering the PH causes dissociation of oxyhemoglobin in the gas glands, oxygen diffuses into the swim bladder, inflation of the swim bladder results into buoyancy and hence a lift.

(c) **Yawing;** lateral deflection of the anterior part of the body of the fish from the propulsive action of the tail.
It's counteracted by the vertical fins; that create a great resistance against water by increasing the surface area against water; and the **general massiveness of the head** and the great water pressure against the side of the body.
Pitching: tendency of the head to vertically plunge downwards, it's counteracted by the dorso-ventral flattening of the body and large horizontal fins, by pectoral and pelvic fins in teleosts.
Rolling: rotation of body about the longitudinal axis, it's counteracted by the vertical and horizontal fins.

33. a) Mass flow is passive bulk transport of fluid from one point (source) to another (sink) due to the hydrostatic pressure difference between them; it requires a hydrostatic pressure difference, a circulating fluid, and no energy.
b) i) A Sink e.g growth region, respiring tissue B Source e.g. photosynthesizing tissue; storage organ
C Sieve tubes/ phloem D Xylem vessels
(iii) Munch's mass flow hypothesis fails to account for the role of metabolically active companion cells; bidirectional flow of phloem sap; different rates of movement in phloem tubes; high number of mitochondria in companion cells; why rates of flow of phloem sap falls in case of metabolic poison injected in bark (phloem)
c) (i) Increase sucrose content in leaves increases sucrose content in phloem; and reducing sucrose content in leaves reduces phloem sucrose content.
ii) Increase in sucrose content of phloem is as a result of increasing light intensity that increases leaf photosynthesis; increasing rate of building up of organic solutes like sucrose that has to be translocated via phloem to the sink.

Peak of sucrose content of phloem is as a result of high optimum light intensities favoring high rate of photosynthesis such that there is high rate of loading of sugars into phloem for its translocation to the sink.

A decrease in sucrose content of phloem is as a result photosynthesis rates decreasing due to reduced sunlight, such that the source leaves load less sucrose into the phloem

iii) Sucrose content of leaves is greater than that of phloem showing that leaves are the source where there should be higher solute concentration in comparison to sink; enabling mass flow of these organic solutes into phloem; and shows that the hydrostatic pressure as a result of osmotic influx of water from xylem is greater at leaves that the phloem /sieve tubes.

34. a) Threat postures e.g.in male robins; Aggressive calls e.g. roaring in bull alligators/lions, croaking in toads; Scent markings e.g. use of solid wastes in hippos; Urination in cats; Waving claws in fiddler crabs; Singing in many bird species; Chemical signals by release of pheromones e.g. in insects
b) (i) Animals avoid wasting time and energy responding to harmless stimulus that do not threaten their survival and reproduction; Filters information from the environment allowing animals nervous system to focus on stimuli

that signal food, mates, or real danger beneficial to its survival; Habituation reduces unnecessary stress and arousal by preventing an organism from responding to stimuli that pose no immediate danger

(ii) Parent-offspring bonding enhances survival e.g. migratory salmon fish can trace their way back to fresh water streams to spawn; Effects communication between parents and the young; Young rapidly acquire survival skills form their parents; Prevents breeding between different species; Allows the young animals avoid predators as they tend to avoid those not imprinted to; Offers parental protection to the young during early stages of life; Ensures that organisms recognize and consume the correct diet they imprinted on while at young age when they become independent.

(iii) Protection of the young; Promotes survival of organisms having short life cycles because it provides the organism with readily made set of behaviors response; Allows animals to fight to be in charge; Allows animals choose mates; Allows animals form groups for protection from danger.

c) (i) **Operant conditioning (Trial and error learning**) is where animal learns to associate a particular act with reward or punishment (reinforcement); animal behavior depends on whether or not a reward appears; Removal of the cerebral cortex does not cause loss of response; Association is less easily removed.

Classical conditioning is where animal learns to respond to an **originally meaningless stimulus** by associating it with a particular outcome. Removal of cerebral cortex cause loss of response; Association is more easily removed.

(ii) Size of reward or punishment (Degree of motivation); State of brain development; State of development of sense organs; Complexity of the learning situation; Frequency and time duration between trials

(iii) Instinctive/innate/unlearned; Carried out by all individuals in a species; Stereotyped/fixed (Responses to the same stimulus are always similar in a species); Inborn; passed on from parent to offspring, Automatic, thus do not require learning/conscious thought, Conditioned; Can be modified following exposure to new stimulus, Rapid and short lived; Many are protective

35. a) **Striated (skeletal) muscle**

Structure	**Function**
Elongated fibres	Allow considerable contraction
Parallel fibres	Give maximum contractile effect
Fibre ends tapered and interwoven	Provide strength
Large number of mitochondria	Provide large amount of ATP
Actin and myosin arrangement in sarcomere	Allows contraction by filaments sliding over each other
Rich supply of blood vessels	Provide adequate supply of oxygen and glucose
Myoglobin present	To store oxygen for release when blood oxygen levels are low
Motor end plates	Allow stimulation of muscle
Fibres arranged in motor units	Permit variable degree of stimulation depending on number of units stimulated

b) **Parenchyma cells**

Structure	**Function**
Many intercellular spaces	Diffusion of gases
Isodiametric cells	Packing material
Unspecialised tissue	Variety of functions
Thin cellulose walls	Permit passage of materials
Transparent cell wall	Permit entry of light for photosynthesis
Permeable walls	Allow water entry for turgidity
Large cells / Large vacuoles	Provide storage space
Chloroplasts present	Allow photosynthesis

Chromoplasts present	In petals provide colour to attract insects for pollination
Leucoplasts present	To store starch

36. a) Yes—if the complementary bases lined up over the entire length of the two strands, they would twist into a double helix analogous to a DNA molecule. The same types of hydrogen bonds and hydrophobic interactions would occur as observed in the "stem" portion of hairpins in single-stranded RNA.
b) In DNA, the secondary structure requires that every guanine pairs with a cytosine and every thymine pairs with an adenine, resulting in consistent ratios between the nucleotides. Chargaff's rules do not apply to RNA, since it is single-stranded and the pairing is not consistent throughout the molecule.
c) DNA has limited catalytic ability because it (1) lacks functional groups that can participate in catalysis and (2) has a regular structure that is not conducive to forming shapes required for catalysis. RNA molecules can catalyze some reactions because they (1) have exposed hydroxyl functional groups and (2) can fold into shapes that that can function in catalysis.
d) In a triplet code, addition or deletion of 1–2 bases disrupt the reading frame "downstream" of the mutation site(s), causing a frameshift; downstream bases are re-arranged into a new sequence of codons; resulting in a dysfunctional protein. But addition or deletion of 3 bases restores the reading frame—the normal sequence is disrupted only between the first and third mutation. The resulting protein is altered but may still be able to function normally. Only a triplet code would show these patterns.
e) A point mutation changes the nucleotide sequence of an existing allele, creating a new one, so it always changes the genotype. But because the genetic code is redundant (degenerate), and because point mutations can occur in DNA sequences that do not code for amino acids, these point mutations do not change the protein product and therefore do not change the phenotype.
f) The wobble rules allow a single tRNA to pair with more than one type of mRNA codon. This is distinct from redundancy, in which more than one codon can specify a single amino acid. If the wobble rules did not exist, there would need to be one tRNA for each amino-acid-specifying codon in the redundant genetic code.
h) Ribonucleases breaking down RNA molecules into their constituent ribonucleotide building blocks; maintaining the balance of RNA in the cell and for regulating gene expression, ribonucleotide products are raw material for synthesis of new nucleic acid; also degrade viral RNA and limit the replication of the viruses.
i) On the lagging strand, DNA polymerase synthesizes new complementary strand as short segments sealed by ligase; moving away from the direction of replication fork against direction of unwinding of DNA helix. On the leading strand, DNA polymerase moves in the same direction as helicase, so synthesis can continue, without interruption, from a single primer (at the origin of replication).

37. a) At the beginning of telophase, the separated chromatids (now individual chromosomes) have reached the opposite ends or poles of the cell; these chromatids start to de-condense, become less distinct. uncoil, lengthen, become thin and appear as threadlike structures called chromatin. The nuclear envelope, which had disintegrated during prophase, starts to reassemble around each set of chromosomes. Within the newly forming nuclear envelopes, small structures called nucleoli, which are involved in ribosome synthesis and assembly reappear. Eventually cytokinesis begins,

b) Cytokinesis in plant cells	**Cytokinesis in animal cells**
Cell plate formed	No cell plate formed
Phragmoplast formed	No phragmoplast formed
No cleavage furrow formed	Cleavage furrow formed
No constriction of the cell membrane	Cell membrane constricts
vesicles are transported to the center of the cell to create the cell plate	contractile ring of actin filaments pulls the membrane tighter until the cell is pinched in two.
Divided cells remain joined by middle lamella	Cells divide completely. (No middle lamella forms)

c) **first law:** in a diploid organism, a pair of alleles control a given characteristic, only one allele of a pair is represented in a single gamete. Each chromosome in a homologous pair carries one allele. During prophase 1, homologous chromosomes pair up at points called chiasma to form bivalents a process called synapsis. During metaphase 1, bivalents line up at the equator of the spindle, during anaphase 1, the homologous chromosomes are pulled to opposite poles separating the two alleles resulting into formation of new cells with only one allele of the pair.
Second law: In dihybrid inheritance, each of the alleles of one pair controlling a given characteristic may combine with either of another pair controlling another characteristic in a single gamete.
In a diploid organism, each characteristic is controlled by a pair of alleles each obtained from each parent on homologous chromosomes. During prophase 1, homologous chromosomes pair up, at point called chiasma to form bivalents a process called synapsis. During metaphase 1, the different bivalents align randomly at the equator of the spindle fibres. This is followed by the subsequent independent assortment when these homologous chromosomes are pulled to opposite poles during anaphase 1, that gives several possible combinations of chromosomes in one gamete hence each of the allele of one pair has equal chances to be either of the alleles of the other pair in a single gamete.

38. (a) Positive feedback amplifies specific physiological processes when a deviation from the set point is necessary e.g. in blood clotting, positive feedback ensures that a small initial clotting response quickly becomes a larger more effective clot, as more platelets are recruited and activated; to eventually stop excessive bleeding.;
Positive feedback loops help ensure that (emergent/ critical) processes are carried out to completion, eg. In nerve impulse propagation, once a sodium channel opens and allows sodium ions to enter a neuron to threshold, it triggers adjacent channels to open, leading to the complete propagation of the nerve impulse along the entire length of the axon;
Ensure a rapid and effective response to a particular stimulus or condition to enhance survival/ enable protection against harmful consequences of slow response e.g. birth; blood clotting

b) (i) **Parturition:** Towards the end of gestation period, the concentration of progesterone in blood greatly reduces; this removes its inhibitory effect towards release of oxytocin hormone; by the posterior pituitary gland; which releases oxytocin into blood, which together with prostaglandins; stimulates the contraction of the myometrium of the uterus. ; This causes the cervix to widen; thereby stimulating the stretch receptors within the walls of the uterus and cervix, ;firing impulses via the autonomic nervous system to the myometrium stimulating **its further contractions**. ; Some impulses from the stretch receptors are conveyed to the hypothalamus, which **stimulates further release of oxytocin** ;by posterior pituitary gland into blood by positive feedback, ;causing **further contractions of the myometrium** of the Uterus.

(ii) When blood sugar levels rise above norm, corrective mechanisms to restore norm fail, due to individual being diabetic; such that insulin is either insufficient or ineffective. As blood sugar levels rise, the body's cells are unable to efficiently take up glucose due to insulin deficiency or resistance. The liver releases more glucose into the bloodstream through gluconeogenesis which increases blood sugar levels even further. Elevated blood sugar levels also increases thirst and hunger causing the individual to consume more food and fluids, increasing their carbohydrate intake; resulting into a vicious cycle creating a positive feedback loop. The more hyperglycemic the individual becomes, the more they may consume, which can further worsen their condition; eventually causing glycosuria, polyuria, multiple organ damage, etc.

(iii) The reception of the initial stimulus from the previous nerve cell depolarizes the region around the first set of voltage gated ion channels in the membrane to open allowing influx/ diffusion of sodium ions into the axoplasm. Membrane potential rises to threshold and this part is depolarized; firing an action potential that **causes spread of local circuits/ currents to surrounding area**; **further depolarize the surrounding area**

of neurone causing **the next set of sodium ions channels to open** and the **process continues; by positive feedback along entre length of axo**n. Meanwhile the previous region where impulse has passed gets repolarised/ hyperpolarized by opening of potassium ion channels such that these ions efflux; to prevent back flow of impulse.

(iv) Once the high critical temperature is exceeded, the metabolic rate starts to rise and continues to rise as long as the ambient temperature continues to rise, chemical reactions in the body double their rate for every 10^oC **rise in ambient temperature generating more heat which raises the metabolic rate further**. This is repeated until hyperthermia occurs characterised by high fever, rapid heartbeat, Rapid breathing, Nausea and vomiting, Confusion, Dizziness, fainting

39. a) **Presentation time:** Increase in temperature from 10^0C to 20^0C causes a rapid decrease in presentation time. Increase in temperature from 20^0C to 30^0C causes a gradual decrease in presentation time to the minimum. Further increase in temperature from 30^0C to 40^0C causes a rapid increase in presentation time.
Statolith movement: Increase in temperature from 10^0C to 20^0C causes a rapid decrease in time taken for the statoliths to fall within the cell. Increase in temperature from 20^0C to 30^0C causes a gradual decrease in time to fall width of cell to the minimum. Further increase in temperature from 30^0C to 40^0C causes a rapid increase in time to fall width of cell.
b. (i) Statolith movement is a gravitational response to the starch grains/ amyloplasts/ starch organelles in plant cells which brings about a geotropic response.
As temperature increase from 10^0C to 30^0C, time to fall width of the cell decreases to the minimum because increase in temperature greatly increases the rate of enzymatic metabolic reactions within the cell including gravitropic responses causing the statoliths to move rapidly to the bottom of the statocytes. 30^oC is the optimum temperature for the enzymatic reactions causing highest gravitropic response to the statolith grains. As temperature increases from 30^0C to 40^0C, time to fall width of the cell increases rapidly because the enzymes and proteins responsible for controlling gravitropism and statolith movement denature losing their functional structure, leading to a decrease in their activity; which disrupts the cellular processes responsible for moving statoliths to the bottom of the statocytes (cells) /High temperatures damage these starch-filled organelles called amyloplasts organelles directly, causing the breakdown of starch granules, reducing their density and ability to move to bottom of the cells they are contained.

ii) **Presentation time** refers to the minimum duration for which the plant statolith (a dense starch granule) is exposed to a particular orientation or gravitational force to bring about a geotropic response. or A minimum period of time for with an originally vertically growing seedling is placed in a horizontal position such that a bending response would result if returned to the vertical.
As temperature increase from 10^0C to 30^0C, presentation time decreases to the minimum because increase in temperature increases enzymatic activity and cellular reactions increasing the rate of statolith accumulation and overall statolith concentration at the bottom of the statocytes hence reducing the time taken for a bending /geotropic response. As temperature increases from 30^0C to 40^0C, presentation time increases rapidly because high temperatures destroy the statolith hence reducing their concentration/ protein denaturation reduces rate of gravitation pull to the statoliths in cells. This increases the presentation time required to cause accumulation of enough statolith at the bottom of cells to cause a geotropic response.
c) Presentation time would increase rapidly further and then stop. Plant response would decrease and then stop. This is because further increase in temperature causes more statolith destruction and metabolic enzyme denaturation until a point when all the statolith has been destroyed. Plants will eventually no longer detect gravity hence its response to gravity stops.
d) Mode of action of auxins: Auxins bind to specific receptors to **activate proton pumps** in the cell surface membrane which pump protons out of the cytoplasm into the cell wall, lowering the pH of the fluid-filled spaces of the cell wall, activating proteins called **expansins** which catalyse the breakdown of cross linkages (hydrogen

bonds) in the cellulose microfibrils and other cell wall constituents loosening the wall's fabric. This increases ion uptake and osmotic uptake of water by the plant cell which increases its turgor. This causes cells to elongate.

Applications of auxins: Used to make chemicals that prevent premature fruit drop eg 2,4,5-T, stimulate fruiting eg Naphthalein acetic acid, inhibit sprouting hence enable potato storage eg 2,4-D, Synthetic auxins like 2,4-D are used as herbicides to control the growth of broadleaf weeds in agriculture.; promote apical dominance; cutting main stem/ shoot to remove source of auxins to encourage sprouting of side branches; treating unpollinated flowers with IAA to promote parthenocarpy; Synergistic with other hormones to initiate secondary growth and ripening of fruits etc; By treating stem cuttings with auxins, growers can encourage the formation of roots and the successful propagation of new plants.

e) **Positively photoblastic is** A condition where germination of seeds occurs only after **exposure to light of suitable quality or quantity** (photoperiod) while **positively phototropic** is a condition where plant parts (shoot) grow towards a unidirectional source of light.

f) Reduces herbivory since it reduces the surface area of exposure to herbivore for example in Mimosa pudica; Causes opening of flowers during day when pollinators are active for example crocus sativus; Enables carnivorous plants obtain nitrogen, phosphorus etc e.g. Venus fly traps snap shut to trap insects; Nastic responses allow plants to adapt quickly to changing environmental conditions, such as light intensity, temperature, humidity, and touch which enhances the plant's chances of survival in its specific habitat.

40. (a) Similarities

In both mean leaf area increases rapidly from day 12 to day 20.

From day 25 to 29, GA application induces gradual increases in mean leaf area of both.

Both attained maximum

Differences

Effect of applying gibberellin to the stem of intact bean plants	**Effect of applying gibberellin to the leaves of intact bean plants**
Mean leaf area remains almost constant from 25 days to 35 days	Mean leaf area increases from 25 days to 35 days
Smaller maximum leaf area is attained	Larger maximum leaf area is attained
Mean leaf area increases at a lower rate	Mean leaf area increases at a faster rate
Attained lower maximum	Attained higher maximum

(b)(i) Larger leaf area and hence more leaf growth is attained when the growing points are removed and no gibberellin applied

(ii) The shoot apex is one of the major producers of auxins, whose high concentration has an inhibitory effect on leaf growth, thus apex removal greatly reduces auxin source, concentration and inhibitory effect on leaf growth, resulting in much leaf growth, hence larger mean leaf area ; thru its apical dominance effect

(c)(i) Made GA to induce larger mean leaf area (MLA) by day 35; Made GA to further induce rapid increase in MLA beyond day 25; Increased the gap between the maximum MLA attained by the stem and control and reduced the gap; Made GA to induce somewhat similar MLA in in plants in which GA Was applied on stem and in the other group in which GA was applied on leaves; By the 25th day, made GA to Induce slower increase in MLA for the plant for which GA was applied on leaves and greater MLA (Stem)

(ii) High auxin concentration inhibits the leaf growth stimulatory effect of gibberellin in dwarf plants

(d)(i) Cell division: Cells divide by mitosis in giving rise to many identical daughter cells

Cell expansion: Cells osmotically take up water and nutrients resulting into increase in size

(ii) Gibberellins stimulate leaf growth through; Activates enzymes that loosen cell walls facilitating entry of expansin proteins; Alters the permeability of the cell wall and cell membrane to ions into the cytoplasm;

Stimulates the synthesis of carbohydrases that hydrolyse complex sugars to simple sugars thereby increasing the solute potential of the cells causing osmotic influx of water; resulting in cell expansion hence leaf growth

(e) **Similarities:** Both are effective in small quantities; Both are result in wide-spread effects; Both induce long-term effects; Both exhibit antagonism and synergism; Both regulate various processes such as growth

Plant hormone	**Animal hormone**
Produced at meristematic cell	Produced by endocrine glands
Simple organic substances	Complex organic substances
Act on nearby target organs	Act on distant target organs
Produce a slow response	Produce a rapid response
Not regulated by the nervous system	Regulated by the nervous system
Transported through xylem and phloem	Transported through blood
Lack feedback mechanisms	Under a feedback mechanism

(f)(i) Short-day plants

(ii) Length of the night is the critical element in light/dark cycle as longer periods of darkness resulted in flowering.

In I, the plants flowered because the length of the dark was longer than the light period

In II, the plants did not flower because the length of the dark was shorter than the light period

In III, the plants did not flower because there was later interruption of darkness that resulted into a shorter dark period

In IV, the plants flowered because there was earlier interruption of light that resulted into longer darkness

Only longer periods of darkness were effective in slow conversion of accumulated Phytochrome far-red to sufficient Phytochrome red ; low level of Pfr induced production of florigen hormone hence stimulated flowering in the plant species

(iii) Red light inhibits flowering; Far-red light stimulates flowering in the species

(iv) Provision of far-red light during unfavorable photoperiod; causes conversion of accumulated phytochrome far-red to sufficient phytochrome red which induces production of florigen hence stimulating flowering

41. a) **Selective breeding**	**Natural selection**
Selection pressure exerted by humans	Selection pressure exerted by environmental factors
Genetic diversity is lowered	Genetic diversity remains high
Does not lead to new species forming	May lead to new species forming
Inbreeding is common, leading to loss of vigor in offspring	Outbreeding is common leading to hybrid vigour
Proportion of heterozygotes in the population is reduced	Proportion of heterozygotes in the population remains high
Genetic isolation mechanisms do not operate	Genetic isolation mechanisms operate

b) loss of vigour, with the population being weakened by a lack of diversity and reduced fertility. Increased danger of a harmful recessive allele expressing itself, because there is a greater risk of a homozygous recessive individual arising; reduced heterosity

42.a) Metameric segmentation is the repeated division of the organism's body into a series of similar segments or metameres. The segments contain a similar set of structures, such as muscles, nerves, blood vessels, and sometimes appendages, that are repeated throughout the body; a characteristic feature in segmented animals like annelids, arthropods,

ii) Coelom is a fluid-filled body cavity found in many animals, including vertebrates and some invertebrates.

b) i) -Cleidoic egg allows reptiles, birds, and monotremes to reproduce successfully on land; as it contains specialized membranes that help retain water and protect the developing embryo from desiccation.
-Provides a protective environment for the developing embryo. It has a tough, calcified shell that acts as a barrier against physical damage and predators. The shell also allows for gas exchange, ensuring the embryo receives oxygen and releases carbon dioxide.
-The yolk within the egg provides a nutrient-rich food source for the developing embryo, allowing it to grow and develop until it hatches.
-Cleidoic egg enables reptiles, birds, and monotremes to reproduce independently of water; allowing them to inhabit diverse terrestrial habitats; reduces competition for suitable breeding sites, as they are not limited to aquatic environments.
-The ability to reproduce on land opens up new ecological niches and allowed these animals to exploit a wide range of habitats increasing their evolutionary success
ii) -The coelom provides a spacious cavity within the body that allows for the development and movement of internal organs. It provides support and protection to the organs, preventing them from being compressed or damaged during body movements.
-The coelom compartmentalizes the organs within the body, enabling their proper placement and organization. This arrangement helps prevent interference between different organ systems and allows for efficient functioning of each organ.
-In some invertebrates, such as annelids and roundworms, the coelom acts as a hydrostatic skeleton. The fluid within the coelom transmits pressure and provides support for body movement. Contraction of muscles against the fluid-filled coelom helps in locomotion and other movements.
-Nutrient and Waste Transport: The coelomic fluid acts as a medium for transporting nutrients, oxygen, and waste products between different organs and tissues within the body. It enables the exchange of materials, facilitating metabolic processes and maintaining homeostasis.
-The coelomic fluid contains immune cells and molecules that help in the defense against pathogens and foreign substances.
-Waste Storage: In certain animals, the coelom can serve as a storage site for waste products. eg in invertebrates, excretory organs called nephridia may be located within the coelom, helping in waste elimination.

iii) Bilateral symmetry is the arrangement of body structures in such a way that an organism can be divided into two nearly identical halves along a central axis.
-Bilateral symmetry allows for efficient movement and locomotion. By having a mirror-image arrangement of body parts on both sides of the body, organisms with bilateral symmetry can move in a coordinated and balanced manner.
-Bilateral symmetry often leads to the specialization of body parts. The development of paired structures allows for the differentiation and diversification of functions. For example, in humans, bilateral symmetry enables the specialization of hands for manipulation, legs for locomotion, and eyes for binocular vision.
-Bilateral symmetry contributes to effective sensory perception by having paired sensory organs, such as eyes, ears, and nostrils, positioned on each side of the body enhances an organism's ability to detect and interpret environmental cues from multiple directions.
-Prey organisms with bilateral symmetry can quickly respond to potential threats from various directions, increasing their chances of escape. Similarly, predators benefit from bilateral symmetry as it allows them to precisely target and capture their prey.
-Bilateral symmetry provides evolutionary advantages by allowing for greater diversification and adaptation.
iv)Metameric segmentation allows for greater flexibility, coordination, and efficiency of movement. Each segment can act somewhat independently, enabling specialized functions in different parts of the body. This segmentation also permits a degree of redundancy, as damage or loss of one segment may not significantly affect the overall functionality of the organism

ALL THE BEST DEAR CANDIDATES