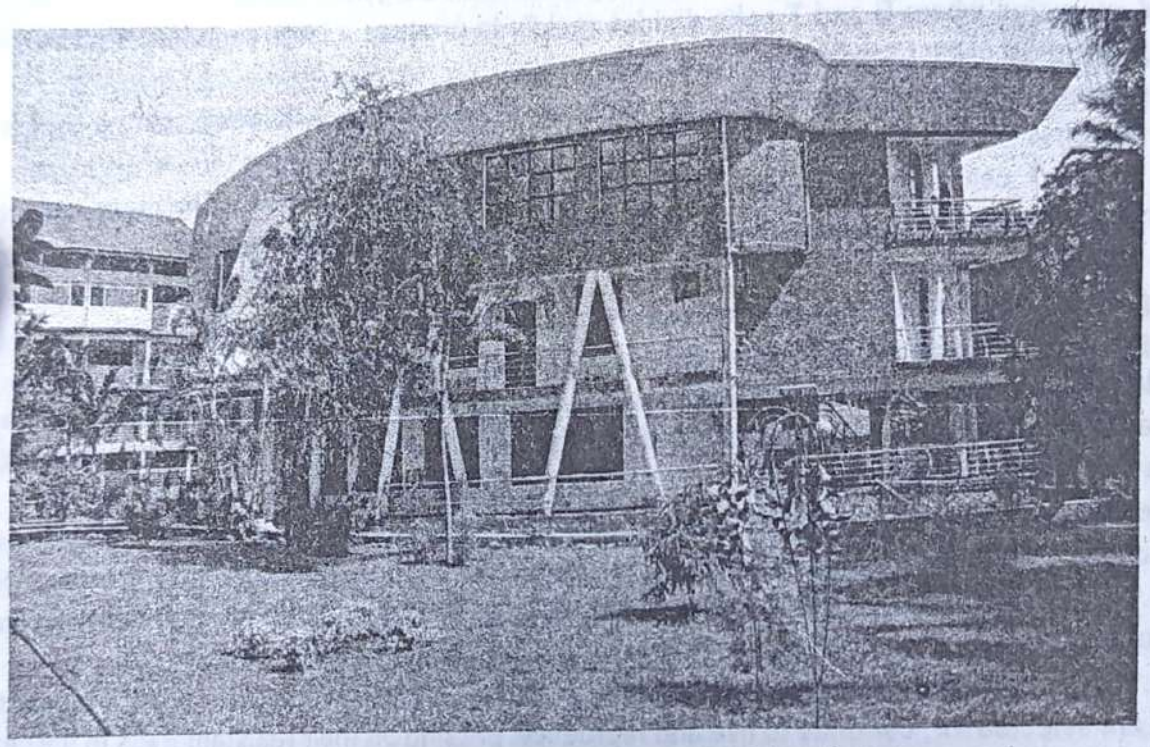
PROPOSED ANSWERS TO THE GRAND ANNUAL UMSSN A'LEVEL BIOLOGY SEMINAR QUESTIONS 2024



HEARTFELT SUCCESS

1. (a) No antibodies present at time of first exposure to the antigen; Antibody concentration rises following exposure to antigen; peak attained following exposure to antigen; first exposure results into antibodies attaining a lower peak than that following second exposure to same antigen; antibody concentration rises more greatly following second exposure than first exposure to the antigen; effect lasts longer time following second exposure than after first exposure

(b) A- Antigen presentation by Antigen-presenting cells/ macrophages/ Dendritic cells to Helper Tcells /CD_4 cells; Clonal selection where specific immune cells (B and T lymphocytes) are selected, activated, and proliferated in response to the recognition of an antigen

B- Clonal expansion where B and T cells divides rapidly to produce a large population (clone) of genetically identical cells; High helper T cell activity

C- Proliferation and differentiation of plasma cells into a few specific B memory cells; a primary immune response

D- High Helper T cell activity; Rapid activation of already-present specific B memory cells to synthesize more quickly a vast number of specific antibodies against the antigen; a secondary immune response

E & F-Highest number of specific memory cells against the antigen

(c) (i) In phase with that of secondary immune response, but lower

(ii) Would induce a primary immune response; due to the specificity of immune responses; there are no (already present) specific Memory cells against this new antigen., whose activation would induce a robust response

(iii) To develop and boost one's immunity against the antigen; by inducing much more robust, longer lived and more effective secondary immune responses, through increasing the load of specific Memory cells and antibodies formed against the antigen; providing stronger and longer-lasting protection.

(d) When these bacteria are exposed to antibiotics, those that have mutations allowing them to survive, are selected for, continue to live and reproduce, passing on their resistant traits to the next generation. Over time, this process results in a population of bacteria that are largely or entirely resistant to the antibiotic. The resistance genome is randomly picked across bacteria thru conjugation, transduction, or transformation.

(e) Hairs in the nostrils trap and filter out larger dust particles from the incoming air stream. Nasal passages are lined with a ciliated epithelium with numerous goblet cells which mucus secreted moistens the incoming air and traps the finest dust particles. Beating of cilia in respiratory tract sweeps away debris, mucus, some bacteria (foreign bodies) thus protecting against bacterial infection, blockage of tract that would result into suffocation. Superficial blood vessels in the nasal cavity warm the incoming air; Giant alveolar cells secrete phospholipid-rich surfactant which lines the inner surface of the alveoli have antiseptic property; Also present are macrophages that engulf foreign particles; Mast cells on stimulation release histamine that induces inflammatory responses

against foreign bodies coupled with diapedesis of phagocytic cells; Reflexes such as sneezing and coughing also expel pathogens

(f) (i) Blood group determination is based on the ABO blood group system and the Rh factor, both of which are determined by the presence or absence of proteins conjugated to sugar (Glycoproteins) called antigens on the surface of red blood cells.
The ABO system is the primary method for classifying human blood based on two antigens, A and B, located on the surface of red blood cells. These antigens are glycoproteins and are inherited from parents.
Type A: Has A antigens on the surface of RBCs and produces anti-B antibodies in the plasma.
Type B: Has B antigens on the surface of RBCs and produces anti-A antibodies in the plasma.
Type AB: Has both A and B antigens on the surface of RBCs and does not produce anti-A or anti-B antibodies.
Type O: Has no A or B antigens on the surface of RBCs but produces both anti-A and anti-B antibodies in the plasma.
Rhesus Factors: is another antigen that can be present or absent on the surface of RBCs; mostly of these antigens is the D antigen. Rh-positive (Rh^+): If a person has the D antigen, they are Rh-positive. Rh-negative (Rh^-): If the D antigen is absent, they are Rh-negative.

(ii) Blood Transfusion involves transferring blood from a donor to a recipient; based on the compatibility between the donor's and recipient's blood to avoid immune reactions; since the recipient's immune system may react to foreign antigens on the donor's red blood cells. If the donor's blood has antigens that the recipient's immune system recognizes as foreign, it will produce antibodies against them, leading to hemolysis (destruction of red blood cells); and agglutination therein.
Type O individuals can donate to any ABO group (universal donor) because their red blood cells lack A and B antigens. Type AB individuals can receive blood from any ABO group (universal recipient) because they lack anti-A or anti-B antibodies. Type A individuals can receive blood from type A or O donors. Type B individuals can receive blood from type B or O donors.
Rh^+ patients can receive blood from both Rh-positive and Rh-negative donors because they do not produce anti-Rh antibodies. Rh^- patients: only receive Rh-negative blood to prevent sensitization to the Rh antigen. If Rh-negative individuals receive Rh-positive blood, their immune system produces anti-Rh antibodies; which leads to complications in future transfusions or pregnancies such as Hemolytic disease of newborn.

2.(a) (i)potometer is filled with water and a leafy shoot of the plant whose transpiration rate is to be determined is cut under water This is then fitted into a potometer carefully in its rubber tubing and an air bubble is introduced by gently removing the capillary tube from the water reservoir
The setup is then placed under the sun and after some time the distance moved by the bubble is

noted and used to determine the rate of transpiration basing on the fact that water loss caused the water uptake and hence the movement of the air bubble.

(ii)A has a lower rate of transpiration compared to B because condition B removes water vapour/moisture/saturated air around the leaves and since water leaves the leaves by diffusion this increases the water potential gradient between the leaf and the environment which leads to an increased diffusion/evaporation hence an increased rate of transpiration under conditions B. Condition C leads to a higher rate of transpiration as compared to A and B because it provides two factors, the wind that removes the diffusion shells around the leaves that facilitates water diffusion out of the leaves and increased temperatures that increase the kinetic energy of the diffusing water molecules.

(b)(i) The rate of water movement through the xylem increases rapidly as the light intensity increases for the first 3 hours, this then increased very rapidly to a peak at 12:00 with further increase in light intensity for the next 2½ hours. The rate then decreased rapidly as the light intensity decreases rapidly, followed by a gradual decrease as the light intensity increased gradually. The rate then decreased rapidly as the light intensity decreased rapidly and then a gradual decrease with a gradual decrease in the light intensity.

(ii)The rate of water movement in the xylem increased rapidly because increase in light intensity increased the rate of photosynthesis in the guard cells, forming more sugars that increase the solute potential in the guard cells which leads to endosmosis, guard cells become turgid and hence opening of the stomata. This leads to loss of water to the environment by the mesophyll cells by diffusion. Increased transpiration creates an osmotic gradient between the mesophyll cells and the xylem in the spongy mesophyll layer which creates a tension in the xylem leading to the building of high cohesion between the water molecules so as to form a continuous column of water in the xylem hence more water pulled up in the xylem.

(iii) At midday, there was highest light intensity that caused most stomata to open providing largest surface area for water loss and highest air temperatures provided much heat of vaporization thus highest rate of water evaporation /loss by transpiration, from mesophyll /air space/stomata; causing water to move across leaf by osmosis; Transpiration/evaporation exerts force causing tension/ pulling force in water columns due to transpiration pull hydrogen bonding between molecules/ cohesion holds water columns together in a continuous non-breaking column there is bonding/ adhesion between walls of xylem vessels and water molecules thus at midday there was highest tension/pulling in water column and highest adhesion between walls of xylem vessels and water molecules that caused collapsing of xylem inwards; making diameter smallest.

(c)(i) Hydathodes: Modified pores in epidermis of leaf that exudes drops of water. Abundant in leaves of submerged aquatic plants e.g. water lettuce, water hyacinth and of herbaceous plants. Pores connect to the plant vascular system by vascular bundle; are made of living cells with numerous

intercellular air spaces filled with water leading to an open pore. Are involved in guttation in which positive xylem pressure/ root pressure causes water to exude from the pores. Halophyte actively secrete salts in the glandular trichomes epidermal cells/margins of leaves causing loss of water actively across hydathodes

(ii) Casparian strip: Impervious cylindrical layer in cell wall of endodermal cells; made of suberin which renders it impermeable to water. It blocks cell wall/ apoplastic transport across endodermis; diverting water into cytoplasmic/ symplastic route. Endodermis also actively secretes salts/ions from cortex into xylem; these ions are prevented from leaking out xylem by the casparian strip; maintaining large water potential gradient forcing water uptake via symplast of endodermal cells (root pressure)

(d)Arteries and arterioles are made up of an elastic tissue that stretches under pressure/when heart beats which prevents their destruction and creating tension on to the heart. This also enables them to recoils/springs back and evens out pressure during blood flow. Their muscle contracts to reduces diameter of lumen/vasoconstriction/constricts vessel which enables changes in flow/pressure. They are made up of a smooth epithelium which reduces friction/blood clots/less resistance

3.(a) Rate of oxygen uptake $= \frac{\text{change in oxygen uptake}}{\text{change in time}}$

Rate of oxygen uptake $= \frac{3.2 - 1.2}{4 - 2}$

Rate of oxygen uptake = 1 arbitrary unit per hour (*range 0.8-1.2 arbitrary units per hour)*

(b) From 0 to 8 hours, the rate of oxygen uptake increases gradually; due to very gradual aerobic respiration by very few yeast cells; From 8 to 14hours, the rate of oxygen uptake increases rapidly; due to increased yeast cell growth/reproduction/division; that causes increased uptake of oxygen; From 14 to 17.5 hours, the rate of oxygen uptake increases gradually; to a peak; due to reduced nutrients/glucose, oxygen starts to decrease and toxins have started accumulating; From 17.5 to 24hours, the rate of oxygen uptake decreases rapidly; because glucose/nutrients/oxygen decreases/ becomes limiting; anaerobic respiration occurs to form ethanol/toxins; and much heat released; making cells to die;

(c) From 0 to 6hours, there is no ethanol produced; because there are very few yeast cells; and there was sufficient oxygen for aerobic respiration; From 16 to 19hours, ethanol production increased gradually; because there are few/just slight increase in the number of yeast cells due to low cell division; From 19 to 23hours, ethanol production increased rapidly; to a peak; due to increased cell growth/reproduction/division; resulting into increased oxygen usage, anaerobic conditions and hence anaerobic respiration which yields more ethanol from pyruvate; From 23 to 24hours, ethanol production decreases rapidly; because glucose is used up and the ethanol produced kills the yeast cells

(d) (i)The number of yeast cells remains constant; because the cells are in interphase which involves synthesis of energy needed for division, DNA replication, Duplication of organelles and cell growth which simply prepare the cell for division but don't increase cell number.

(ii) The number of yeast cells increased rapidly; because the yeast cells have entered the M-phase particularly in telophase/cytokinesis where the actual division of the cell takes place forming daughter cells thus increasing in the cell number

(e) The time is 3 hours; because it is the time between beginnings/endings of increase in DNA concentration/replication and the repeat of the cycle; This is because DNA replication takes place only during interphase and thus once per cell cycle.

4. (a) Chlorophyll molecules in both photosystem 1 and 11 absorb light energy , they become excited and emit electrons ,electrons from photosystem are accepted by electron acceptor ferrodoxin while electrons from photosystem 11 are accepted by electron acceptor plastoquinone, the electrons are then carried through a chain of electron carriers from higher to a lower energy level, some energy is emitted which is used to combine ADP with a phosphate unit to form ATP.

(b) Little green light reaches bottom as absorbed by surface water dwellers ; Red and blue light is not absorbed and so penetrates and reaches the bottom; Variation in pigments of sediment dwellers exist; Bacteria with chlorophyll are at an advantage as chlorophyll absorbs red and blue; These bacteria Survive to reproduce in greater numbers; Pass on advantageous alleles/genes in greater numbers / increase in frequency of advantageous alleles in subsequent generations; Increase in frequency/numbers of bacteria with chlorophyll;

(c) Intermittent light supply, Intermittent /flashes of light/discontinuous light yields more photosynthetic products than continuous light supply, continuous light supply produces much ATP and NADPH+H$^+$, accumulate and slow down the process, dark periods allow dark stage to use up the much ATP/NADPH+H$^+$ completely.

Temperature co-efficient; Light stage show unity temperature co-efficient, no increase in rate of reaction with increase in temperature but for dark reaction, reaction affected by temperature increase due to temperature sensitive controlled enzymes and increase with increase in temperature

5.(a) Similarities

Both attain a maximum/peak
Both decrease gradually after attaining a peak
Both are equal at a depth of around 44cm
Differences
Dry mass of T. latifolia attains a peak earlier than T. angustifolia
Dry mass of T. angustifolia attains a higher peak than T. latifolia
From 0 to about 15cm, dry mass of T. latifolia increases to attain a peak while dry mass of T. angustifolia is constant and zero.

From 15cm to about 80cm, dry mass of T. latifolia decreases rapidly while dry mass of T. angustifolia increases rapidly to attain a peak
From 80cm to about 115cm, dry mass of T. latifolia is zero and constant while dry mass of T. angustifolia decreases rapidly.

(b)T. angustifolia.

Increase in water depth from -18cm to 45cm, the dry mass of T. angustifolia is increases gradually and is lower than that of T. latifolia because they are less adapted to survive compared to T. latifolia in the shallower waters hence gradual increase due to reduced access to the available resources that include nutrients present in water. T. latifolia dry mass increased rapidly in the same range due to a highly competitive advantage for the available resources in shallow waters such as increased access to light, space and nutrients such as nitrates and phosphates in water.
Increase in water depth from about 45cm to 80cm, the dry mass of T. latifolia decreases rapidly due to limited access to the sunlight and other nutrients for growth. The dry mass of T. angustifolia decreases gradually because under natural circumstances, the less successful competitor rarely becomes extinct, but merely becomes rare and they can also trap sunlight in the deeper waters hence can survive in the deep waters.

(c)Fundamental niche refers to the potential niche that would occur for an organism without the competitor while a realized niche refers to the niche that is restricted by presence of a competitor. The realized niche of T. angustifolia is between water depth of 15cm to 80cm because its dry biomass decreases and its out competed by T.latifolia. The fundamental niche for T. angustifolia is between -10cm to about 15cm due to the zero and constant biomass of T.latifolia hence absence of its competitor.

(d) Capture-mark recapture.

In this method, a number of aquatic animals are captured using traps which are set up randomly around an area. The animals captured are then marked using tags for example the fish can have tags attached on the opercula. The number of animals marked in the first capture is recorded as N and these are allowed to mix with the population for a given sufficient period of time. After a given period of time, the traps are again set up randomly and the number of animals in the second capture is noted as M, the total number of captured and had been marked(recaptured) is noted as R. The total number of the population is determined by use of Lincoln index as
Estimated population size = N*M/R
Assumptions made include; Organisms mix randomly within a population.
Sufficient time is given between the first capture and recapture to allow random mixing.
It is applied to populations whose movement is restricted geographically.
Marking does not hinder movement of organisms or make them conspicuous to predators.
Changes in population as a result of immigration, emigration and death are negligible.
Removal method

This method is suitable to estimate the number of small organisms such as insects within a known area or volume of water. Using a sweep net, a number of animals captured is recorded and the animals are kept. This procedure is repeated three times and the gradually reducing numbers ids recorded. A graph is plotted of number of animals captured per sample against the previous cumulative number of animals captured.

By extrapolating the line of the graph to the point at which no further animals would be captured (that is number in sample =0) the total population may be estimated.

6.(a) Slow twitch muscles contract slowly and less powerfully whereas fast twitch muscles contract very fast and more powerfully.

Slow twitch muscles contract over a longer period of time hence suited to endurance work like marathon whereas fast twitch muscles contract over a shorter period of time hence suited for intense exercise like weight lifting.

Slow twitch muscles have a larger reservoir of myoglobin for storage of oxygen which facilitates aerobic respiration to avoid accumulation of lactic acid compared to fast twitch muscles.

(b) Muscular movements involve alternate contraction and relaxation of muscles.

Contraction.

Arrival of an action potential at the synaptic terminal of motor neuron causes an influx of Ca^{2+} ions from the extracellular fluid into the pre-synaptic neuron's cytosol followed by exocytosis of synaptic vesicles containing acetylcholine.

Acetylcholine diffuses across the synaptic cleft of neuromuscular junction to depolarize the sarcolemma and trigger an action potential that spreads through the transverse tubules, causing the sarcoplasmic reticulum to release Ca^{2+} into the sarcoplasm.

Ca^{2+} bind to troponin of actin to cause cooperative conformational changes in troponin-tropomyosin system, releasing the inhibition of actin and myosin interaction.

Myosin hydrolyses ATP and undergoes a conformational change into a high-energy state.

The myosin head binds to actin forming a cross-bridge between the thick and thin filaments.

This is accompanied by energy release, ADP and inorganic phosphate dissociation from myosin.

The resulting relaxation entails rotation of myosin head, which flexes the cross bridge to move actin a small distance pulling the Z-discs towards each other, thus shortening the sarcomere and the I-band.

The collective flexing of many cross bridges by myosin to move actin in the same direction results in muscle contraction.

Relaxation

Ca^{2+} are pumped back into sarcoplasmic reticulum.

Again, ATP binds to myosin head, detaching it from actin as the myosin head "recharges" or "cocks".

Troponin-tropomyosin regulated inhibition of actin and myosin interaction is restored.

Finally, active tension disappears and the rest length is restored.

This completes the contraction-relaxation cycle.

(c)There are three major instabilities in fish i.e. rolling, pitching and yawing.
Rolling involves rotation of the body about its longitudinal axis. It's overcome by dorsal, ventral (vertical) and pectoral (horizontal) fins acting like stabilizers on a ship.

Pitching refers to the tendency of the fish's anterior end to plunge vertically downwards (transverse axis rotation). It's overcome by;
pectoral fins and to a lesser extent pelvic fins
dorsal-ventral flattening of the body in the dogfish.

Yawing is the tendency of lateral side to side deflection of the anterior part of body resulting from the propulsive action of the tail (vertical axis rotation). It's overcome by;.
general massiveness of anterior part of body
water's pressure against the body side
water's pressure against the vertical fins (dorsal, anal, ventral fins)
lateral flattening (compression) of the body
(d)(i) ATPase prepares myosin for binding with actin by moving it to a higher energy state and cocked position so that it can bind with actin when exposed.
Myosin releases energy as ATP as it hydrolyses under influence of ATPase enabling it to be in power stroke so that it moves the actin filaments and Z-Disks towards the M line shortening the sarcomere resulting into muscle contraction.
ATPase removes cross bridges when it binds with myosin so that it returns into a cocked position enabling it to bind with actin at the next contraction.

(ii) A and B
The rate of ATPase activity is lower in solution B compared to solution A. This is because in solution B, there is inhibition of actin myosin interaction by tropomyosin hence little ATP binds to myosin for hydrolysis by ATPase.
Unlike solution A, myosin is freely interacting with actin and ATPase is hydrolyzing ATP so that contraction takes place.
B and C
ATpase activity was higher in solution C than solution B due to presence of Calcium ions in solution C; calcium ions binding on troponin causes displacement of tropomyosin exposing the myosin head binding site on actin and stimulating hydrolysis of ATP to ADP and Pi; increasing the ATpase activity; the energy from hydrolysis is used by the myosin head to bind the actin forming cross bridges;

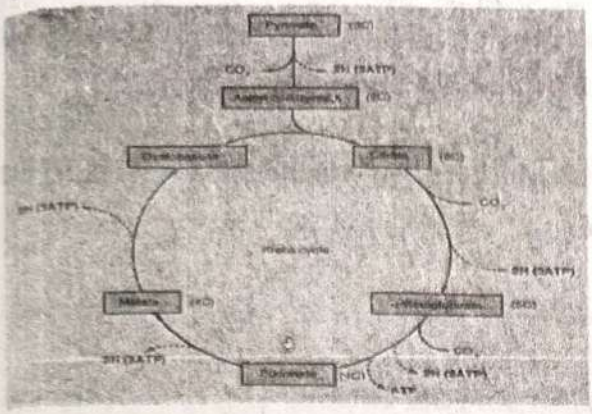
7.(a)similarity.
At ethanol concentration of about 5.2% rate of formation of formaldehyde is the same as the rate of formation of ethanal.
Differences.
From ethanol concentration of 0% to 5.2%, the rate of formation of formaldehyde is higher than the rate of formation of ethanal.
From ethanol concentration of 0% to 10%, the rate of formation of formaldehyde decreases whereas rate of formation of ethanal increases.
From about 5.2% to 12% ethanol concentration, the rate of formation of formaldehyde is lower than the rate of formation of ethanal.
From 10% to 12% ethanol concentration, the rate of formation of formaldehyde decreases rapidly whereas the rate of formation of ethanal remains constant.

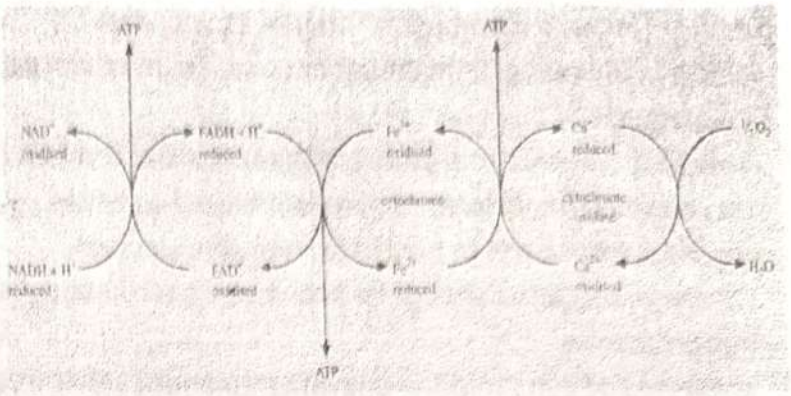
(b) From the g... increasing ethanol concentration increases the rate of formation of ethanal. This is because ethanol ... competitive inhibitor with methanol in binding into active sites of alcohol dehydrogenases
At lower ethanol concentratio... ...nol is still in higher concentration compared to ethanol and therefore has a competitive advantage in binding into alcohol dehydrogenases. As ethanol concentration increases, it outcompetes methanol in binding into active sites of dehydrogenases resulting into its conversion into ethanal.

(c)(i) Pollutants containing methanol should be avoided. This is because they lower the rate of formation of ATP as they reduce the activity of dehydrogenases in the respiratory pathway.
According to the graph, there is generally higher amount of ATP formed in absence than in presence of methanol. This is because methanol competes with a number of substrates for binding into active sites of dehydrogenases. This eventually lowers the rate of enzyme-controlled reactions in respiration hence less ATP formed.

(ii) A person who has faced a problem of methanol poisoning can be assisted by administering to him a large amount of ethanol. This is because high ethanol concentration in body cells will outcompete the methanol concentration and the harmful effects of methanol will be minimal.

(d) Ethanol first undergoes dehydrogenation to form ethanal by ethanol dehydrogenase. Ethanal then undergoes reduction by $NADH_2$ and decarboxylation to form pyruvate which is a substrate of respiration.
Pyruvate then undergoes further reactions as summarized in the illustrations below.





(e) enzymes can be categorized in different ways according to various criteria as shown below.
Basing on substrates they work on; Peptides – Peptidase; Proteins-Proteases
Carbohydrates- carbohydrases
Basing on area of their action.
Intracellular enzymes;
They catalyze reactions within the cells where they are synthesized E.g. enzymes of mitochondria and chloroplasts.
Extracellular enzymes;
They catalyze reactions outside the cells where they are synthesized e.g. digestive enzymes.
Ecto enzymes;
They catalyze reactions outside the body of the organism where they are synthesized e.g. Enzymes of saprophytes (saprotrophozymes)

Basing on the type of reaction they catalyze,
Oxidoreductases; are involved in biological oxidation and reduction reaction. They include hydrogenases which catalyze addition of hydrogen atoms to a substrate and oxidases which catalyze removal of hydrogen atoms from a substrate.
-Hydrolases; catalyze the addition of water to or the removal from a substrate.eg protease.
Transferases; These catalyze transfer of chemical groups or atoms from one substrate to another. Those that transfer amino groups [NH_2] are called transaminases.
Lyases; break chemical bonds other than hydrolysis thus creating double bond. They include carboxylase which remove carboxyl group [COOH] from intermediates in respiratory pathways.
Isomerases; These enzymes catalyze the transfer of an atom from one part of a molecule to another.
Ligases or synthetases; catalyze joining together of two molecules coupled with the breakdown of ATP e.g., phosphokinase which catalyze the addition of phosphate group to a compound.

(f) Co-factors are non-protein substances that are required by some enzymes for their efficient activity. There are three major categories of co-factors i.e. prosthetic groups, co enzymes and inorganic ions.

Prosthetic Groups. A prosthetic group is an organic non-protein substance that is permanently bound (forms a permanent integral association) to the enzyme; and is required for its efficient activity. For example, haemoglobin has haem which enables binding of oxygen.

Co-enzyme

This is an organic non-protein substance that forms a temporary integral association with enzyme; and required for efficient action /activity of enzymes.

e.g. NAD work hand in hand with dehydrogenases,

Co-enzymes cause change in active site such that substrate fits better.

Inorganic ions

Metal ions which mold the enzyme into shapes that enable substrate binding.

- Inactive enzymes (zymogens) usually require metal ions to activate them e.g.

Cl for ptyalin; Ca^{2+} for thrombokinase

8. (a)(i) Diuresis is a condition in which the kidney filter too much body fluids resulting in an increase in your urine production and the frequency with which you need to the use the bathroom;

(ii)Low water levels in blood/ high osmotic potential/ low water potential; is detected by osmoreceptors; in the hypothalamus; resulting in to secretion of more ADH/vasopressin hormone; from posterior pituitary gland; in to blood; where it is transported to distal convoluted tubule and collecting duct; making them more permeable to water; hence more water is reabsorbed in to blood and this returns water levels back to normal.

(b)(i) As plasma concentration increases to 282 a.u; there's no increase in ADH/ADH concentration remains constant; After 282, there's rapid increase in ADH concentration;

(ii)Up to 293 a.u, ADH can achieve sufficient water reabsorption; After this point, water needs to be taken in by drinking to avoid dehydration;

c) Blood loss/vomiting NOT dehydration or anaemia.

d)Vasopressin helped early terrestrial animals to conserve water, adapting to land environments. Vasopressin maintained blood pressure, ensuring adequate blood flow to vital organs and this is very important maneuvering new environments.
Vasopressin regulated electrolyte balance, crucial for nerve and muscle function and this improves on adaptability to new environments.

9.(a) (i) in the presence of abscisic acid, calcium ion enters into the guard cells and act as second messenger inactivating proton pumps; causing efflux of potassium ions and chloride ions. This results into a decrease in water potential of guard cells below the water potential of surrounding epidermal cells. Osmotic efflux of water from the guard cells occurs resulting into stomatal closure.

(ii) binding of the sperm onto the plasma membrane causes a change in the plasma membrane promoting the release of Ca^{2+} ions in the cytoplasm of the ovum. The sudden increase in Ca^{2+} causes the cortical reaction in which secretary vesicles in the cytoplasm of the ovum move towards and

fuse with the plasma membrane, expelling their contents into the space between the ovum and the zona pellucida.

(iii) Fall of statoliths onto the endoplasmic reticulum in a different part of the cell brings about the release of calcium ions there. The effect of the raised concentration of calcium ions is to activate calmodulin, a small protein that is present in cells and which is known to initiate the actions of several enzyme systems. These enzymes then activate growth of the cell. Activated calmodulin may switch on the cell membrane pumps for calcium ions which pass across the tissue of the stem or root from cell to cell extending the region of enhanced or inhibited growth.

(iv) When an impulse arrives on the presynaptic knob, the calcium ion channels in the presynaptic membrane are opened. Calcium ions from the synaptic cleft enter the knob and cause the vesicles to move close to the presynaptic membrane. When these vesicles reach the membrane, they discharge/release the transmitter substances through the membrane to the cleft. The released neurotransmitter substances then diffuse across the synaptic cleft attaches to specific receptor sites on the postsynaptic membrane.

(b) (i) auxin concentration increases in agar block in side of shoot when shoot is lit from side, compared to in dark; more auxin has moved to side of shoot away from light source; less auxin moves downwards in light; light influences distribution of auxin.

(ii) auxin move laterally away from light in plant shoots, creating greater concentration of auxin on side away from light; cells stimulated to elongate; resulting in bending towards the light/positive phototropism; more light absorbed increases the rate of photosynthesis.

11. (i) Similarities

In both initial and final fruit is different

Differences

Fruit diameter in group II	Fruit diameter in group III
From 6 to 15 days after pollination, it increased gradually	It decreased very gradually
From 15 to 24 days after pollination, it increased rapidly	It remained almost constant
From 24 30 days after pollination, it increased gradually	It remained almost constant
Attained larger final diameter	Attained smaller final diameter

(ii)Similarities

Both groups registered changes in fruit diameter with time

Differences

Fruit diameter in group I	Fruit diameter in group III
From 6 to 15 days after pollination, it increased rapidly	It decreased very gradually
From 15 to 30 days after pollination, it increased very rapidly	It remained almost constant
Fruit diameter after 6 days was large	Had small fruit diameter after 6 days

Attained larger final diameter	Attained smaller final diameter

(b) (i) From 6 to 15 days after pollination, group II registered gradual increase in fruit diameter due to low concentration auxins with in the fruit from the external/ exogenous source which replaced the achenes/seeds whereas group III registered a gradual decreased due to decreasing levels of auxins within fruit tissues after removal of seeds that produce them thus lowering the rate of cellular division and expansion; rapid and gradual increase in fruit diameter registered in group II due to continuous application of auxins which promoted increased cellular division and expansion and reaching maturity whereas fruit diameter remained almost constant in group III due to depletion of auxins within fruit tissues thus limiting cellular division and expansion;

(ii) From 6 to 15 days after pollination, group I registered rapid increased due to endogenous production of auxins by the achenes/seeds which were still young whereas gradual decrease in diameter of fruit in group III was due to decreasing levels of auxins within fruit tissues after removal of seeds that produce them thus lowering the rate of cellular division and expansion; from 15 to 30 days after pollination, group I registered very rapid increase in fruit diameter due to growing achenes/seeds which increased auxins production that further enhanced cellular division and expansion within fruit tissues up to maturity whereas the fruit diameter remained almost constant in group III due to depletion of auxins within fruit tissues thus limiting cellular division and expansion; also developing seeds produce gibberellins and cytokinins which have synergistic effect in promoting growth; accounting for the greater diameter attained in group III than group I

(c)Synthetic broad-leafed herbicides are selective weed killers, destroy broad-leaved weeds by disrupting growth of their meristematic tissues and cause death from excessive growth. They do not affect cereal crops treated, reduce competition for resources between cereals and broad-leaved weeds which increase productivity;

(d)Preharvest/ premature fruit drop/fall is prevented by spraying trees with synthetic auxins that inhibit fruit abscission; the advantage of the tendency is conservation of resources by reducing the number of fruits and seeds produced that may fail to survive during unfavourable environment conditions;

(e)The ovule's placenta and the ovary produce auxin that promote cellular division and expansion within fruit tissues and prevent abscission of the fruit;

12 (a) Concurrent mechanism is when blood flows in the same direction as the respiratory medium passing over the respiratory surface resulting in only half (50%) of the available oxygen from the medium diffusing while counter current mechanism is when respiratory medium flows across the respiratory surface in an opposite direction to the blood flow resulting in too much oxygen (80-90%) from the medium being extracted;

(b) These are called the carotid bodies and aortic bodies, respectively. These are sensitive to changes in carbon dioxide; pH; and can also detect changes in oxygen. When the CO2 partial pressures increase in blood; the chemoreceptors detect any of these changes, they send nerve impulses to the inspiratory center in the brain through the glossopharyngeal and vagus nerves; the inspiratory center sends more frequent nerve impulses to the external intercostal muscles; through intercostal nerves; and the diaphragm; through the phrenic nerves; causing them to contract. As a result, breathing becomes faster and deeper until carbon dioxide levels return to normal. Decrease in CO2 levels in blood; reduces stimulation carotid and aortic bodies thus decreasing the firing of impulses to the inspiratory centre thus reducing breathing rate;

(c)(i) As depth increases from 0 to 100 meters; pressure increases gradually.

(ii)Gradual increase in pressure with increase in depth from 0 to 100meters leads to oxygen poisoning; due to the increasing pressure with depth compared to that in the apparatus hence a lot of oxygen is pushed into the body tissues; causing muscular twitching, nausea, dizziness, impaired vision, convulsions and finally death.

(d) (i)To prevent body bends from compressed air spaces; where nitrogen bubbles form in bloodstream and tissues due to quick reduction in pressure; therefore, ascending a slow pace helps divers to reduce the risk of decompression sickness by allowing excess nitrogen in the body to be released safely.

(ii)Inhalation is more active because it's brought by contraction of several muscles like the diaphragm, external intercoastal muscles while normal exhalation is brought about by elastic recoil of tissues that was stretched during inhalation.

Significance; the active contraction of the several muscles mentioned above provide a sufficient force to overcome a series of resistance such as;

The recoil of the elastic tissues of the lungs and thorax; the frictional resistance of air as it passes through hundreds of thousands of small bronchioles leading to the alveoli; the resistance created the surface tension at the fluid-gas interfaces in the alveoli;

(iii) Fish use water as a gas exchange medium with low partial pressures of O2 compared to air used by terrestrial organisms; in order to acquire sufficient amount of O2 from the medium; fish must ventilate their respiratory surfaces more frequently than terrestrial organisms;

(e)Oxygen carriage; by having greater blood volume e.g. man's blood is about 7% of body weight while in diving marine mammals it is about 15% of the body weight.
Enlarge blood vessels to work as reservoirs of oxygenated blood.
High concentration of myoglobin to have large oxygen reserves.
Slower heart beat to conserve use of oxygen
Reduction of blood supply to organs and tissues tolerant to oxygen deficiency e.g. digestive system, muscles, etc.
Compression of air spaces to reduce unnecessary body bends e.g. lungs, middle ear, etc.

Higher proportion of red blood cells to carry enough oxygen before diving and increase supply of oxygen to active body tissues.
Respiratory centers do not function automatically to cause breathing at a certain concentration of CO_2; thus, CO_2 tolerant.

13. (a)*(i) From 0 to 3 days, population of Mucor sp increased gradually; from 3 to 7 days, population of Mucor Sp increased rapidly to the peak; from 7 to 12 days, population of Mucor Sp decreased rapidly; from 12 to 18 days, population of Mucor sp decreased gradually to extinction;*

(ii) From 0 to 12 days, population of Coprinus sp was still zero; from 12 to 21 days, population of Coprinus sp increased gradually; from 21 to 35 days, population increased rapidly to the peak; from 35 to 49 days, population of Coprinus sp decreased rapidly; from 49 to 56 days, population of Coprinus sp decreased gradually;

(iii)From 0 to 3 days, population of Ascobolus remained at zero, from 3 to 7 days, population of Ascobolus sp increased gradually; from 3 to 7 days, population of Ascobolus sp increased gradually; from 7 to 21 days, population of Ascobolus sp increased rapidly; from 21 to 35 days, population of Ascobolus sp decreased rapidly; from 35 to 49 days, population of Ascobolus sp decreased gradually to extinction;

(b) Mucor sp; gradual increase in population for the first 3 days, few spores have given rise to fruiting bodies and still getting adapted to the environment; rapid increase in population from 3 to 7 days due to increase in number of fruiting bodies bodies emerging from spores; rapid decrease in population from 7 to 12 days results from increased competition for food nutrients; gradual decrease in population to extinction from 12 to 18 days resulted from depletion of food nutrients(sugars, amino acids, fatty acids, glycerol and others which left-overs from digestion that have not been absorbed in the herbivore's gut; they are short-lived food sources and some are lost to bacteria; this accounts for the relatively lower population attained;

Ascobolus Sp; from 0 to 3 days no organism registered, dung surface still covered by left-overs of digestion not absorbed by herbivores; from 3 to 7 days population increased gradually due to few spores giving rise to fruiting bodies and partial exposure of their source of food by removal of left-overs of digestion; from 7 to 21 days population increased rapidly to peak; more spores give rise more fruiting bodies, complete exposure of their source of food as a result of depletion of left-overs digestion; from 21 to 35 days population rapidly decreased due to increased competition for food nutrients by large numbers and decreasing source of food; from 35 to 49 days population decreased gradually to extinction due to depletion of food source; attained a relatively large population because the cellulose and hemicelluloses provide nutrients for relatively long period of time;

Coprinus Sp; from 0 to 12 days population was still zero; no spore had given rise to fruiting bodies; dung surface still covered by left-overs of digestion and cellulose and hemicelluloses; from 12 to 21

days population increased gradually due to few spores germinating into fruiting bodies and partial exposure of their source of food by action of other organisms; from 21 to 35 days population increased rapidly to a peak due to more spores germinating into fruiting bodies and complete exposure of their source of food; from 35 to 49 days population decreased due to increased competition for nutrients by large numbers and decreasing amount of food nutrients; from 49 to 56 days population decreased gradually due to food source getting depleted; lignified structures(fibers and xylem vessels) are broken down slowly and provide nutrients for longer period of time accounting the larger maximum population attained;

(c)Saprophytic such as Mucor and Rhizopus; suitable organic compound to provide raw materials for biosynthesis and respiratory substrates e.g. glucose, amino acids, sucrose, maltose, starch, cellulose, lignin;
Suitable source of growth factors and inorganic ions which include vitamins(thiamine) and potassium, phosphorus, magnesium respectively are required for proper growth;
Water; is required for numerous biochemical reactions by providing a suitable medium and contributes to greatly to their mass;
Optimum temperature; most fungi have can survive between 5 to 35 0C with an optimum of 250C for efficient enzyme activity;
Optimum pH; most fungi prefer neutral and slightly acid conditions for normal continuity enzymatic controlled reactions;
Oxygen concentration; fungi require oxygen for aerobic respiration thus they grow on the surface of the medium not inside it since very few can endure anaerobic conditions;

(d) Saprotrophic feeding results; in breakdown of organic materials of dead organisms and their waste products; the component chemical elements are eventually released for re-use by autotrophs; results into humus formation that ameliorates soil properties; results in decreasing the volume of detritus within the environment;

14.(a) (i) Similarities
In both the amount of compost is the same at the start;
In both the amount of compost decreased with time;
In both rate of decomposition remained constant;

Differences

Batch one	Batch three
From 0 to 10 days, rate of decomposition increased very gradually;	Rate of decomposition increased rapidly;
From 10 to 20 days; rate of decomposition remained almost constant;	Rate of decomposition increased gradually;

(ii) Similarities
In both rate of decomposition remained constant from 20 to 30 days;
Differences
From 0 to 10 days, rate of decomposition increased rapidly in batch three whereas in batch two rate of decomposition increased gradually;
From 10 to 20 days, rate of decomposition increased gradually in batch three whereas in batch one, rate of decomposition increased very gradually; from 20 to 30 days, rate of decomposition remained almost constant in batch two whereas in batch three rate of decomposition very gradually;

(b) (i) Batch three had a higher rate of decomposition than batch two due to chopping which increased the surface area for microorganisms to break down the compost; heaping contributed increased heat generation within the compost which increases the rate of respiration; speeding the decay process;

(ii)It increases the rate of decomposition by minimizing heat loss to surrounding environment which enhance respiratory rates of microorganisms

(c) It increases the efficiency and more nutrients are absorbed by the organism; extracellularly digestion of the prey organism is started by enzymes secreted by cells of the endoderm within the enteron and intracellularly digestion is completed within food vacuoles in the endoderm cells;

15. (a)A-phosphate group, B-Deoxyribose sugar, C-Nitrogen bases

Structural characteristics

Polynucleotide/polymer/made of many repeating units(nucleotides)
made of two anti-parallel nucleotides/strands
has complementary nitrogen bases
has a constant distance between the strands

(b)In an HIV Virus, structure B has an oxygen atom on 2'C

(c)To avail enough genetic material (DNA) for the resultant daughter cells

(d)DNA-Polymerase proofreads and corrects mismatched base pairs by replacing them with the correct complementary bases using its exo-nucleases activity.
Damages that occur to DNA as a result of exposure due to unwinding or unzipping associated with replication are repaired by DNA repair mechanisms.

(e)(i) 13 different amino-acids
(ii) Stops or greatly reduces the functionality of the receptor. This is because the few amino acids present lead to the formation of different protein structures from the normal structure of the acetylcholine receptor. Because the functionality of the acetylcholine receptor entirely depends on its precise 3D structure, changing its structure stops acetylcholine from binding to it hence no functionality.

Due to the degenerate nature of the genetic code, it's possible that the resultant codon still codes for the same usual amino acid or a slightly different amino acid whose presence slightly changes the structure and functionality of the protein. Substitution can only be much more dangerous if it results in the formation of a stop codon, but this is rare. On the contrary, deletion always leads to the formation of a protein with fewer amino acids. The level of severity depends on the position of the mutation. If it occurs close to the origin of transcription, no protein will form thus loss of all the benefits of having such a protein

15.(a) Environmental stress refers to the external factor that affects an organism's survival, development, growth and reproduction. For example, abiotic factors such as soil and water salinity, sunlight radiations, pollution, light intensity (photo stress) and biotic factors such as herbivory, parasitism, competition, pests and pathogens WHILE Physiological drought refers to the inadequacy of water in an organism attributed to excessive water loss to the environment accompanied by insufficient water absorption /uptake for example physiological drought in halophytes and marine fish.

(b)(i) The various forms of biotic stress to plants are; herbivory, attack by pathogens, competition on for sunlight and mineral salts, parasitism.

In response to herbivory; plants use physical defense and chemical defence mechanisms.

Physical involves development of protective devices such as thorns, barbs, spikes, spiny leaves, fibrous and inedible tissue, hairy leaves and even stings on themselves discourage herbivores from eating them.

Chemical defence involves production of unpleasant chemicals such as tannins with a bitter taste that deters herbivores. Tannins is toxic to insects by binding on the digestive enzyme in the saliva of insects and inactivate them. Some plants produce volatile organic compounds which act rather like pheromones between themselves and other organisms particularly insects. These diffuse through air around the plant and signal other plants to defend themselves. For example, upon inoculation of insect pest saliva in the plant tissues, this elicits gene switching i.e., in cabbages when attacked by the caterpillars of the cabbage white butterfly, they produce a chemical signal which attracts the parasitic wasp *Cotesia glomeruta*. This insect lays its eggs in the caterpillars which are ten eaten alive thus protecting the plant.

To prevent competition for light, the shade plants absorb light of long wavelength unlike sun plants. This enables both plants to coexist in the same ecosystem.

Plant responses against pathogens is divided into physical defence and chemical defence responses.

Physically, they rapidly produce callose upon attack by pathogens. Callose contains beta-1,3-linkages and beta -1,6-linkages between the glucose monomers. Callose is deposited between cell walls and cell membranes in the cells next to the infected cells. The Callose Papillae act as the barriers preventing pathogens entering the plant cells around the site of infection. Also, lignin is

added to callose in plasmodesmata thus sealing off infected parts and preventing the spread of pathogens.

Chemical defence involves production of powerful chemicals that either repel the insect vectors of the pathogen or kill invading pathogens. The chemicals include insect repellants such as Pine resin and Citronella from Lemon grass, insecticides such as pyrethrins made by chrysanthemums and act as insect neurotoxins and caffeine toxic to insects and fungal pathogens. Some plants produce antibiotics such as Phenol, defencins -plant like proteins that disrupt the cell membrane of bacteria and fungi, some plants produce cyanide compounds which when broken down by pathogens, the cyanide released kills them.

ii) Plant responses to abiotic stress.

Plants develop a number of protective responses such as leaf shading by deciduous plants to reduce on the rate of transpiration thus involves formation of abscission layers leading to leaf fall. This is triggered by increased levels of abscisic acid as a result of a decrease in water content /water stress in the plants. This occurs during the dry season characterized by hot temperatures thus high rate of water loss from the plant.

To prevent freezing of cells due to extreme coldness, the cytoplasm and the cell sap of the plant cells have solutes that lower freezing point of cells which would otherwise disrupt the cell membranes and their functionality,

In response to temperature/heat stress, leaves have shiny cuticles that reflect most of the sunlight radiations reducing heat absorption

Some plants employ reverse stomatal rhythm to overcome water stress; by opening their stomata only at night where environmental conditions only permit reduced rates of transpiration unlike during day

(c).+/+ relationships exhibited are categorically known as mutualistic relationships where both partners benefit these include , nitrogen fixing bacteria(*Rhizobia*) and legumes, bacteria convert atmospheric nitrogen into plant usable form nitrates, mycorrhizae (fungi and plant roots), fungal hyphae grow just on the surface of the root or some may penetrate the plant tissues, in either case, masses of fungal hyphae in the soil help to break down organic matter releasing suitable salts/nutrients that are taken up by the plant, the hyphae also provide large surface area or absorption of materials such water, mineral elements, other than plant roots alone. This enhances drought resistance in plants by acting as extensions of the root system, by wrapping around the plant roots prevents entrance of pathogens thus preventing plant diseases and enhance pest resistance.

16.(a)Before birth, PVR remained constants, during birth, it reduced very rapidly and remained constant after birth

(b) Higher in the foetus but lower in the baby this is because the hypoxia in the foetal lungs causes pulmonary vaso-constriction to greatly minimize pulmonary circulation since lungs are non-functional, hence high pulmonary vascular resistance. However, in baby the inhalation of oxygen leads to pulmonary vaso-dilation to ease blood from to the lungs to for oxygenation. This leads to lowering of pulmonary vascular resistance

(c) The structural arrangement of the tissue/flaps is in such a way that high pressure on the left side of the heart after birth cannot flip them inside out yet the high blood pressure on the left side of the heart can during foetal stage.

(d) Mixing of oxygen poor with oxygen rich blood. Oxygen poor-blood is delivered to their tissues, leading to sub-optimal/low energy production. This makes these individuals to always feel weak and have low quality life. As babies, the appear blue, which attracts unnecessary attention from people.

(e) Pressure on the left side of the heart rises relative to that on the right side of the heart; closure of Ductus venosus as well as Ductus arteriosus; foetal haemoglobin is gradually replaced with adult haemoglobin; reduction in pulmonary vascular resistance

(f) Prevents blood from losing pressure and spending a lot of time going through pulmonary and liver capillaries from which it picks and delivers nothing respectively. This is because the lungs and liver are redundant since the fetus gets blood with a well-regulated composition. Blood can swiftly reach the fastest-growing organs on time and at the right pressure.

f) To deliver nutrients needed for lung tissue development but also to eliminate metabolic wastes produced by growing lung cells

17.(a) Initially, the number of T4 is high and an increase in the number of HIV particles increases the number of T4 cells.
From around the 6th month to 1 year, a further increase in T4 cells reduces the number of HIV particles. From 1 year to the 10th year, a decrease in the number of T4 cells leads to a decrease in the number of HIV particles.

(b)HIV viruses are phagocytosed by antigen-presenting cells (monocytes, macrophages and dendritic cells), which process and present the viral peptides/antigens on their surface molecules (MHC-II). Using their surface molecules (CD4), T4 cells recognize the foreign viral peptide/antigens and proliferate.

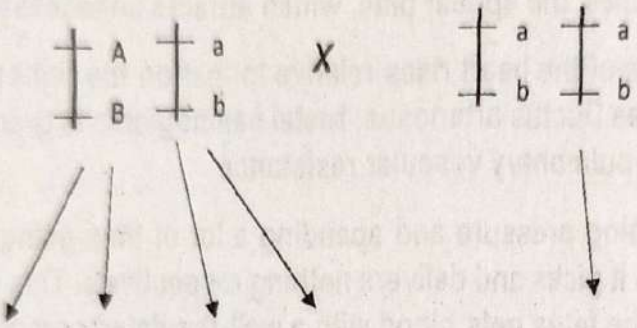
(c)(i) The dangerously low T4 number experienced during this time means immune deficiency/compression. This low immunity makes HIV patients easily and frequently fall sick from many opportunistic and non-opportunistic infections/pathogens such as mycobacterium, leading low quality of life.
(ii)Most infectious: in the first year and the last two years of infection, very many viral particles, meaning higher chances of infecting others
Least infectious: between the first to the 3rd year of infection, the lowest viral number, meaning few chances of transmission.

18. (a)24 Big ears, buggy eyes:1 Big ears, normal eyes:1 Small ears, buggy eyes:24 Small ears, normal eyes

(b)Let A and B represent the dominant alleles for big ears and buggy eyes respectively while b and a represent the recessive alleles for normal eyes and small ears respectively.
Since the experimental phenotypic ratio is different from the expected ratio 1:1:1:1 mendelian ratio, genes for ears size and eye shape occur very close to each other on the same chromosome/linked thus do not assort independently during meiosis I. despite linkage, some crossing over occurred.

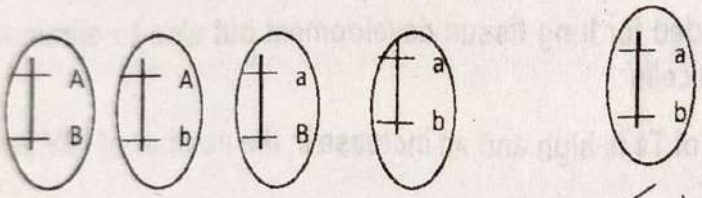
Parental phenotypes: Big ears and buggy eyes X small ears and normal eyes

parental genotype:



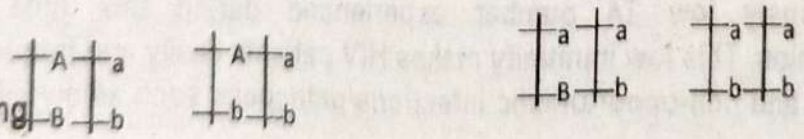
Meiosis:

Gametes:



Random fertilization

Offspring genotype



(d) C.O. V= (Number of recombinants/total progeny) *100; = (2+2)/ (48 +2+2+48) *100

= 4%is equal to hypothetical distance between the genes; =4 units

19. (a) An escape response is a response that bring about rapid withdrawal of the animal from a potentially harmful stimulus. It is mediated by a reflex arc in which stimuli are received by receptors, impulses are transmitted through the nervous system and a contraction occurs in the appropriate muscles. Organisms that exhibit escape responses include; earthworms, squids, crayfish;

(b)(i) Motivation is the factor that controls responsiveness/ internal state of an organism that must precede a specific act of behaviour whereas motivating stimulus refers to type of stimulus that increases the responsiveness of an organism towards a specific behavioural act;
(ii) Imprinting is a type of learning in which young organisms associate themselves with large moving objects immediately after birth during the critical/ receptive period in the animal's life whereas imitation is a type of learning in which an organism copies the behaviour of another animal that occurs any stage in the animal's life;

(iii) Pheromones are substances secreted by one organism that stimulate a physiological or behavioural response in another of the same species whereas hormones are organic substances produced by glands transported in blood and exert their effect on other structures within body other the gland;

(c) Exogenous rhythms are rhythmical behavioural patterns that are controlled by environmental factors/changes such as the 24-hour cycle(photoperiod); examples include; migration, breeding seasons, hibernation; they increases chances of survival of organisms through; escaping adverse weather conditions like winter periods, producing young ones during favourable conditions when food is in plenty; minimizes competition among organisms for resources like food, breeding sites; reducing the risk of predation; exploiting resources in different ecological areas;
(d)(i) Removal of cerebral cortex results in loss of the center for intelligence and higher activities of the brain; making training such dogs impossible
(ii) This reduces the risk of being exposed to predators; minimizes the rate of water loss from their tissues in the natural environment
(iii) Nerve cells contain more RNA than any other type of cell; RNA production increases during learning to increase protein synthesis;

20.(a) *Is the type of learning where a stimulus is associated with another which would not necessarily evoke a response.* Examples include; instrumental and classical conditioning;

(b) Classical conditioning/conditioned reflex	Instrumental/operant conditioning (trial and error
Organism associates particular stimulus with a reinforcer/unconditioned response;	Animal associates a particular behavioural act with reinforcer;
Reinforcement (+/-) appearance is controlled by the person/experimenter;	Animal's own behaviour determines whether reinforcement appears or not;

(c) The hypothalamus is attached by numerous nerves to the brain and is exceptionally well supplied with blood from the rest of the body; it therefore receives a lot of information about conditions inside the body and in the external environment; it uses this information to regulate physiological processes and to control a number of vital homeostatic processes; which determines the degree of the drive of an organism towards a given behaviour;

(d) (i) Pheromones functions as natural sex attractants to attract mates during courtship in insects, birds, fish and mammals.
(ii)They are used in finding food, for example on food-seeking expeditions, worker ants lay down scent trails which can be followed by other workers.
(iii) Alerts animals in case of danger such alarm pheromones in bees, cat fish;
(iv) Regulate population size in social animals such as bees where they play an important part in directing the development and behaviour of different castes in a colony.

(e) (i) Mate cannibalism is due to increased aggressiveness of females; it is minimized by portraying proper courtship displays such as stridulation; songs and approaching the female when it is eating; it is common in some spider sps; praying mantis

(ii) Fighting is minimized through establishment of social hierarchies/pecking orders that decreases the amount of individual aggression associated with feeding, mate selection and breeding site selection; ensuring that resources are shared out so that the fittest survive and reducing the injury to the stronger animals;
21.(a) It states that only one species (a population) in a given community can occupy a given ecological niche at any one time;

b. (i.) Inter specific competition/ competitive exclusion

In the same culture, population of *P. aurelia* increases to the maximum as population *P. caudatum* decreases to the minimum beyond six days

(ii) P. aurelia has a higher maximum population than *P. caudatum* because *P. aurelia* is a better competitor than *P. caudatum*, being small in size it requires less food to survive, and is better able to survive when food is scarce unlike *P. caudatum* which is large in size and requires a lot of food to survive which is not readily available in the culture, *P. aurelia* has a faster reproductive rate and greater efficiency in obtaining, it also withstands high levels of toxic substances; however, *P. caudatum* attains a maximum before *P. aurelia* because it grows faster than *P. aurelia*.

(iii) It results into species diversification since competitive exclusion principle drives species to occupy different ecological niches; this involves modifications in organisms to suit the different ecological niches promoting diversity.

(c) Through resource partitioning where competitors are driven to occupy/ utilize different resources such as food in the same ecosystem, examples include; specialization of morphology and behaviour

for different foods such as beaks of birds which may be modified for picking up insects, drilling holes, cracking nuts and tearing flesh; vertical separation / stratification such as canopy dwellers and forest floor dwellers; horizontal specialization such as occupation of different microhabitat

It can also be modified due to niche specialization where organisms with a previously overlapped niche shift their niches to avoid competition

(d) Broad spectrum pesticide kills both the target and the non-target organism such as natural predators and natural competitors that would prevent the pest population from increasing. Due to random mutations in the pest, their genome changes and produces proteins that breakdown the pesticide causing pesticide resistance and thus flourish rapidly with control agents checking them hence pest resurgence.

(e) (i) During incubation feeding reduces thus resorting to stored food in the body such as fats; metabolism of fats results into release of the stored pesticide into blood in high concentration reaching toxic levels thus high death rate in reproductive stage than juveniles which feed normally and do not rely on stored food;

Increased exposure to pesticide by adult birds compared to juveniles, adult females spend more time on the ground / or in vegetation during egg laying and incubation compared to their juvenile which may have limited exposure foraging range thus reducing their exposure to pesticide;

Reproductive stage requires more energy thus feeding more rapidly making them more vulnerable to pesticide effects unlike juveniles that have a lot of energy reserves from their parental feeding thus less exposure to the pesticide

(ii) There will be more deaths in reproductive birds than in juveniles compared to the first experiment because during drought there is food shortage coupled with increased energy demand in reproductive individuals. This results into increased metabolism of stored food reserves where pesticide is stored therefore its releases into blood reaching levels causing high death rate

24. (a) Dominant Epistasis: dominant gene at one locus masks phenotypic expression of another gene (both dominant and recessive form) on a second locus.

(b) Let: Y represent allele for yellow fruit

y represent allele for green fruit
A represent allele for no pigment deposition
a represent allele for pigment deposition

Yellow fruit	Green Fruit	White Fruit
YYaa; Yyaa	yyaa	YYAA; YyAA; yyAA; YYAa; YyAa; yyAa

(C) *Parents:* ♂ X ♀

Parental phenotype: white fruits X green fruits

Parental Genotype: YYAA X yyaa

Meiosis

Gametes YA X ya

Random Fertilization

F1 generation : YyAa

F1 phenotype : all white fruits

Selfing F1 offsprings

Parents:	♂	X	♀
Parental phenotype:	white fruit	X	white fruit
Parental genotype :	YyAa	X	YyAa

Using a punette square

Meiosis :

Gametes :

Random fertilization:

F2 generation:

♂ / ♀	YA	Ya	yA	ya
YA	YYAA	YYAa	YyAA	YyAa
Ya	YYAa	YYaa	YyAa	Yyaa
yA	YyAA	YyAa	yyAA	yyAa
ya	YyAa	Yyaa	yyAa	yyaa

F2 phenotypic ratio: 12 white fruits: 3 yellow fruits: 1 green fruit

(d) two cycles

ii) Mass of DNA

From 0 hour to 12 hours is the first growth (G1) phase; cell contents replicate except DNA; from 12 hours to about 18 hours is the synthesis (S) phase; DNA replicates to double original mass; from 18 hours to about 23 hours is the second growth (G2) phase and mitosis; no DNA synthesis; at about 23 hours cytokinesis occurs; halving the DNA mass in each new cell to the original mass;

Cell mass

0 hour to about 23 hours marks the period of interphase and mitosis; during which organelles like mitochondria, cytoskeletal elements, endoplasmic reticula, ribosomes, Golgi apparatus, centriole, etc. replicate and increase in number; and the cell grows (G1 phase); DNA replicates; and the

chromosome content doubles; histones and other nuclear proteins are synthesized (S phase);
Synthesis of additional proteins that support cell metabolism occurs (G2 phase);
At about 23 hours cytokinesis divides the parent cell into equal sized daughter cells;

(iii) Nutrient availability, sufficient nutrients are required to provide energy and materials needed for division.
Environmental factors such as temperature, PH, stress can induce cell division
Cell density, high density can trigger division
DNA damage, cells may divide in response to repair mechanisms or in presence of damage.
Cell Size, cells must reach a certain size to divide to ensure that they have adequate resources.
Extracellular signals, hormones (like Growth hormone and FSH can induce division) and other signals from surrounding cells can promote or inhibit division.

25. (a)(i) October to April and November to February
(ii) it enables the ewes give birth in at a time of the year where food is plenty and the temperatures are cool for increased survival of the young ones.

(b) The regulation of the onset of oestrus in ewes depends on day length.

(c) When obliterated, the villi and microvilli are removed which reduces the surface area for exchange of materials at the placenta. The simple squamous layer is way too thin and can allow very many harmful substances to cross the placenta to the foetus which is dangerous to the growing foetus.

(d) Size of the substance; substances such as viruses are too small and easily cross the placenta;
Polarity of the substance; non polar substance such as alcohol can easily cross the hydrophobic placental membrane;

(e) It allows exchange of materials between the mother and the foetus without mixing of blood

Oxygen, water, amino acids glucose, essential minerals, etc. are transferred from maternal to foetal blood.
Carbon dioxide, urea and other wastes are transferred from foetal blood to maternal blood to allow their excretion by the mother and prevent harmful accumulation in fetus.
Allows certain maternal antibodies to pass into the fetus, providing it with some immunity against diseases.
It protects the fetus by preventing certain pathogens and their toxins from crossing the placenta.
It permits maternal blood system and fetal blood system to operate at different pressures without harm to the mother or foetus,
It produces certain hormones as pregnancy progresses for example progesterone

26. (a) shape of beak, different diets; some eat insects, some eat seeds/nuts; beaks become adapted over many generations by variation (mechanisms) and most efficient forms are selected;

(b) ancestors from South American landmass blown by storms/winds; or carried on driftwood;

(c) new variations would arise due to meiosis/fertilization; (and) due to continued mutation; most successful variations would survive better (than less suitable adaptations); to many different niches on the island to which the birds might become adapted

(d) that they are now separate species; due to reproductive isolation;

(e) bill shape/bird song/mating dances or ritual movements;

(f)(i) populations/islands X and Y are relatively close/not geographically isolated; thus, birds can still come into contact and breed together; no chance for any mutations to become genetically isolated/no chance for demes to become established; so little divergence occurs between X and Y/still reproductively compatible; population Y probably arose from population X because of prevailing winds; chromosomes of hybrids will still pair in meiosis (so gametes can form);

(ii) populations/islands Y and Z are geographically isolated; thus will not normally interbreed; thus mutations/genetic variation in the two populations will occur independently; thus become isolated by post-zygotic isolation/chromosomes of Y differ from those of Z/will not pair in meiosis (to form gametes); Z probably arose from Y as blown by winds rather than originating from X; not diverged sufficiently to have different courtship rituals/behavioural patterns; some Y may still be blown to Z allowing occasional interbreeding (although this has now become ineffective);

(iii) population/island X is geographically isolated from population Z; by ocean and island Y; thus mutations/genetic variation in the two populations has continued independently; they are now reproductively isolated because their courting/mating behaviours differ; incompatible mating rituals/courtship dances/plumage colours/breeding times; this is pre-zygotic isolation; ref to chromosomes of X will no longer match with those of Z even if they could mate;

27. (a) Similarities: At 0.2 and 6.5 weeks, both are the same; Both attain peak; From 2-3 and 6-7 weeks; both decreases. From 7-8 weeks; both increases.
Differences: From 0–1-week, compost temperature increases while maximum air temperature is constant.
From 1-2 weeks, compost temperature increases while maximum air temperature decreases.
From 0.2- 6.5 weeks, Compost temperature is higher than maximum air temperature.
From 6.5-8 weeks, compost temperature is lower than maximum air temperature.
From 3-6 weeks, maximum air temperature increases while compost temperature decreases.
Temperature within compost attains higher peak than maximum air temperature.

(b) From 0-1 week; compost temperature increases rapidly because at the start of composting, microorganisms, such as bacteria and fungi which thrive in moderate temperatures (mesophillous microbes); metabolize & break down easily degradable compounds such as simple sugars and starch generating heat. The compost pile's temperature rises rapidly as microbial activity intensifies. Oxygen levels are typically high, supporting high aerobic respiration.

From 1-3 weeks; compost temperature increases gradually further to the peak; as the high compost temperature now favours thermophilic microorganisms; which thrive in high temperatures; are more efficient at breaking down more complex organic materials, such as cellulose, lignin, and hemicellulose. The high temperatures in this phase are necessary for breaking down these tougher materials; and even kills weed seeds within the compost. This raised temperature kills and selects against activity of mesophillous microbes.

From 3-7 weeks, temperature within compost falls to ambient temperature as the readily degradable material becomes exhausted. The population of thermophilic microbes declines, and mesophilic microorganisms become active again, feeding on secondary sugars from the extracellular digestion by other microbes, continuing the decomposition process.

From 7-8 weeks; compost temperature is low and increases slightly as its maintained at ambient levels; as decomposition process has slowed down significantly; due to the depletion of biodegradable organic matter; and much has now stabilized into humus; and the temperature becomes consistent with the surrounding environment, typically slightly below ambient temperature due to ongoing slow microbial activity and cooling effect of the compost.

(c) The raised temperature speeds up the decay process; it selectively favours organisms adapted to survive at higher temperatures; and it may even be high enough to kill the weed seeds present in the rotting material preventing weed growth.

(d) (i)

Fungi	Plants
cell walls of fungi are composed of chitin	cell walls are made primarily of cellulose
Heterotrophic	Autotrophic
Lack roots, stems, and leaves but have hyphae	Have roots, stems, and leaves
Fungi do not contain chlorophyll	Do contain chlorophyll
Are decomposers (Saprophytes)	Are producers in ecosystem
Store energy in the form of glycogen	Store energy in the form of starch
Reproduce by means of spores	Reproduce by means of seeds; or vegetative propagation

(ii) Phytophthora infestans has sporangia, which structures release spores which are easily dispersed by wind allowing the fungus to spread rapidly across large areas; It secretes enzymes like cellulases and pectinases that break down plant cell walls, aiding its entry and further colonization of plant tissues; Has haustoria that penetrate the host's cell walls and act as feeding organs; releasing enzymes onto host tissue and absorb nutrients like sugars, amino acids from the host cells, which are essential for the growth and reproduction of *P. infestans*.; Both sexual and asexual means of reproduction increases chances of survival; tolerance to harsh conditions of drought and low nutrient availability;

(e) (i) Saprotrophs break down dead organic debris which decomposition process converts complex organic compounds into simpler forms like carbon dioxide, water, and inorganic nutrients; helping clear organic waste from the ecosystem, preventing the build up of detritus; which would pollute the environment.

Decomposition process recycles essential nutrients, such as nitrogen, phosphorus, and potassium, back into the environment; which are then reabsorbed by plants, which form the base of the food chain.

The recycled nutrients are critical for maintaining soil fertility and ensuring the growth of plants, which in turn supports herbivores and higher-level consumers.

Saprotrophs contribute to the formation of humus; improving the soil's structure, water retention, and fertility, making it more suitable for plant growth.

saprotrophs contribute to the maintenance of habitats promoting biodiversity.

(ii) Recycling practices help farmers manage waste more efficiently reducing costs associated with waste disposal; Recycling organic materials returns nutrients back to the soil improving soil fertility which leads to enhanced crop yields; Maintaining sustainable productivity over long term; Recycling agricultural waste minimizes the release of pollutants into the environment; Enhanced plant growth sequesters carbon mitigating climate change and global warming, contributing to environmental sustainability; Enhanced conservation and biodiversity

28. (a) (i) ATP-creatine is the immediate source of energy, followed by Glycolysis and then later Aerobic respiration.

ATP-creatine provides energy for the shortest time followed by Glycolysis, while Aerobic respiration provides energy for the longest time.

(ii) ATP-CP SYSTEM: Immediate source of energy; and muscle solely/mainly uses it as source of energy for the first 10s of exercise; since it supplies much energy but so quickly since oxygen gas is not used in the process. ATP is rapidly hydrolysed in just a single step reaction to ADP, Pi and energy.

Creatine phosphate provides Pi used to rephosphorylate ADP to regenerate ATP.

However, this energy system is used for a very short time, since ATP and CP exist in very small amounts in muscle cells thus rapidly get depleted.

ANAEROBIC/GLYCOLYSIS: The energy supply increases rapidly from the 10th second and remains high and constant for relatively a long time as the main energy source up to the 3rd minute of exercise. Glycolytic energy is used for relatively a short time. Glycogen stores in muscle and liver cells are used and no oxygen is required in the synthesis of ATP. Glycogen is broken down to glucose; used to generate ATP by glycolysis and lactic acid fermentation; anaerobism is used for a short time still since it yields little energy and produces toxic product (lactate causes muscular tiredness, pain, cramps)

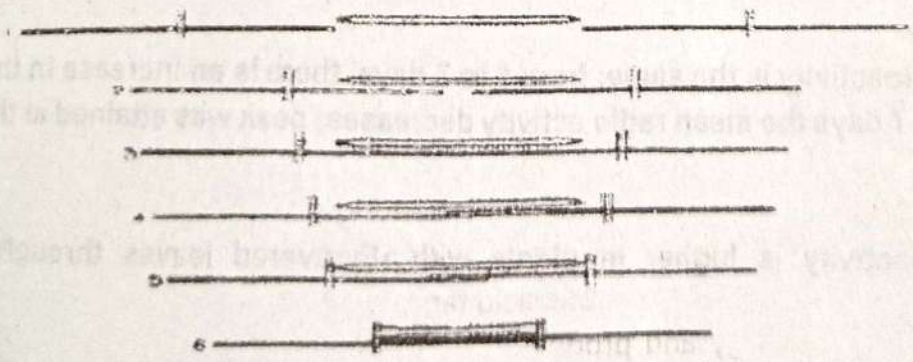
AEROBIC: Energy supply builds up slowly/ gradually for the first 30s, but later increases rapidly and remains as the major energy source beyond the 4th minute of exercise. This provides a long-term

energy source; and uses glycogen, glucose and fats to replenish ATP molecules required for energy production. The system takes a little longer as compared to the other two systems since it takes some time for oxygen gas to enter/ diffuse into and build up in muscle cells (from air/ myoglobin/haemoglobin) for oxidizing respiratory substrates, but continues for a much longer time since the process yields much ATP/energy, no lactic acid is produced thus muscles not cramped. The oxygen taken in is also part of oxygen debt to reduce lactate that accumulates thru anaerobism; (to glucose/pyruvate);

(b) (i) From 135 to 112 % resting length, active tension increased gradually to the maximum of 100 % because the sarcomere/ muscle was contracting. There was gradual cocking of bulbous myosin heads into their binding sites on actin filaments, and thus more actin-myosin cross bridges were being formed, increasing the tension. The process involves actin filaments sliding past myosin filaments that brings Z-lines of sarcomere closer shortening the muscle.

At maximum tension, all myosin heads present are cocked into their binding sites on actin filaments. Maximum possible cross-bridges were formed.
From 112 to 108 % resting length, the tension remained constant at 100%, during which all cross bridges still existed but the bulbous myosin heads bent pulling actin filaments towards the M-line till when they just touch it.
When % resting length fell from 108 to 85, active tension reduced gradually due to overstraining of the muscle fibre. The great tension created by the pull of actin filaments by myosin heads caused the actin to destroy the M-line, and thus the cross- bridges broke way gradually, and the actin filaments of sarcomere gradually slide past each other.

From 85% to 50% resting length, active tension fell rapidly to zero, due to rapid breaking away of cross-bridges that reduced the tension further. Actin filaments of sarcomere further rapidly slide over each other; and at zero tension, all cross-bridges are broken and the actin filaments touch the opposite Z-line of Sarcomere.



(ii) Striations of the filaments allows for efficient and powerful contractions; Cells are multinucleated allowing for enhanced protein synthesis and muscle repair, as well as coordination of the cellular processes necessary for muscle contraction; Rich blood supply to provide necessary oxygen and nutrients for energy production; Ability to stretch and return to their original shape which allows for flexible movements; Innervated by motor neurons that stimulate contraction allowing for precise control of muscle activity

29. (a) (i) Allows fast transport of more oxygen for respiration so that this oxygen is delivered to tissues at a high rate; keeps oxygenated and deoxygenated blood separate maintaining high blood pressure to body and lower pressure to lungs; as circulatory body systems are kept separate;
(ii) Bradycardia is a heart condition that results in a heart rate that is slower than normal. Atropine is a competitive inhibitor of acetylcholine; yet acetylcholine slows heart rate / reduces frequency of depolarisation by hyperpolarising heart muscles; atropine binds / blocks (acetylcholine) receptors; at SAN; reducing acetylcholine binding to its receptor; preventing acetylcholine inhibiting depolarisations; leading to opening of sodium channels instead; increasing depolarisations; and tachycardia therein
(b) (i) Exercise increases respiration rate so carbon dioxide concentration increases while oxygen concentration decreases; blood pH decreases / acidity increases; which is detected by chemoreceptors in aorta / carotid artery / medulla; & baroreceptors / stretch receptors detect changes in blood pressure; impulses (from neurones of peripheral receptors) sent to {medulla / cardiac centre / cardio-acceleratory centre; of medulla Oblongota.
(ii) Bradycardia and no ventilation so as to limit rate of oxygen delivery to and consumption by tissues while still supplying (sufficient) oxygen to vital organs of heart and brain; Shunting effect of blood flow whereby there is vasoconstriction of peripheral blood vessels and vasodilation of vessels to the heart and brain.
(c) Plaques / atheroma forms in (coronary) artery; causing narrowing / blockage of the coronary artery; therefore, reducing the blood supply to cardiac / heart muscles; so, heart muscles die; heart (muscles) stops contracting; if enough cardiac muscle cells die; so, oxygen is not (well) supplied to brain cells (stroke); causing death
30. (a) Similarities:

In both, the initial mean radioactivity is the same; from 0 to 3 days, there is an increase in the mean radio activity; from 3days to 7 days the mean radio activity decreases; peak was attained at the same time; attained peaks;
Differences:
Generally, the mean radioactivity is higher in plants with uncovered leaves throughout the investigation.

Mean radioactivity in leaves not covered	Mean radioactivity in leaves covered
From 0 to 3 days, the mean radioactivity increases rapidly	From 0 to 3 days the mean radio activity increases gradually
From 3 days to 7 days the mean radioactivity decreases rapidly.	From 3 days to 7 days the mean radioactivity decreases gradually
Attained a higher peak	Attained a lower peak
From 0 to 7 days mean radioactivity was higher	From 0 to 7 days mean radioactivity was lower

(b) The difference in mean radioactivity between the two groups of plants can be attributed to the exclusion of light in the leaves covered with aluminum foil. Light stimulates opening of stomata causing water to evaporate to the atmosphere from the substomatal air chamber; leading to reduction in water potential; water is then drawn from the neighbouring mesophyll cells to the substomatal air chamber; from one mesophyll cell to the adjacent ; by osmosis along the osmotic gradient; then water is drawn from the xylem to the adjacent mesophyll cells; the effect is transmiited through the stem xylem, upto the roots; causing a continuous stream of water through the xylem of the stems to the leaves; this is responsible for the rising of water and dissolved minerals like ^{32}P from the roots to the leaves; this results in accumulation of ^{32}P in the leaves increasing the mean radioactivity. The mean radioactivity is higher in leaves that were not covered because more stomata were opened by light, higher rate of transpiration and accumulation of ^{32}P.
The mean radioactivity of uncovered leaves decreased rapidly while the covered leaves decreased gradually. This is due to high rate of photosynthesis in uncovered leaves which increases phosphate uptake by the photosynthesizing cells. Photosynthesis utilises phosphates (containing ^{32}P) in ATP synthesis during light reactions and other metabolic processes. Increased photosynthesis leads to increased phosphate uptake, retention and utilization.
In covered leaves (without light) there is reduced photosynthesis, phosphate uptake and utilization.

(c) (i) Once the phosphates are absorbed by the root hairs by diffusion and active transport; they move along cell walls (apoplast pathway). In mass flow, the phosphate ions are carried along in solution by water being pulled upwards in the plant in the transpiration stream, due to the transpiration pull i.e. the phosphate ions dissolve in water and move within the water columns being pulled upwards.

The phosphate ions can also move through the Symplast pathway i.e. from one cell cytoplasm to another. When the phosphates reach the endodermis of the root, the Casparian strip prevents their further movement along the cell walls (apoplast pathway). Instead, the phosphate ions enter the cytoplasm of the cell (Symplast pathway) where they are mainly pumped by active transport into the xylem tissues; their accumulation in the xylem of the stem leads to reduction of water potential; causing water to be drawn from neighbouring cells into the xylem; generating a hydrostatic pressure, root pressure which moves the water column up the stem to short distance;

Once in the xylem, the minerals are carried up the plant by means of mass flow of the transpiration stream. From the xylem tissues, phosphates reach the leaves where they are utilised by diffusion and active transport i.e. the phosphates move laterally (sideways) through pits in the xylem tissue to the sinks by diffusion and active transport.

(i)Ensures reliable and statistically significant results. It accounts for variability among individual plants and allows for a better mean measurement of radioactivity in each condition.

(ii)The amount of ^{32}P in the leaves continued to increase initially because the uptake and transport of phosphate from the roots to the leaves occurs over time. Even after transferring to a non-radioactive solution, the pre-existing ^{32}P already taken up and transported to the leaves remained there until it was gradually metabolized. Also, some phosphates are recycled from senescing tissues are re-utilized.

(d) (i) Exposing the plants to moving air would likely increase the amount of 32P accumulated in the leaves. Moving air increases transpiration rates because the wind sweeps away the diffusion shells around the leaf, thereby maintaining a steep diffusion gradient which keeps the rate of transpiration high. This stimulates the uptake and transport of nutrients including phosphates from the roots up the plant.

(ii) Darkening the leaves would likely lead to a decrease in the amount of starch and soluble sugars in the covered leaves. Photosynthesis, which produces glucose and starch, relies on light. In the absence of light, the plants would not produce these carbohydrates efficiently, and any pre-existing starch would be utilized for respiration, leading to reduced overall levels ^{32}P.

31. (a) Similarities

Both have the same concentration at day one

Differences

Group I	Group II
From day1 to day 2, serum calcium concentration increased gradually	Serum calcium concentration decreased gradually
From day 2 to day 3, serum calcium concentration increased rapidly	Serum calcium concentration decreased rapidly
From day 3 to day 5, serum calcium concentration decreased gradually	Serum calcium concentration decrease gradually
Between day 1 and day 5, serum calcium concentration was above norm value	Serum calcium concentration was below norm value

(b) Group III, from day 1 to day 5; the serum calcium concentration was maintained constant within the normal range; The parathyroid was functioning normally, producing the parathormone regulating the levels of serum calcium at the set point under negative feedback mechanism.

Group I, from day 1 to day 2; Serum calcium concentration increased gradually because small amounts of parathormone released into blood stream which resulted into gradual; release of Ca^{2+} ions from bones, absorption of Ca^{2+} from the gut and reabsorption of Ca^{2+} from the proximal

convoluted tubule(PCT) in the kidney nephron which ensures retention of high calcium ions levels in the body fluids; from day2 to day 3; rapid increase in serum Ca^{2+} concentration due to increased parathormone secretion into blood stream which resulted into increased; bone breakdown to release Ca^{2+} ;absorption from the gut and reabsorption in the PCT that retains higher calcium ions levels; from day 3 to day 5; serum Ca^{2+} gradually increased due to further production of parathormone which gradually increased bone breakdown with calcium deposits almost depleted;
Group II; from day 1 to day 2; serum Ca^{2+} concentration decreased gradually because parathormone production ceased and its concentration in blood gradually reduced; lowering; Ca^{2+} release from bones, absorption in the gut; reabsorption from the PCT; from day 2 to day 3; serum Ca^{2+} concentration rapidly decreased due to rapid decrease in parathormone concentration in blood which greatly reduced bone breakdown, reabsorption in the PCT and absorption in the gut; from day 3 to day5 ; serum Ca2+ concentration gradually decreased due to very low levels of parathormone in blood leading to very low bone breakdown releasing very little Ca^{2+} ions, very low reabsorption in PCT; reduced absorption in the gut;
(c)Tetany is a condition that results from underactivity of the of the parathyroid glands(hypoparathyroidism) which results into hypocalcaemia (lower calcium ion concentration in blood below norm range/ 7mg per 100cm3). It is characterized by increased excitability of the nervous system; muscular activity becomes spasmodic and uncontrolled.
(d)Subsequent injection of parathyroid extracts/ parathormone
(e)Serum calcium concentration would be below that of group I individuals and above group II individuals

(f) After the menopause estrogen production ceases, lifting the inhibition on parathormone output which increases the decalcifying activity of parathormone on the bones; increased breakdown of bone structure makes them more fragile and prone to fracture.
32. (a) As the relative amount of starch decreases/decreases rapidly; the percentage of open stomata increases rapidly to a maximum, from time of 6am to 10:30am;
As the relative amount of starch increases more rapidly, the percentage of open stomata remains constant; from 12pm to 2pm;
As relative amount of starch increased gradually, the percentage of open stomata decreased gradually from 2pm to4 pm.
As relative amount of starch increased rapidly, the percentage of open stomata decrease rapidly from 4pm t0 8pm;
(b)i) decrease in relative amount of starch to a minimum lead to increase in the percentage of open stomata to maximum; this is because more starch in the guard cells is broken down; to more glucose; catalysed by enzymes like phosphorylase.
Increase in conc. Of glucose in guard cell lowers water potential in guard cells; causing water to be drawn into guard cells by osmosis from the surrounding epidermal cells. the guard cells become turgid and many stomata open.

Low and very slow increase in the relative amount of starch leads high and constant percentage of open stomata; this is because there is no more starch broken down to form more glucose; increase in relative amount in guard cells, leads to decrease in the percentage of open stomata; this is because a lot of glucose in the guard cells is converted to starch; increase in the amount of starch in the guard cells causes the water r potential to become high and water is lost from the guard cells by osmosis; to the surrounding epidermal cells, the guard cells become flaccid and many stomata close while few remain open

(ii) increase in time of the day from 6am to 1030am leads to a rapid increase rapid increase in the percentage of open stomata to a maximum, this is because during this time of the day light intensity increases increasing rate of photosynthesis; more sugars are formed in the guard cells; water potential is lowered the guard cells; causing water to be drawn into the guard cells by osmosis; guard cells become turgid and stomata open.

Increases in time of the day from 12pm to 2p, leads to percentage of open stomata to remain constant; this is because there is no further photosynthesis and no further formation of sugars in the guard cells;

Increase in time of the day from 2pm to 8pm, leads to decrease in the percentage of open stomata; this is because during this time of the day light intensity decreases reducing rate of photosynthesis; the amount of sugars formed in the guard cells; where more sugars respired; decrease in the conc. Of glucose in the guard cells causes the water potential to become high, water is lost from guard cells and they become flaccid hence many stomata close

(c) CO2 and O21 enter into mesophyll cells; CO2 is accepted by PEP to form a 4 -c OAA reaction catalysed by PEP carboxylase; OAA is reduced by reduced NADP and energy provided from hydrolysis of ATP; malic acid is formed; while O2 is used to respire glucose; to generate energy in form of ATP;

(d)(i) water potential of surrounding solution= osmotic potential + pressure potential

= -1700+ 1200; =-500Pa

(ii) It will lead to increase in stomata l aperture; this is because the surrounding epidermal cells have a higher water potential; while the water potential of guard cells is lower; this will cause water to drawn into the guard cells; by osmosis; from the surrounding epidermal cells; the guard cells will become more turgid; thick inner walls of guard cells curve outwards to attain a convex shape causing increase in the stomatal aperture

33. (a) 1.07g of water are produced by 1g of fat;

321g of water are liberated by (321/1.07) g of fat=300g

1g of fat requires 2 dm3 of oxygen

300g of fat require 300*2dm3= 600dm3 of oxygen

(b) It possesses a counter current heat exchanger mechanism in which a cold fluid in its nares flows in opposite direction to that of expired air hence extracting most of the moisture in it

(c)The human has a higher proportion of fat than camel in the ratios of 10:2 and 10:1 respectively;

In human the fat is distributed almost uniformly all over the body under the skin and around delicate organs whereas in the camel the fat is concentrated around the hump;

(d) In for insulation and absorb shock;
In camel; to conserve water and allow heat loss to environment;

(e) The kidney nephrons of the camel have longer loops of Henle than those of humans which increases the surface area for reabsorption;

(g)During day time camel's body temperature increases with increase in environmental temperature by absorbing heat through conduction, convection and radiation; stores it in the body to reduce the temperature gradient between the body and the external environment; reducing heat absorbed by the body from the environment; water loss by evaporation that serve to cool the body; conserves energy that would be used in endothermic body cooling mechanisms;

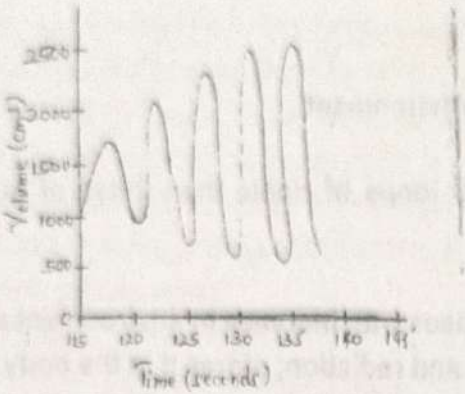
(f) (i) Temperate mammals are larger in size than desert mammals in order to reduce the surface area to volume ratio; reducing the rate of heat loss to the external cold environment;
Desert mammals are smaller in size which provide a large surface area to volume ratio over which the excess heat is lost rapidly to the hot environment;

(ii) Body extremities of desert mammals are less hairy than temperate mammals; to enhance heat loss the hot environment; body extremities of temperate mammals have much hairs that insulate the body against heat loss to the cold environment;
Body extremities of desert mammals are highly vascularized which increases blood supply hence more heat is lost to the surrounding compared to those of temperate with less blood capillaries reducing blood supply which minimizes heat loss to cold environment;
Body extremities of desert mammals are larger compared to those of temperate mammals in order to present a large surface area over which heat is dissipated to external environment while temperate mammals have smaller ones that present a smaller surface area over which heat is lost;
34.(a) (i) 5 seconds are taken to complete 1 cycle; 1 second is taken to complete 1/5 cycles

60 seconds are taken to complete 1/5 X 60 cycles=12; Therefore, the breathing rate is 12 cycles per minute. (ii) Tidal volume =750cm^3

(iii) Pulmonary Ventilation= breathing rate x tidal volume; = 12 x 750; = 9000cm^3min^{-1}

(b)



(c) With onset of exercise, the tidal volume and breathing rate increase hence increase in pulmonary ventilation. This is because during exercise, the rate of aerobic respiration of muscle cells increases. Therefore, fast transport of larger volumes of oxygen to the muscle cells to meet their metabolic demands and rapid expulsion of carbon dioxide before accumulating are required hence the increase in pulmonary ventilation.

(d) Increase in carbon dioxide concentration would cause increase in the ventilation rate.

(e) When CO_2 increases in blood it rapidly diffuses into the cerebrospinal fluid reacting into increase in H^+ ions; this increase in acidity stimulates cells in the floor of the fourth ventricle to generate impulses which excite the inspiratory center in the medulla oblongata. Increase in CO_2 concentration in blood is also detected by the peripheral chemoreceptors in the carotid and aortic bodies which are stimulated to send impulses via the glossopharyngeal nerve and vagus nerve respectively to the inspiratory center in the medulla oblongata which in turn sends impulses to the diaphragm via the phrenic nerves and to the intercostal muscles via the intercostal nerves. This causes rapid contraction of external intercostal muscles and diaphragm muscles resulting into faster inspiration; the lungs become inflated and expand which stimulates the stretch receptors in their walls to send impulses along the vagus nerve to the expiratory centre in the medulla oblongata which temporarily switches off the inspiratory centre and inspiration; this causes external intercostal muscles and diaphragm muscles to relax; resulting into decrease in volume of the thoracic cavity and increase in pressure beyond atmospheric pressure; resulting into expulsion of air from the lungs;

The above mechanism prevents accumulation of carbon dioxide beyond the norm which would have adverse effects.

(f) The diaphragm muscles relax causing the diaphragm to return to its dome shape. External intercostal muscles relax, while the internal intercostal muscles contract and the ribcage moves downwards and inwards. As a result, the volume of the thoracic cavity decreases and the pressure increases beyond atmospheric pressure. Consequently, air is forced out of the lungs.

(g) The smoke addict breathed out a lower volume of air than the non-smoker. This is because of the following reasons:

Smoke contains nicotine which causes constriction of the finer bronchioles, increasing resistance to flow of air out of the body
Nicotine paralyses the cilia which remove dirt and bacteria; the accumulation of extra material in the air passages can restrict air flow
Smoke acts as an irritant which causes secretion of excess mucus from goblet cells and excess fluid into the airways making it more difficult for air to pass through them out of the body
The lungs lose elasticity so it becomes more difficult to exhale air hence a lot of air remains in the lungs during expiration
(h) (i) During autum, respiratory quotient increases beyond 1.0 and then decreases and remains constant at 0.7 during winter.

The hedgehog is a hibernator and therefore undergoes fattening in autum in preparation for the winter season where it becomes dormant a process which involves physiological conversion of carbohydrates to fats with less oxygen atoms for storage hence more carbon dioxide is evolved than oxygen used resulting into increase in respiratory quotient in autum.

During winter, the respiratory quotient decreases and remains constant at 0.7. This is because the hedgehog undergoes hibernation due to the very cold temperatures where it becomes dormant and resorts to aerobic respiration of fat.

(ii) At the start of germination when there is simultaneous aerobic and anaerobic respiration due to impermeable seedcoat;

Under conditions of water logging

(iii) They are used to determine:
The type of substrate being respired
Whether respiration is aerobic or anaerobic
The physiological process taking place e.g. conversion of carbohydrates to fats
35. (a) (ii) From 40 minutes to 50 minutes, as core temperature decreases, energy loss through evaporation decreases;
From 50 minutes to 65 minutes, as core temperature increases, energy loss through evaporation also increases.

(b) As the core temperature decreases, energy loss through evaporation also increases.

Ingestion of ice results into decrease in temperature of the hypothalamus below the norm due to loss of heat by blood to the gut. This stimulates the heat gain centre of the posterior hypothalamus to send impulses via efferent nerves to the sweat glands inhibiting further production of sweat hence decrease in heat loss in form of latent heat of vapourisation hence the temperature is raised back to the norm.

(c) Increase in temperature beyond the norm was detected by hot receptors in the skin which sent impulses via afferent nerve to the heat loss centre of the anterior hypothalamus which sent impulses to various effectors stimulated corrective mechanisms including increase in rate of sweating,

decrease in metabolic rate, vasodilation of superficial blood capillaries, that restored the body temperature back to the norm

(d) (i)The skin has the following parts involved in temperature regulation:

Thermoreceptors that is hot and cold receptors. The hot receptors detect increase in skin temperature and send impulses to the heat loss centre of the anterior hypothalamus that sends impulses to effectors bringing about corrective mechanisms that decrease body temperature back to the norm.

The cold receptors detect decrease in temperature and send impulses to the heat gain centre of the posterior hypothalamus that stimulates corrective mechanisms that increase body temperature back to the norm.

Sweat glands. These are stimulated to increase sweat production which increases heat loss in form of latent heat of vapourisation during hot conditions to bring about cooling. During cold conditions, sweat glands are less stimulated and so there is a decrease in sweat production hence decrease in heat loss to the surrounding.

Erector pili muscles and hairs. The erector pili muscles contract during cold weather making the hairs to stand upright on the skin, a thick layer of air is trapped hence insulating the body against heat loss. The erector pili muscles relax during hot conditions, the hairs lie flat on the skin and less air is trapped between the hairs hence less insulation against heat loss.

Superficial arterioles. These constrict during cold temperatures resulting into decreased blood flow through capillaries and hence decrease in heat loss from the body. During hot conditions, the superficial arterioles dilate; more blood flows through capillaries and more heat is lost via the skin by conduction, convection and radiation resulting into decrease in body temperature back to the norm.

Subcutaneous fat. This provides insulation to the body against heat loss during cold conditions.

(ii) The counter current heat exchange system is found in appendages and minimizes heat loss to the surrounding.

Each appendage is composed of an artery and a vein that are in close contact and running parallel to each other.

As warm arterial blood from the heart flows towards the appendage, it loses heat to the venous blood, which is colder. As a result, the temperature of arterial blood reduces such that by the time it reaches the end of the appendage it has lost most of the heat to venous blood. This reduces the temperature gradient between the appendage and surrounding hence reduction in heat loss from the body and blood flowing to the heart is warmed.

(f) Plants	Animals
Lose heat to the surrounding through transpiration	Lose heat through sweating
Control does not involve the brain	Control involves the brain
Does not involve hormones	Involves hormones
Are more tolerant to temperature changes	Less tolerant to temperature changes

(g) Maintaining a constant body temperature is essential for efficient enzyme activity. Enzymes work effectively within a narrow optimum temperature range to maintain metabolism. Low temperatures below optimum inactivate enzymes while high temperatures beyond the norm denature enzymes which is fatal.

Extremely high or low temperatures alter the structure and functioning of cell surface membranes which affects the entry and exit of substances resulting into death of the organism.

(h) In positive feedback mechanisms, the effect of deviation from the norm intensifies the original response such that the change tends to proceed in the same direction as the initial stimulus. Therefore, positive feedback mechanisms cause larger temperature deviations that hinder metabolism, leading to unstable conditions and death.

36.(a)*The first law, states that the characteristics of an organism are controlled by internal factors which occur in pairs but only one can be carried in a single gamete".*

Explanation by meiosis

The genes which determine organisms' characters occur in two alternative forms called alleles located on pairs homologous chromosomes

homologous chromosomes separate (segregate) during anaphase 1 of meiosis to opposite poles;

Subsequent cell division results into two gamete cells each containing one of the two alleles; hence the alleles occur as pairs in body cells but singly in gamete cells.

The 2nd states that each of the pair of internal factors / contrasted characters may combine randomly with both pair

Explanation

Different pairs of homologous chromosomes align/ assort independent of each other in meiosis (metaphase 1) at the equator of the spindle;

When they separate, during anaphase 1; one chromosome of the homologous pair goes to one pole and the other to a different pole in a random manner. The two genes/alleles /pair of internal factors are located on different but homologous chromosomes. It is therefore purely random means by which alleles of one gene become combined with alleles of another gene

(b)

Complete linkage	Incomplete linkage
Two or more genes located on the same chromosome close to each other	Two or more genes located on the same chromosome distant from each other
No crossing over can take place	Crossing over takes place
No recombinants formed	Formation of recombinants

(c) hint

- The phenotypic variations expressed in the offspring show that genetic recombination occurs during meiosis and new genotypes are formed.,
- The parents must have been heterozygous.
- The gene for eye color is sex linked since its recessive allele (lozenge) is only showing up phenotypically in male offspring

Let;
W represent allele for long wings; w represent allele for curved wing, R represent allele for red eye color, r represents lozenge eye color, XX represent the genotype of female
XY represent the genotype of male

Phenotype		Genotype
i)	Curved wing mutant	ww
ii)	Lozenge eye mutant	rr
iii)	Female parent	X^RX^rWw
iv)	Male parent	X^RYWw

Parental phenotypes: wild type long winged X Wild type long winged, red eyed female

Red eyed male

Parental genotypes (2n) X^RYWw X X^RX^rWw

Meiosis

Gametes (XRW) (XRw) (YW) (Yw) (XRW) (XRw) (XrW) (Xrw)

(d) Random fertilisation using a punnete square

random fertilization

Gametes of the female parent

Gametes of the male parent

♂ \ ♀	X^RW	X^Rw	X^rw	X^rW
X^RW	X^RX^RWW	X^RX^RWw	X^RX^rWw	X^RX^rWW
X^Rw	X^RX^RWw	X^RX^Rww	X^RX^rww	X^RX^rWw
YW	X^RYWW	X^RYWw	X^rYWw	X^rYWW
Yw	X^RYWw	X^RYww	X^rYww	X^rYWw

males

long wings red eyes 3(300 flies in question)

long wings lozenge eyes 3(300 flies in question)

Curved wings lozenge eyes 1(100 flies in question)

Curved wings red eyes 1(100 flies in question)

Females

Long winged red eyed 6 (600 flies in question)

Curved winged red eyed 2 (200 flies in question)

(e) Haploid Organisms: In haploid organisms, such as bacteria and some fungi, there is only one set of chromosomes, so there is no segregation of alleles as seen in diploid organisms.

Mutations: Mutations can introduce new alleles or change existing ones altering the expected inheritance patterns and deviating from Mendelian ratios.

Multiple Alleles: The presence of more than two o alleles for a: single gene leads to more complex inheritance patterns than Mendel's two-allele model.

Codominance: In codominance, both alleles in a heterozygote are fully expressed, resulting in a phenotype that displays both traits simultaneously, rather than one dominant trait

Incomplete Dominance: Incomplete dominance occurs when the phenotype of a heterozygote is intermediate between the phenotypes of the homozygous parents, deviating from the dominance principle.

Complementary Genes: Complementary genes work together to produce a specific phenotype, with the interaction between two or more genes deviating from Mendel's independent assortment.

Gene Complexes: Gene complexes involve multiple genes that collectively influence a trait, deviating from the concept of single-gene inheritance.

Epistasis: Epistasis occurs when one gene masks or modifies the expression of another gene, altering the expected phenotypic ratios from Mendelian inheritance.

Lethal Genes: Lethal genes can cause the death of an organism when present in certain genotypic combinations, affecting the segregation ratios predicted by Mendel's laws.

Linked Genes: Linked genes are located on the same chromosome and tend to be inherited together, deviating from Mendel's principle of independent assortment.

Sex-Limited Genes: Sex-limited genes are expressed only in one sex, leading to phenotypic differences between males and females that Mendel's principles do not account for.

Sex-influenced Genes: Sex-influenced genes are expressed differently in males and females, leading to variations in phenotype based on sex that are not explained by Mendelian dominance.

Polygenic Traits: Polygenic traits are controlled by multiple genes, each contributing to the phenotype, resulting in a continuous range of variations rather than discrete Mendelian classes,

Pleiotropy: Pleiotropy occurs when one gene influences multiple traits, which deviates from the expectation that a single gene affects only one trait.

37(a) (i)Light of wave length 430 nm appears blue because it only stimulates the blue cones in the eye

(ii)Light of wave length 550nm appears yellow because it equally stimulates the red cone

and green cones hence yellow color perceived

(iii)Light of wave length 57Onm appears orange because of differential stimulation of red cones and green cones but stimulating more of red cones than green cones hence orange colour

(b)Each cone synapses with a single bipolar neuron and each bipolar synapses with a ganglion cell. This arrangement provides maximum acuity due to no Combining of information as each part of an image is detected by a different cone cell, hence light from two closely placed small objects will fall on separate cones, separate action potentials are formed, on transmission to the brain interpreted as separate images unlike rods which exhibit retinal convergence hence are highly sensitive due to summation but are of poor visual acuity.

(c) (i)The mammalian eye contains rods which exhibit retinal convergence as many rod cells make a synaptic connection with a single bi-polar neuron which in turn connect with a single optical fiber; each rod upon stimulation establishes its own generator potential ,several generator potential produced independently spatially summate to form a larger excitatory potential that can reach threshold for an action potential to be fired hence high sensitivity of mammalian eye unlike the compound eye where individual ommatidium function independently to produce individual impulses hence low sensitivity to light.

(ii) Compound eyes have lower visual acuity because ommatidia are numerous and large compared to cones and rods, each ommatidium has its own small lens and captures its own part of the image, hence processes a small fraction of the visual field, the resolution is therefore spread out, providing low visual acuity while the mammalian eye has a higher visual acuity due to possession of a single lens , all the incoming light is focused on the photoreceptors also it contain Cones where each cell

synapses with a single bipolar neuron and each bipolar neuron synapses with a ganglion cell hence providing maximum acuity due to no Combination of information for each object part

(iii) Compound eyes detect flickering faster than the mammalian eye because an individual ommatidium receives light and generates an impulse more rapidly than the rod and cone cells in the eye

(d)(i) Rod cells receive low light stimulus, Rhodopsin absorbs the light energy the retinene changes from cis to trans forms, rhodopsin then splits into its constituents , scotopsin and free trans retinene (bleaching) Membrane of the outer segment becomes impermeable to Na+ and its diffusion back into the rod cell stops .Inner segment continues to actively pump out sodium ions , the Inside of a rod cell becomes more negative than usual negative resting potential, and the membrane of the rod is said to be hyperpolarized This reduces the rate of release of glutamate to the surrounding tissue fluid from the rod cell, the Membrane of bipolar neuron becomes hyperpolarized and that of the ganglion cell becomes depolarised. Generator potential is formed across the membrane of the ganglion which builds up reach threshold value, and action potential generated transmitted via optic nerves to the brain, which interprets and reverses the inverted image to a correct position

(d) (ii) Dark adaptation refers to a brief period of insensitivity to light of low intensity after moving from a place of light of high intensity. This is because much of the retinene is in trans form thus low sensitivity to light; for regainment of light sensitivity again , trans retinene has to be converted back to Cis retinene which process is a slow enzyme catalyzed reaction hence for that period the rod cell is unsensitive ; upon synthesis of adequate cis retinene ; the rod regains sensitivity hence when it is struck by dim light, it is bleached; producing generator potential which build up to reach the threshold producing an action potential hence light sensitivity of rod cell regained.

38(a) (i) First phase (from 1ms to 3.4ms) latent phase

Second phase (from 3.4 ms to 6ms) contraction phase

Third phase (above 6ms) relaxation phase

(ii) Latent phase: zero/ no tension in muscle; a short delay between the point of stimulation and the actual contraction of the muscle; during this time series of changes occur that lead to conversion of electrical energy of the stimulus to mechanical energy. Latent phase is also caused by inertia of the recording device. Following arrival of impulse at muscle; the depolarization spreads all over the sarcomere along its sarcolemma causing release of calcium ions from SR along the T- tubules into sarcoplasm to activate myosin head and bind to troponin so as to expose actin-binding sites. Sarcomere is still relaxed during this phase.

Contraction phase: Twitch occurs i.e. sharp rapid contraction of muscle due to the stimulation being of sufficient strength. Binding of Calcium ions to troponin and myosin head provides mechanical energy that starts contraction phase. Tropomyosin displaces to expose the actin-binding sites for the bulbous myosin head and myosin heads cock into their binding sites forming cross-bridges; leading to actual shortening of sarcomere (due to actin filaments sliding past myosin filaments). Tension increases in the muscle.

Relation phase: Energy from hydrolysis of ATP is used to actively pump calcium ions out of sarcoplasm back into the SR leading to breaking of actin-myosin cross bridges. The actin filaments slide further away from M-line; tension decreases and the sarcomere lengthens returning the muscle fibre to its resting state

(iii) 1.8ms-3.4ms=1.6ms;

(iv) 18mm ÷ 1.6ms = 11.25; multiply by 1000 to convert from ms to s = 11 250 mm/s

(v) Due to synaptic delay that occurs during the time of transmission of an impulse across a neuromuscular junction, time of release of a neurotransmitter substance, time for diffusion across the neuromuscular junction / synapse and time taken for muscle (fibrils) to contract

(b) (i) Acetylcholine diffuses across the synaptic cleft and binds on the receptor sites on the ligand gated sodium ion channels in the motor end plate inducing the ligand gated sodium ion channels to change shape and open and allow rapid entry of sodium ions from the synaptic cleft into the muscle fibre by facilitated diffusion. Motor end plate becomes depolarized and the potential formed is the excitatory post synaptic potential (EPSP) and when the EPSP build up to the threshold, an action potential is generated.

(ii) Inhibitory drugs stop synaptic transmission, prevent release of neurotransmitter substances from the synaptic knobs, block functioning of the neurotransmitter substances at the receptor molecules on the post synaptic neurone

Excitatory drugs, amplify the synaptic transmission by mimicking the normal transmitters

Stimulating the release of more transmitter substances preventing or slowing down the normal breakdown of neurotransmitter substances causing continuous stimulation of the post synaptic neurone

Reducing the threshold/liminal for stimulation of the post synaptic membranes resulting in facilitation.

(c) (i) The toxin binds to/competes for / blocks the acetylcholine receptors; acetylcholine cannot depolarise the membrane / the toxin does not cause depolarisation; the muscle fails to contract.

(ii) The Insecticide inhibit acetylcholinesterase, an enzyme responsible for degrading acetylcholine at synapse. Acetylcholinesterase (AChE) is an enzyme located in the synaptic cleft that quickly breaks down acetylcholine into choline and acetate, terminating the signal and allowing the synapse to return to its resting state; preventing continuous stimulation of muscles. Due to the inhibition of acetylcholinesterase, acetylcholine accumulates in the synaptic cleft. The excess acetylcholine continuously stimulates the acetylcholine receptors on the post-synaptic membrane(sarcolemma), leading to prolonged depolarization of a muscle cell, hence continuous contraction.

39.(a)(i) This is because much of the rhodopsin is bleached / broken down by light, into opsin and trans retinene, retinene is in trans form thus low sensitivity to light; for regainment of light sensitivity again, trans retinene has to be converted back to Cis retinene which process is a slow enzyme catalysed reaction and so takes time

(ii) Rhodopsin pigment absorbs green light more readily than red / is more sensitive to green light; (after resynthesis) less (intense) green light is needed to break down rhodopsin compared to red light;

(iii). white has high proportion of wavelengths to which rhodopsin is not sensitive, hence sensitivity of rod cells is higher for green spots

(b) (a) (i)concentration of sodium ions increase rapidly up to the peak due to opening of sodium gates, membrane becomes more permeable to sodium; sodium ions move in by diffusion / along a concentration gradient

(ii)Concentration of sodium ions inside the axon decreases rapidly to minimum, due to closure of sodium gates, membrane becomes less permeable to sodium ions, also activation of sodium potassium pump which and sodium (ions) pumped out; active transport / ATP involved/energy required;

(iii) ATP production / respiration ceased; yet ATP is needed for sodium pumps / active transport / to move ions against concentration gradient/energy required;

39. (a) Existence within life cycle of a species two distinct haploid and diploid forms; differing in structure; mode of reproduction and habit/at times habitat; each being able to reproduce to give rise to another.

(b) Dominant stage provides adequate support and nutrients to the other stage; Dominant stage can survive environment stress; Alternative mechanisms of reproduction increase the population/chances of survival; Spore formation by meiosis causes variation in characters; Dispersal by vast number of spores enables colonization of wide habitats; Resistant spores survive unfavorable environmental conditions

(c) Desiccation: Waxy cuticle; storage structures developed etc. Support: Developed strengthened vascular tissue Nutrition requires water: well developed roots develop below the ground Reproduction: Gametophyte generation reduced and protected inside sporophyte; male gametes carried by wind/insects/pollen tube; female gametophyte protected by ovule; seed adapted to remain dormant in dry conditions and dispersal from parent gametophyte Gas exchange; Numerous stomata; Large intercellular air spaces Adapted to constant changes in temperatures, light intensity, pH, etc.: Tolerant tissues

e) Sporophyte generation is diploid; thus, able to suppress effect of harmful recessive alleles in heterozygous state; Gametophyte is suppressed; less dependence on water evolutionary

f) Double fertilization; Broad leaves; Phloem with companion cells; Complex vascular tissue; Seeds enclosed in a fruit wall; Bear flowers

g) (i) Gametophyte has antheridia that bears haploid antherozoids and archegonia that produces haploid eggs by mitosis; the sperm cells swim thru a film of moisture; to fuse with egg cell; forming zygote that matures into a diploid sporophyte.

(ii) Its gametophyte/prothallus lacks cuticle so prone to desiccation/not tolerant to desiccation; Needs water to carry male gametes to egg before fertilization which is not readily available on land; avascular thus makes uptake of water inadequate and offers little support in the less viscous air medium; rhizoids have poor water absorbing ability; very small thus prone to extreme temperatures and heat when on land; etc.

(iii) Ferns produce gametes mitotically; genetic variation is only thru random mutation while mammals produce gametes by meiosis that involves variation arising thru crossing over between linked genes into new recombinations; random distribution of chromosomes during metaphase I, random segregation of homologs in anaphase I etc.

40. (a) (i) Secretion of enzymes that digest host tissue; Anticoagulant production in blood feeders; Secretion of digestive enzymes to aid penetration into host; Ability to respire anaerobically in oxygen deficient environment; High chemosensitivity to locate optimum locations to lodge in host body; Tolerance to harsh host conditions e.g. low nutrient levels

(ii) When a female anopheles mosquito is having a blood meal; to prevent blood from clotting in its stylets, it releases saliva into the host which contains sporozoites.

Sporozoites are carried to liver from where they infect the liver cells, reproduce by schizogony (multiple fission) into merozoites; which further reproduce by schizogony into more merozoites and trophozoites; which further reproduce by schizogony into more merozoites; which further infect red blood cells resulting into their rupture characterised by chills.

Merozoites later form gametocytes which produce male and female gametes. When a female anopheles mosquito is having a blood meal from an infected person; it sucks the male and female gametes of the plasmodia; which on reaching stomach and crop fuse to form a zygote; vermiform in shape. Zygote penetrates the gut walls and lodges in the mosquito tissues, developing a cyst around itself forming a sporocyst. The sporocyst ruptures the protective cyst to form sporozoite and the cycle is repeated.

(b) (i) Misuse of the old antimalarials as patients frequently do not follow medical prescriptions, maintaining a selection pressure for the residual resistant strains to flourish; In addition, due to antigenic variation and evolution of drug resistance mechanisms arising as the drugs interact with the parasites; such that overtime the old forms could not effectively wipe out the parasites;

Novel drugs are less frequently abused; increased awareness of need to prevent emergence of resistance; controlled use;

(ii) The emergence of resistance of mosquito vectors to insecticides such as DDT and dieldrin; the difficulty of controlling the breeding of mosquitoes because they lay eggs in small bodies of water; the resistance of some strains of *Plasmodium* to anti-malarial drugs such as chloroquine; Complex

life cycle of plasmodia whereby it employs two hosts makes them difficult to eradicate; Both asexual and sexual stages increases chances of survival of malaria parasites; Ability to evade host immune system by lodging in red blood cells; High reproduction rate thru multiple fission
(c) Sickle cell gene confers a selective advantage to individuals heterozygous for the gene; as the selection pressure acts against the homozygous normal who greatly suffer and die of malaria while the sicklers die of the pleiotropic effects of the recessive gene due to multiple-organ dysfunction. Carriers only have mild non-severe malaria-like symptoms which they recover from and on the other hand their red blood cells carry sufficient oxygen for survival and have no organ damage.

41.(a)(i) At light intensity below 140 a.units rate of photosynthesis of crop B is slightly higher
Above 140 a.units of light, rate of photosynthesis of crop A is higher;
Crop B attains maximum rate of photosynthesis at 800a.units of light and becomes constant and for crop B rate increases rapidly;
Rate of photosynthesis of crop A above 140 a.units of light is higher/increases rapidly kept increasing for crop B, rate increased gradually and becomes constant at 800 a.units;

(ii) At light intensity of 140 a.units both plants A and B attain the same rate of photosynthesis;
As light intensity increases rate of photosynthesis in both crops A and B increase until 800 a.units when crop B becomes constant;
(b)(i) Light intensity
(ii) Other limiting factors e.g. temperature, CO_2 concentration, amount of chlorophyll etc.

(c) RUBISCO fixes O_2 as well CO_2, oxygen acts as a competitive inhibitor competing with O_2 for the active site; of enzyme RUBP-carboxylase/photorespiration; With the aid of PEP-carboxylase has a higher affinity for CO_2 at low CO_2; CO_2 is incorporated into malate which is shuttled to bundle sheath cells in absence of RUBISCO is more efficient; CAM have diurnal buildup of malic acid in vacuoles, prevent water loss in hot climates;

(d) Effects of light on abundance of plants.
High light intensity leads to high photosynthesis, growth and reproduction rates hence high abundance.
Low light intensity leads to low photosynthesis, growth and reproduction rates hence low abundance;
Red and blue light wavelengths stimulate more photosynthesis, more growth and reproduction rates hence high abundance;
Green light wavelength stimulates less photosynthesis hence less growth and reproduction rates resulting in less abundance;
Red light which is abundant in sunlight stimulates flowering in long day plants leading to high reproduction rates and hence high abundance;
Red light inhibits flowering in short day plants leading to reproduction rates and hence low abundance;

Far red light stimulates flowering in short day plants thereby leading to their reproduction and high abundance;
Far red light inhibits flowering in long day plants hence reducing their abundance;
Exposure to longer periods of light in a 24-hour hour cycle inhibits flowering in short day plants hence reduce their abundance but stimulates flowering in long day plants, increases reproduction and results in high abundance;
Exposure to shorter periods of light in a 24-hour cycle stimulates flowering in short day plants, increase reproduction rates and abundance but inhibits flowering in long day plants, reduce rates of reproduction and consequently reduce their abundance;
Red light induces seed germination of positively photoblastic seeds thereby increasing their abundance;
Far red light induces seed germination of the negatively photoblastic seeds hence increase their abundances;
Flowering and opening of flowers in some plants e.g. dandelion is induced by high light intensity resulting in pollination, fertilization and reproduction hence high abundance;
High light intensity also stimulates high production of chlorophyll for maximum light absorption leading to high photosynthesis, growth and development hence high abundance;
Exceedingly high light intensity bleaches chlorophyll molecules reducing light absorption, photosynthesis, growth, reproduction and hence abundance;
Photoperiodism stimulates behavioral patterns like migrations in birds which disperse the plant propagules increasing their abundance to places where birds have migrated;

Effects of light on morphology of plants
Red light stimulates leaf expansion in dicots while far red light inhibits it;
Red light stimulates unrolling of leaves of grasses while far red inhibits it;
Red light stimulates chloroplasts development; while far red light inhibits which leads to chlorosis;
Red light inhibits internode development; while far red light stimulates it;
Darkness causes elongation of internodes while light inhibits it;
Darkness causes development of embryonic leaves; while light causes development of adult leaves;
Far red light stimulates lateral roots growth while red light inhibits lateral root growth;
Red light stimulates unhooking of the plumule in dicots while far red light inhibits it;
Blue light stimulates increase in stem diameter of plants; while other light qualities have no significant effect;
Exposure of a plant to blue light quality increases stomata frequency which thus changes morphology;

42. (a) Xylem vessels/tracheids/sclerenchyma are found at the central regions of the roots;
And in the mid-ribs/netveins of leaves; they are arranged in ring forms or scattered in
The stems of plants; they are highly lignified; adding extra mechanical strength;

Stems of herbaceous plants contain numerous thin-walled parenchyma cells, when These cells are fully filled with water they become turgid, providing extra support;

Collenchyma located at the periphery in the cortex (cortical regions) of the roots/stems/leave cells have extra cellulose deposited at their corners for extra strength;
Roots of some plants develop into prop roots like maize plant/buttress roots/deep roots; for firm anchorage providing support;
Leaves of some plants like passion fruits; develop into tendrils to wind around stems
Other structures to provide support;
Some plants possess stems which are big to support the shoot system of the plant

(b) Rays/medullary rays: Channels running radially/outwardly from the medulla/pith to the cortex; forming a connection for lateral transport of water and mineral salts; transport of food across, storage of food in winter and gaseous exchange.
Cork: Cells impregnated with suberin form epidermis for protection of stem against desiccation, mechanical damage, and entry of pathogens; loose parenchyma cork cells rupture forming lenticels for gaseous exchange and transpiration
Leads to formation of more xylem, the lignifications of the walls of the xylem vessels and tracheids provide extra mechanical strength.
More xylem and phloem tissues formed for transport of materials within plants like water, mineral salts and sugars
Leads to increase in girth of the stem so it efficiently supports the aerial parts

(c) (i) Lenticel is mass of loosely packed porous thin-walled parenchymatous cells in the cork/ phellem of stems formed during secondary growth. Loosely packed parenchyma cork cells that are impregnated with suberin rupture due to increase in girth of stems create large air spaces for gaseous exchange; and transpiration that open to the outside via a pore

(ii) Annual rings/growth rings, are concentric layers of wood that form in the trunks of trees. They represent a year's worth of growth. The formation of annual rings occurs as a result of seasonal changes in the environment, especially in temperate regions where there are distinct growing and dormant periods.

In the spring, the vascular cambium is very active and forms more xylem vessels that are lighter, soft, less dense with a wider lumen and relatively thin walls to conduct large quantities of water for growth.

In autum, the soil is drier after the relatively warmer summer. There are less xylem vessels formed which are narrower, and with a greater proportion of thick-walled sclerenchyma fibres. Autum wood is therefore more compact, harder, denser and darker than spring wood.

In winter, the cambium remains dormant and no xylem is formed. The autumn wood produced at the end of one year as growth ceases will therefore be immediately next to the spring wood of the

following year which differ markedly in appearance. This gives the appearance of a series of concentric rings, the annual rings.

Annual rings are used in dendrochronology. This is dating of wood by recognition of the pattern of annual rings which gives the time during which the wood was growing

Annual rings are also used in dendroclimatology which is the study of climate using tree ring data. Annual rings are used to reconstruct past climate. More and wider tree rings indicate growth during favourable climatic conditions whereas thinner rings and less rings indicate the xylem formed during unfavourable environmental conditions.

(d) In leaves of long day plants, redlight is absorbed by phytochrome red, and is immediately converted to phytochrome far red, high levels of phytochrome far red in the leaf tissues stimulates conversion of precursor florigen hormone into active florigen, active florigen is transported via sieve tubes into the tip of the shoot where it stimulates flower buds to develop into flowers/induce flowering.
In seeds of some plants, the red light is absorbed by the phytochrome red are immediately converted to phytochrome far red, high levels of phytochrome stimulates the embryo to secrete the hormone Gibberellins on uptake of water. which stimulate synthesis of hydrolytic enzymes in the aleurone layer that are used in mobilization of food reserves in the storage centre which will promote the process of seed germination.

(e) (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. e.g. 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.

43.(a) In the lungs: The pH of blood in the lungs is relatively higher/more alkaline because CO_2 is being expelled during exhalation. At this higher pH, hemoglobin's affinity for oxygen increases, allowing it to bind more oxygen efficiently. Hemoglobin becomes saturated with oxygen/forming oxyhemoglobin, which is then transported to tissues.

In tissues: In actively respiring tissues, CO_2 is produced as a metabolic waste; this CO_2 diffuses into the red blood cell, where it reacts with water to form H_2CO_3 catalyzed by carbonic anhydrase; which then dissociates into H^+ and HCO_3^-; this increase in H^+ lowers the pH/making it more acidic;

as a result, hemoglobin's affinity for oxygen decreases, causing it to release oxygen into the tissues where it's needed

(b)

(c) (i) because the body needs to get more blood to the muscles, it diverts blood flow from non-exercising tissues like kidneys, intestines. Muscles need more blood to account for the new oxygen demand. The sympathetic nervous system causes vasoconstriction of the organs not needed and then sends more blood to the muscles.

(ii) blood flow to the skeletal muscles increases during exercise to supply more nutrients like oxygen and glucose to the muscle cells to provide energy for contractions, and also elimination of wastes like carbon dioxide,

Blood flow to the skin increases to eliminate the excess heat and wastes accumulated due to exercise, so there is vasoconstriction of the blood vessels

Blood flow to the kidneys and intestines decreases in order to supply more blood to the muscles, as these organs do not have immediate needs for energy, less urine output is needed during exercise, and there is need to increase blood pressure to pump more blood to skeletal muscles.

Generally, the total amount of blood increases during exercise in order to supply more nutrients to the actively respiring cells and drain wastes for if they accumulate can damage the cells.

(iii)more heat in exercising muscle / increase in body temperature; as respiration releases some energy as heat; ATP to ADP releases some energy as heat; muscle temperature rises, above normal body temperature; so, more oxygen release (from haemoglobin / RBCs);

(iv)Protons/H+ ions accumulate; increasing acidity following dissociation of carbonic acid; leading to Bohr effect. Oxyhaemoglobin releases more oxygen/ has lower affinity for oxygen / has lower saturation of oxygen; at a certain partial pressure of oxygen; Protons buffered by haemoglobin forming haemoglobinic acid;

44.(a)

DNA code	A	C	C	C	C	A	T	T	T	C	A	T	C	C	A
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
mRNA codon	U	G	G	G	G	U	A	A	A	G	U	A	G	G	U
tRNA anticodon	A	C	C	C	C	A	U	U	U	C	A	U	C	C	A
Polypeptide chain	Tryptophan			Glycine			Lysine			Valine			Glycine		

(b) A wrong base is inserted at position 4/thymine replaces cytosine; this alters the genetic code and this does not encode/make right sense for amino acid glycine; during translation. The right amino acid is missing and a different polypeptide chain is formed.

(c)(i) 8 amino acids. (9th codon UAG is stop codon doesn't code for any amino acid)

ii) Number of amino acids= (n-1)+ 2(n-1); =(9-1) +2(9-1); =24 amino acids; where n is number of codons;

(d) i) TACCGGAGCTAGTGCCGGTGGTACATC ii) codon 3: AGC; codon 9: not applicable (stop codon UAG)

(e) i) no change in the amino acid since AUA is also a codon for the same amino acid; same sequence of amino acids; hence same polypeptide formed; code is degenerate;

ii) The polypeptide will only 10 amino acids; the 11th codon, UAA is stop codon; therefore a non-functional polypeptide formed;

(f) DNA synthesis occurs in 5' to 3' direction because DNA polymerase enzyme only adds nucleotides to a growing DNA strand to the 3' hydroxyl (-OH) group of the last nucleotide in the chain. This results in the new strand always elongating in the 3' end.

(g) Each has a specific anticodon region that pairs with the complementary codon on the mRNA during translation.

The 3' end of the tRNA has an amino acid binding site where a specific amino acid is covalently attached allowing it to be delivered to the ribosome.

The three-dimensional shape of the tRNA fits it into the ribosome facilitating efficient translation.

(h) Majority of mutations are harmful; however, a small proportion may have beneficial effects and may spread through the population over successive generations by natural selection; mutations may lead to genetic variation which are the raw materials for evolution; in plants, mutations like polyploidy confer the following advantages; increased hardiness; resistance to diseases and adverse weather conditions; faster growth rate;

(i) Mutations are random changes in an organism's DNA. These changes can occur due to environmental factors like radiation or chemicals/simply as errors during DNA replication; majority many mutations are neutral or harmful, but a few can result in beneficial traits that help an organism survive better in its environment; once a mutation occurs, it introduces new genetic variation within a population; organisms with beneficial mutations are more likely to survive, reproduce and pass on their genes to the next generation; while those carrying unfavorable genes are selected against and with time are wiped out the environment. Subsequently, the following generations will have organisms that are better adapted to their environment

45. (a)(i) using curve for five hours.

Increase in temperature from 0°C to about 35°C causes a rapid increase in the quantity of products formed; further increase in temperature beyond 35°C causes a rapid decrease in the quantity of products formed.

(ii)Increase in temperature from 0°C to about 35°C causes a rapid increase in the quantity of products formed, this is because increase in temperature leads to an increase in kinetic energy of the substrates and the enzyme; increasing the chances of collision between the enzyme and the substrate/increasing the effective collisions; this results into increased rate of formation of enzyme-substrate complexes and high rate of product formation. Further increase in temperature beyond 35°C causes a rapid decrease in the quantity of products formed. This is because very high temperatures cause high vibrations of the molecules within the enzyme that results into breaking of

hydrogen bonds holding the 3-D shape of the enzyme. This results into change in the shape of the active site; making the enzyme unable to bind the substrate perfectly.

(b)(i) 1-hour 45°C
2 hours 39°C
5 hours 32°C
(ii) When incubated for longer periods of 5 hours, the molecules within the enzyme vibrate for longer periods. Even with low temperatures and lower kinetic energy, vibrations are strong enough to cause breaking of hydrogen bonds hence lower optimum temperatures. When incubated for 1 hour, the molecules within the enzyme vibrate for shorter periods of time, this makes the bonds break only if the vibrations are very high at very high temperatures hence higher optimum temperatures for 1 hour and lower optimum temperatures for 5 hours.

(c)Non-compe itive inhibitors; bind on the allosteric site; a site on the enzyme other than the active site; causing deformation of the active site. At this time, the substrate cannot perfectly bind to the active site hence are inhibited from forming the enzyme-substrate complex.

46. (a) (i) A change in a nitrogenous base or base sequence (genetic code) of a chromosome/ DNA, leading to formation of a new allele. It can have a positive effect as new structure from change in amino acid sequence results in a protein more efficient in its function than it would before; increasing the individual's success at survival and reproduction; increased genetic vigour
(ii) It can sometimes have no effect as the gene can be recessive so there is no significant change to the phenotype of the individual; or it could be a silent mutation, changing the base pair (triplet code) but not changing the actual amino acid it codes for; due to degeneracy of the code, so no change to the protein produced.
(b) Non-disjunction occurs due to failure of formation of spindle fibres from centrioles; during nuclear division; such that chromosomes are not separated evenly/ equally to opposite poles of spindle / cells/ gametes; such that resulting gametes have less or extra chromosomes; such that on random fusion which normal gametes; zygotes results with diploid number less or extra in chromosome number; but not entire chromosome set; leading to aneuploidy; characterised by offspring with congenital abnormalities such as down's syndrome due to trisomy 21, turner's syndrome, etc.

47 (a) (i) Fovea is concentrated by cone cells that allow for acuity/ precision and in colours perception so as the eagle spots clearly its prey. Cone cells have very little retinal convergence, where each cone cell synapses to its own separate bipolar neurone, so signal from each can be detected separately; as separate impulses are sent to the brain; easily distinguishing between two different cones being stimulated; giving a very high visual acuity.
Cone cells are of three types; blue, green and red cones; each with different kind of visual pigment; and are stimulated by varying wavelengths of light. There is also differential overlap in the wavelengths of light that stimulates the three cone types such that certain wavelengths can stimulate a range of the cone types; as in either one type at a time; two types at a time, and three

types at a time. The relative stimulation of the three types of cone types determines the colour perceived by the eye which also enhances clarity of eagle's prey.

(ii) At night dim light strikes the eye and it has abundant rod cells; highly distributed all over the retina except the fovea and blind spot; allowing for high visual sensitivity as light refracted to the edges of retina even at low intensity is picked up. In addition, many rod cells are connected to a single neurone, so stimulation at only low intensity on summation produces a combined threshold stimulus to generate impulse to bipolar neurone and then eventually to the brain to enable owl see.

(b) Adaptation of receptors is the gradual cessation of response of receptors to prolonged steady sustained unchanging stimulation. At first, on stimulation many generator potentials are generated leading to high frequency of firing of impulses to brain to bring about response. But on maintenance of the continuous steady stimulus; the frequency of the action potentials goes on reducing; till when the firing potential falls below threshold; (as sodium channels eventually start closing; receptor membrane becomes less permeable to ions; and synaptic neurotransmitter signal becomes insufficient); no impulse is transmitted and thus no response results.

Significance of adaptation is Providing animals with precise information about changes in the environment; Prevent overloading the CNS with irrelevant and unmanageable information, increasing efficiency and economy of the nervous system; Enable CNS ignore unchanging background information; Concentrate on monitoring aspects of environment with most survival value; Adaptation reduces the metabolic demand on receptors allowing the body to conserve energy, directing it to more significant needs, such as reacting to new stimuli.

48.(a) Oxygen debt is the amount of oxygen required to break down the accumulated lactic caid after a strenuous exercise; it also used to replace the oxygen reserves in the body; it restores creatine phosphate;

(b) (i) Similarities

Both increase gradually from 4 to 6 minutes;

Differences

From 1 to 4 minutes, concentration of lactate increases while concentration of glucose;

From 6 to 10 minutes, the concentration of lactate decreases while glucose concentration increases

From 10 to 12 minutes, the concentration of lactate decreases while glucose concentration of glucose is constant;

From 0 to 1 minutes, glucose concentration decreases while lactate concentration is zero and constant;

Lactate concentration attained a peak while glucose concentration has no peak

(ii) similarities

Both attained a peak; both increase from 1 to 6 minutes; both decrease from 6 to 12 minutes;

Differences

From 2 to 4 minutes, lactate concentration increases rapidly while oxygen uptake increases gradually;

Oxygen uptake attains a higher peak while lactate concentration attained a lower peak;

From 0 to 1 minute, oxygen uptake increases rapidly while lactate concentration is zero and constant;

(c)(i) As oxygen uptake increases from 0 to 1 minutes; the lactate concentration remains constant at zero; from 1 to 6 minutes; as lactate increases, oxygen uptake also increases; from 6 to 12 minutes; as lactate concentration decreases, also oxygen uptake also decreases;
(ii) As oxygen uptake increases from 0 to4 minutes, the concentration of glucose decreases to attain a minimum;
Further increase in oxygen uptake from 4 to 6 minutes; the concentration of glucose increases gradually;
As oxygen uptake decreases from 6 to 12 minutes, the glucose concentration increases gradually to attain a constant/maximum
(d)(i) As oxygen uptake increases from 0 to 1 minutes; this is because aerobic respiration can provide enough energy for about 90 minutes after the start of exercise; from 1 to 6 minutes; as lactate increases, oxygen uptake also increases, this is due to anaerobic breakdown of sugars to release energy and increased production of lactate in the muscles as a result of low oxygen supply to muscles; ; from 6 to 12 minutes; as lactate concentration decreases, also oxygen uptake also decreases; due to completion of exercise; more oxygen was taken in to breakdown the accumulated lactic acid ;
(d) (ii) As oxygen uptake increases from 0 to4 minutes, the concentration of glucose decreases to attain a minimum; due to increased energy demand for energy in form ATP by muscles during the exercise; hence increased respiration of glucose by aerobic and anaerobic pathways;
Further increase in oxygen uptake from 4 to 6 minutes; the concentration of glucose increases gradually; due to diffusion of accumulated lactic acid into blood where it is carried away from muscles; mainly to the liver where it reconverted to pyruvate and reduced NAD; some of the pyruvate enters the normal aerobic pathway through the Krebs cycle yielding ATP; this ATP is used to convert the rest of pyruvate back to glucose by reverse glycolysis (up to 75% of pyruvate);
As oxygen uptake decreases from 6 to 12 minutes, the glucose concentration increases gradually to attain a constant/maximum; due to completion of exercise at the 4th minute; decreased aerobic and anaerobic breakdown of glucose to provide energy; due to reduced energy demands by the body;

(e) (i) the lactate concentration for an endurance athlete would delay to increase/start to increase beyond 1 minute and will attain a low maximum; this due to acclimatization towards the strenuous activity that include increased accumulation of oxygen reserves; increased lung vital capacity; increased cardiac output that increases the supply of oxygenated blood to the muscles; favouring aerobic respiration; lowering rates of anaerobic respiration and accumulation of lactate in muscles;
(ii) The available amount of ATP in muscles is sufficient only for a limited period of time (3 second) for maximum contraction; so, creatine phosphate acts as an immediate source of phosphate group that can be removed to release energy to make energy in form of ATP from binding ADP and Pi

49.(a) In panting, heat is lost with minimum water loss whereas in sweating, heat is lost with excessive water loss leading to dehydration.
In panting, salts are not lost thus osmotic pressure not altered but in sweating much salts are lost thus lowering the osmotic pressure of the organism;
(b) (i) Panting results into hyperventilation thus much carbon dioxide is eliminated from the body which is responsible for acidity thus making blood more alkaline;

(iii) The alkaline medium/pH of blood increases the permeability of muscles and nervous tissues to calcium ions making them more excitable than they would be resulting into increased muscle contractions;

(c)Hyperventilation causes blood vessels to the heart, brain, hands and legs to constrict leading to reduced blood flow to those organs which cause headache, anxiety, dizziness and cold hands; Also, the increased alkalinity due to hyperventilation lowers the unloading of oxygen from haemoglobin reducing oxygen delivery to tissues and rates of respiration hence minimizing energy production;

(d) (i) counter current heat exchanger is heat conservation system in limbs where is effective heat transfer at all levels to the peripheral of the limb by conduction from the incoming warmer arteriole blood to the outgoing colder venous blood whereas counter current multiplier effect is a system of parallel and opposite flow of renal fluid in the descending and ascending limbs of loop of Henle in the kidney with active salt concentration in the medullary interstitial tissue causing an increase in salt concentration in the renal fluid in the descending limb and decrease in salt concentration in the ascending limb to cause production of hypertonic urine

(ii) Counter current heat exchange mechanism in body extremities mainly in legs of wading/aquatic birds, artic animals in which the venous and arterial blood vessels are in close proximity thus heat is conserved and less heat is lost to the environment.

Counter current flow mechanism in bony fish, maintains a steep diffusion gradient between blood and water hence much oxygen is extracted and high activity of the organisms;

Counter current multiplier of the kidney nephron due to impermeable descending limb to salts and permeable to water, permeability of ascending limb to salts and its permeability to water thus aims at multiplying the osmotic pressure of the medulla and ensure water reabsorption;

Hair pin counter current exchange mechanism of the vasa recta/ capillary network around the kidney nephron which aims at maintaining the osmotic pressure of blood;
Counter current heat exchange mechanism in the nares of the camel, due to presence of a very cold fluid which flow in opposite direction with the expired air which serve to cool the inspired air and dries expired air hence conserving water;

Counter current exchange mechanism in the closed swim bladder of fish e.g. cod fish; At its anterior end is a structure , the gas gland rich in blood capillaries; in which arterial and venous capillaries are interspersed amongst each other; the counter current system operates in order to facilitate secretion of oxygen into the bladder; by automatically increasing and decreasing the amount of gas in the bladder, the fish can match the density of the surrounding water thus preserve neutral buoyancy.

50.(a) Cavitation refers to the condition when a xylem vessel tends to fill with air and water vapour as the water contents of the tree trunks gradually decreases; due to shaking, bending, and shortage of water; its effects are minimized through; water flows from one vessel to anther; water bypasses the air locks by moving through the neighbouring parenchyma cells and their walls; in some trees and shrubs, water only moves through the young outer wood(sap wood) since only a small proportion of vessels need to be function at any one time to account for the observed flow rates;
(b) Modification of munch's theory of translocation involves the use of transfer cells to load and unload of the phloem with sugars;

At the source or mesophyll cells, the transfer cells or the companion cells actively pump hydrogen ions (H^+) into the neighbouring mesophyll cells; using the hydrogen pump.

This creates a proton gradient between the transfer and mesophyll cell, resulting in diffusion of protons from the mesophyll cells in to the transfer cells; down their concentration gradient while they are being co-transported with sucrose.

This raises the osmotic influx of water into the transfer cells; and mass flow of the solution with sucrose to move by mass flow from the transfer cells into the phloem sieve tubes; via the plasmodesmata. At the sink, sugars leave the sieve tubes into the transfer cells; via the plasmodesmata; from where they diffuse into the nearby sink cells.

(c)During the day, the stomata open; because there is active pumping of potassium ions into the guard cells; since sunlight activates ATPase enzymes; and leads to production of large amounts of ATP; in photophosphorylation whose hydrolysis avails the energy for active pumping of the potassium ions. Increase in K^+ level, raises the osmotic pressure within the guard cells; which leads to osmotic influx of water into the guard cells; which increases their turgidity; hence opening the stomata.
At night, the open stomata close, due to less or no sunlight to activate ATPase enzymes and no ATP production due to absence of photophosphorylation. The potassium ions hence diffuse out of the guard cells to the epidermal cells which cause osmotic efflux of water from the guard cells to the epidermal cells thereby reducing their turgidity hence closing the stoma.

(d)The sieve tubes are closely lined with companion cells using numerous plasmodesmata for exchange of materials.
The linked companion cells to the sieve tube elements possess numerous mitochondria for fast production of energy for active transport of sugars within the tubes.

The companion cells are highly metabolically active, more than the sieve tubes which reflect that the energy used during translocation is obtained from the companion cells.

Treating the companion cells with metabolic poison reduces translocation in the sieve tubes.

(e) Abscisic acid combines with specific receptors on the cell surface membrane of the guard cells that surround stomata. This binding of abscisic acid increases the concentration of calcium ions in the guard cells (more enters from outside and some is released from intracellular stores).

The calcium ions act as a second messenger by altering potassium channels in the cell surface membrane in a way that causes potassium ions to diffuse from the guard cells to the epidermal cells. Abscisic acid may also inhibit the action of the proton pump that moves hydrogen ions out of the guard cells. The solute concentration in the guard cells is therefore reduced and their water potential becomes higher than in the epidermal cells. Water therefore leaves by osmosis, so the volume of the guard cells decreases, they become less turgid and therefore the stomatal pore closes.

51.(a) (i) Polymorphism is the existence within a particular species of two or more distinct types/ forms/ morphs of individual. The forms may differ in biochemical, morphological and behavioral characteristics. Such as sexual dimorphism or genetic polymorphism.

(ii) Industrial melanism refers to increase in the frequency of the dark/ melanic form of a species due to the effect of release of pollutants by industries. Such as the peppered moth in U.K. With reference to the population dynamics of peppered moths in the UK, the typical light (grey) peppered moths had a selective advantage affording camouflage in the pre-industrial era; on the light tree trunks and walls. The mutant (black) peppered moths had a selective disadvantage as it could easily be spotted by the predator. However, with increased industrialization, the mutant moths gradually increased in number as they could afford camouflage on the darkened backgrounds of the tree backs and walls; covered by soot. On the other hand, the light peppered moths could be spotted by predators against the dark background. They selective advantage possessed by the mutant forms made them reproduce more than the light peppered moths; and the black peppered moths eventually became the predominant species.

(b) Transient (Unstable) Polymorphism	Balanced (Stable) Polymorphism
Different forms exist in a population under an intensive selection pressure	Different forms coexist in the same population in a stable environment
Genetic frequency of each morph is not in equilibrium but determined by the selection pressure	Genetic frequency of each morph exhibits equilibrium
Morphs evolve	Morphs do not evolve
e.g. –Peppered moth in U.K	e.g. -Blood groups in humans -Sex in animals -Shell coloration in Land snail *Cepaea nemoralis*

(c)Genetic factors such as gene reshuffling during gamete formation; mutations; natural selection; selective predation;

(d) Transient (Unstable) Polymorphism alters genetic equilibrium of the morphs depending on the prevailing selection pressure; resulting into directional selection .Organisms at one extreme of a phenotypic characteristic are selected for ,survive, reproduce and pass on their characteristics to the next generation, organisms at the other extreme of a phenotypic characteristic are selected

against , fail to propagate their characteristics to the next generation, which in turn leads to evolutionary change in species composition into better adapted organisms in the subsequent generations