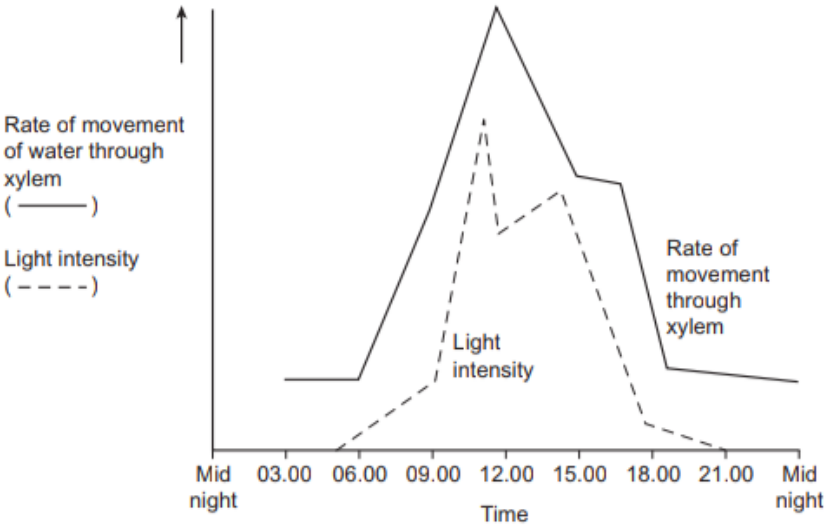
S.6 BOT II EXAMINATIONS
BIOLOGY(P530/2)
(THEORY)

TIME 2HOURS 30MINUTES

INSTRUCTIONS TO CANDIDATES
*This paper consists of **six** questions*
*Answer question **one** in section **A** plus **three** others from section **B***
Candidates are advised to read the questions carefully, organize their answers and present them precisely and logically, illustrating with well labelled diagrams where necessary.

SECTION A (40MARKS)

1. The graph in the **figure 1** shows the rates of water movement through the xylem of a twig from a tree and light intensity over a 24-hour period. Study the figure and answer the questions that follow.



(a) (i) Describe the relationship between the rate of water movement through the xylem and light intensity. (03marks)

Between 0300hrs and about 0600hrs in absence of light, rate of water movement through the xylem remains constant;
Between about 0600hrs and 1080hrs as light intensity increases; rate of water movement increases rapidly;
Between 1080hrs and 2100hrs as light intensity decreases, rate of water movement through the xylem decreases;

(ii) Explain the changes in the rate of water movement through the xylem over the 24-hour period. (07marks)

From 0300hrs to about 0600hrs, rate of water movement through the xylem is low and remains constant; because there is no light; thus stomata are closed; no transpiration occurs;
From about 0600hrs to 1080hrs, rate of water movement through the xylem increases rapidly; because increased light intensity; increases stomatal aperture; rate of transpiration increases rapidly; creating a transpiration pull; that draws water molecules through the xylem by cohesion;
From 1080hrs to 2100hrs, rate of water movement through the xylem decreases; because decreased light intensity; decreases the stomatal aperture; decreasing loss of water from the leaves by transpiration;

(b) Explain

(i) the difference in the diameter of the trunk of the tree on which the twig had been growing at 1200 and 0300hrs. (04marks)

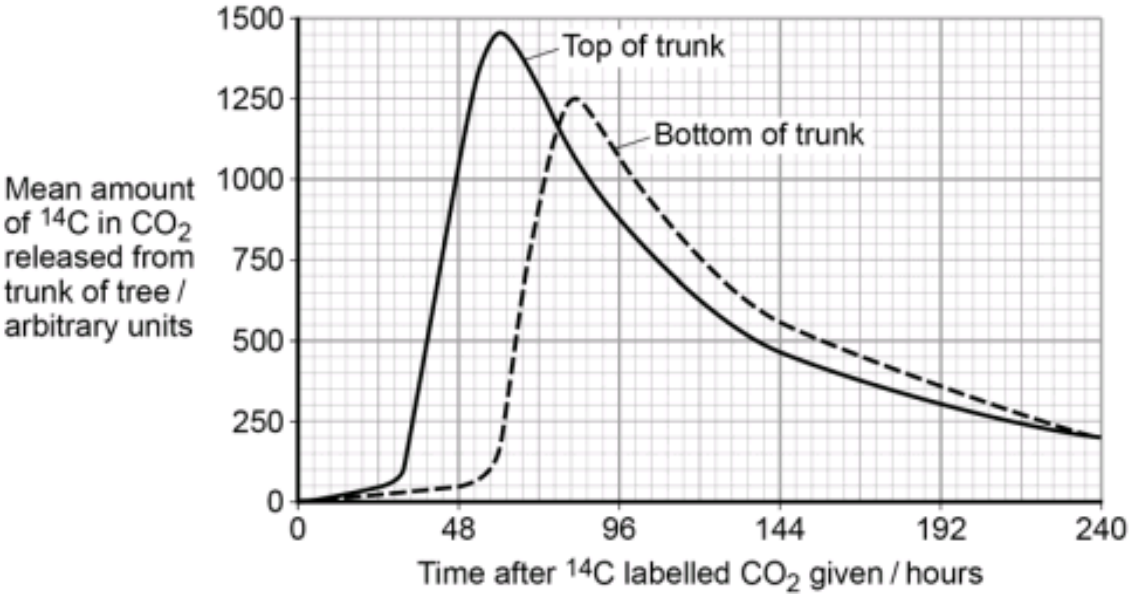
Diameter of trunk of the tree at 1200hrs is lower than at 0300hrs; because at 1200hrs, light intensity is higher than at 0300hrs; rate of transpiration is higher; tension (negative pressure) is higher in the xylem vessels; thus causing a more reduction/ shrinkage in the trunk diameter at 1200hrs than at 0300hrs;

(ii) how the xylem is adapted for movement of water up the trunk of the tree. (06marks)

Xylem vessels and tracheids consists of long cells joined end to end forming a continuous column to allow transportation of water over long distances;
End walls of xylem vessels are broken to allow uninterrupted flow of water from roots to leaves;
Lumina of vessels and tracheids are narrow increasing the capillary forces;
Cellulose cell walls impregnated with lignin which increases adhesion of water molecules of upward movement of water; and also have great tensile strength preventing the vessels and tracheids from collapsing under large tension forces set up by transpiration pull;
Xylem vessels are hollow allowing water to move freely without any obstruction;
Tracheids have tapering end walls containing cellulose lined with pits that allow water to pass from one cell to another;
Side walls of vessels and tracheids have bordered pits (perforated) allowing sideways movement of water and mineral salts;

In an investigation on translocation of radioactive carbon dioxide, a large clear plastic bag was put over the leaves and branches of each tree and added radioactive carbon dioxide. The main trunk of the tree was not in the plastic bag.

The graph in **figure 2** shows the amount of radioactive carbon released from the top and bottom of the main trunk of the tree over 240-hour period. *On the surface of the trunk of these trees, are pores for gaseous exchange.*



(c) (i) Compare the variation in the mean amount of radioactive carbon released from the top of the tree trunk and bottom of trunk. (06marks)

Similarities

In both bottom of trunk and top of trunk, mean mount of radioactive carbon released,
-attains a peak;
-are equal at 76.8hours;
-increases from 0hours to 62.4hours;
-decreases from 84hours to 240hours;

Differences

Mean amount of radioactive carbon released from top of trunk	Mean amount of radioactive carbon released from bottom of trunk
Higher peak is attained	**Lower peak is attained**
Peaks earlier	**Peaks later**
Higher from 0hours to 76.8hours	**Lower from 0hours to 76.8hours**
Lower from 76.8hours to 240hours	**Higher from 76.8hours to 240hours**

(ii) How long did it take the radioactive carbon to get from the top of the trunk to the bottom of the trunk? Explain your answer. (02marks)

21.6hours; (accept up to 24hours); time between peak of mean amount of radioactive carbon in carbon dioxide at top of trunk and bottom;

(d) Describe a technique which can be used to monitor the movement of radioactive carbon from the top of the trunk to the bottom of the trunk. (05marks)

Radioactive tracer technique; in which radioactive carbon incorporated in to photosynthetic products for a plant exposed to radioactive carbon dioxide as a photosynthetic substrate is detected by cutting sections of the stem; placed in contact with a photographic film; autographs made; sites of radioactivity corresponding precisely to the positions of the phloem;

(e) Explain how plant tissues for translocation are suited for this function. (07marks)

Sieve tube elements are joined end to end allowing long distance transport of manufactured food;
End walls of sieve tubes are perforated forming sieve pores allowing flow of materials from one cell to another;
Sieve tubes lack nucleus when mature, and with little peripheral cytoplasm more room is created for passage of organic materials in solution;
Numerous mitochondria in companion cells to provide large amounts of energy for active transport of materials;
Plasmodesmata allow lateral movement of materials between sieve tubes and companion cells;
Cytoplasmic strands/ protein filaments aid in cytoplasmic streaming; whose movements sweep with them materials thus transporting materials from one part of cell to another;
Sclereids and fibres have lignified walls offering extra strength to tissues preventing their collapse during translocation;
Phloem parenchyma have the ability to divide forming more phloem cells; increasing surface area for transporting of organic food materials;

SECTION B (60MARKS)

2. (a) Explain the glowing eyes of the nocturnal mammals at night when shone with light. (05marks)

Nocturnal mammals e.g. cats have a reflecting layer, tapetum; in the choroid; behind the retina that reflect light back through the rods into the eye; increasing sensitivity of the eye at extremely low light intensity/dim light/ at night;

(b) Account for the greater sensitivity of rods towards light than cones. (07marks)

Several rods synapse with/are linked to a single bipolar neuron; which in turn synapses with a single ganglion cell; and on simultaneous stimulation; separate generator potentials sum up/summate; producing an action potential; fired as nerve impulse in an optic nerve fibre; while in cones no retinal convergence occurs; thus increasing sensitivity of rods over the cones; *Rej Description of retinal convergence alone(candidate should clearly bring out significance of retinal convergence in rods over the cones)*

(c) Describe the physiological behavior of a rod in bright light. (08marks)

In bright light/light of high intensity; Retinene/retinal changes from its normal isomeric form, cis ; to trans form; causing splitting/breakdown/bleaching of rhodopsin into scotopsin(opsin); and trans-retinene/retinal; permeability of the outer segments to sodium ions decreases; inner segment actively pumps out sodium ions into the tissue fluid surrounding rod cell; interior of the rod cell becomes more negative than usual / hyperpolarized; inhibiting the release/secretion of glutamate/neurotransmitter by outer segment into tissue fluid; action potential is produced in the ganglion cell; transmitted to the brain via optic nerve; interpreted as bright light;

3. (a) Describe the characteristics of apical meristematic cells in plants. (06marks)
Are relatively small in size; are cuboidal in shape; large nucleus; thin cellulose cell walls; few small vacuoles; dense cytoplasmic strands; tightly packed with no air spaces between them; cytoplasm contains small undifferentiated plastids/proplastids;

(b) Explain the role of the following apical meristematic tissues in plant development.

(i) Procambium (07marks)
Gives rise to the vascular tissues; including pericycle; phloem; xylem and vascular cambium;
Innermost cells of procambial strands differentiate into protoxylem/primary xylem; coupled with loss of protoplast; breakdown of the end walls of adjacent cells; and secretion of lignified secondary wall as annular; or spiral bands;
Outer most cells of the procambial strands differentiate into protophloem/primary phloem; consisting of sieve tube elements and companion cells;
Procambial cells immediately inside the protophloem differentiates into metaphloem sieve tubes and companion cells; with procambial cells immediately inside the protoxylem differentiating into metaxylem cells; coupled with loss of end walls; and primary cell walls internally covered by scalariform; reticulate and pitted secondary wall;

(ii) Ground tissue (07marks)
Cells of the ground tissue, the cortex and pith; differentiate into parenchyma; coupled with the development of thin cellulose cell wall; extensive vacuolation of the cytoplasm; and stiff deposition of cellulose in the outer cortex;
Cortical cells immediately around each vascular bundle become elongated; with tapering end wall; primary cellulose cell wall heavily impregnated with lignin; forming sclerenchyma fibres;

4. (a) Both Mutation and gene reshuffling play a role in evolution. Explain the differences in the extent of their roles. (10marks)
Gene reshuffling plays a limited role in effecting long term evolutionary change compared to mutation; because independent segregation of chromosomes; and crossing over; may establish a new combination of genes in one generation; and undo it in the later generation; thus new genetic combinations formed are non-persistent; while effects due to mutation are relatively persistent; thus can be transmitted through many generations; without further change; natural selection acts on it; subsequently causing a long term evolutionary change;

(b) Account for the causes of sterility in polyploidy (06marks)
Crossing of two different varieties of species with different sets of chromosomes; resulting in production of diploid off springs with non-homologous chromosomes; unable to pair during meiosis; therefore, incapable of producing gametes;
Fusion of diploid gamete derived from a tetraploid parent with normal haploid gametes; resulting into production of triploid off springs; successful pairing; and separation of homologous chromosomes during meiosis is difficult; thus unable to produce viable gametes;

(c) Explain the difference in the existence of polyploidy condition in plants and animals. (04marks)
Polyploidy condition is more common in plants than animals; because it leads to increased number of chromosomes; thus normal gamete formation during meiosis is more prone to error; thus in animals majorly depending on sexual reproduction; chances of fertilization and reproduction are reduced; while plants can propagate themselves vegetatively; thus able to reproduce despite being polyploids;

5. (a) Describe how chemosynthesis occurs in nitrifying bacteria. (12marks)
Ammonia from breakdown of animal and plant proteins; is liberated into the soil; combines with carbon dioxide; forming ammonium carbonate; oxidized to nitrous acid; liberating energy; under the influence of *nitrosomnas*; and *nitrococcus;*
Nitrous acid immediately combines with salts of magnesium or calcium; forming respective nitrites; oxidized to nitrates; by *nitrobacter*; releasing energy;
Energy released in both cases is used to synthesize organic compounds;

(b) Account for the co-existence of purple Sulphur bacteria and weeds in the ponds and rocks. (08marks)
Use of different light absorbing pigments; the purple form of bacteriochlorophyll in purple Sulphur bacteria; and chlorophyll in weeds; with the purple form of bacterial chlorophyll absorbing ultraviolet; and infra- red light in the visible spectrum; on either sides of those absorbed by chlorophylls and related pigments; allowing wave length of light needed by the bacteria pass straight through the weeds; and absorbed by bacteria;

6. (a) What is chemiosmosis? (02marks)
Is a process by which hydrogen ions (protons) move from an area of high concentration to an area of low concentration through transport proteins on the selectively permeable membrane; as result of proton gradient formed across the membrane not readily permeable to ions;

(b) (i) Briefly explain how ATP is synthesized by chemiosmosis in the mitochondria. (08marks)
Hydrogen atoms are picked by NAD in the matrix; split into protons and electrons; protons are pumped/actively transported from the mitochondrial matrix into the space between inner membrane and outer membrane of mitochondrion; using energy released from electron transport chain;
Electrons are passed along cytochromes placed at different energy levels; located within inner membrane;
Protons accumulate; creating a steep concentration gradient between the intermembrane space and matrix; protons rapidly diffuse back into the matrix from the intermembrane space via chemiosmotic channels at different energy levels; energy is released; used to combine ADP and inorganic phosphate; forming ATP; catalyzed by ATP synthetase/synthase/ATPase enzyme;
Protons combine with electrons in the matrix; forming hydrogen atom; which reduce oxygen to water;

(ii) How is the process in (i) above different from that in the chloroplast? (05marks)

Chemiosmosis in mitochondrion	Chemiosmosis in the chloroplast
Electrons formed by splitting of hydrogen atoms	Electrons formed by photolysis of water
Pumping of protons is from matrix to intermembrane space	Pumping of protons is from stroma to thylakoid space
Diffusion gradient is established between matrix and intermembrane space	Diffusion gradient is stablished between stroma and thylakoid space
Oxygen is utilized	Oxygen is released
Source of energy for pumping of protons is from oxidation of organic compounds;	Source of energy for pumping protons is from sunlight
Can take place in absence of sun light	Only occurs in presence of sunlight

(c) How is the mitochondrion suited for its function? (05marks)
Highly folded inner membrane to increase surface area for electron transport chain;
Narrow intermembrane space allows proton gradient to be rapidly established for chemiosmosis to occur;
Matrix contains ribosomes and circular DNA for protein synthesis; reducing on importation of proteins from the cytoplasm;
Matrix contains enzymes that catalyze reactions of the Krebs cycle;
Stalked particles/granules on the inner membrane with chemiosmotic channels for diffusion of protons into the matrix emitting energy for phosphorylation;
Impermeable inner membrane to positive /hydrogen ions/protons allows accumulation of hydrogen ions into the intermembrane space;
Thin outer membrane reduces the distance over which materials pass in and out of the membrane;
Inner membrane contains protein molecules that actively pump protons into the intermembrane space;
Double membrane isolates the mitochondrion from interference by the processes in the cytoplasm;

END