UNIVERSITY OF FORT HARE

FACULTY OF SCIENCE AND AGRICULTURE

BOTANY DEPARTMENT

TIME: 3 HOURS **MARKS: 100**

MODULE: BOT312

MODULE NAME: Plant Anatomy

--------------JUNE EXAM 2023---------------

THIS PAPER CONSISTS OF TWO (2) PAGES, INCLUDING THE COVER PAGE

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INSTRUCTIONS:

Answer FOUR questions ONLY. Please note choice between Questions 3 and 4. Candidates are advised to make suitably labelled neat diagrams as an aid to answering the questions where applicable.

Question 1

a) What are the constituents of the plant cell wall? (7)

Cellulose, which is associated with hemicelluloses and pectic substances; Lignin; Cutin, suberin and waxes; Enzymes

b) Write notes to compare and contrast primary and secondary cell walls. (10)

Primary cell wall is formed after the middle lamella. It is deposited by cells before and during active growth. It is formed while the cell is still growing. The primary wall is the cellulose-containing layer laid down by cells that are dividing and growing. To allow for cell wall expansion during growth, primary walls are thinner and less rigid than those of cells that have stopped growing. A fully grown plant cell may retain its primary cell wall (sometimes thickening it), or it may deposit an additional, rigidifying layer of different composition, which is the secondary cell wall. Thin primary walls are capable of serving a structural, supportive role only when the vacuoles within the cell are filled with water to the point that they exert a turgor pressure against the cell wall.

Secondary cell wall is responsible for most of the plant's mechanical support as well as the mechanical properties prized in wood. It is mainly for support and is comprised primarily of cellulose and lignin. Secondary wall is composed of three layers, which they designated as outer (S1), middle (S2) and inner (S3). The separation into the three S layers results mainly from different orientations of microfibrils in the three layers. The S2 layer is the thickest. The S3 layer may be very thin or lacking entirely. The S3 layer is toward the cell lumen.

c) What constitutes a stele? (3)

Vascular tissues, pericycle and pith

d) Elaborate on the role of endodermis in controlling the movement of water and mineral ions from the cortex to the stele. (5)

Water enters root hair cell by osmosis ---> H_2O pass from root hair cell to the inner cell by osmosis. From the epidermis to the endodermis there are three pathways in which water can flow: Apoplastic; Transmembrane; Symplastic.

The endodermis is the inner layer of cells of the cortex which separates it from the stele. Early in its development, the casparian strip which is a fatty substance is deposted in bands on the transverse walls and radial walls in the longitudinal direction. It renders them relatively impermeable to water and presents a barrier to inward movement of water and dissolved mineral ions in the apoplast. The soil solution is thus forced to pass through the selectively permeable cytoplasm (the symplasm).

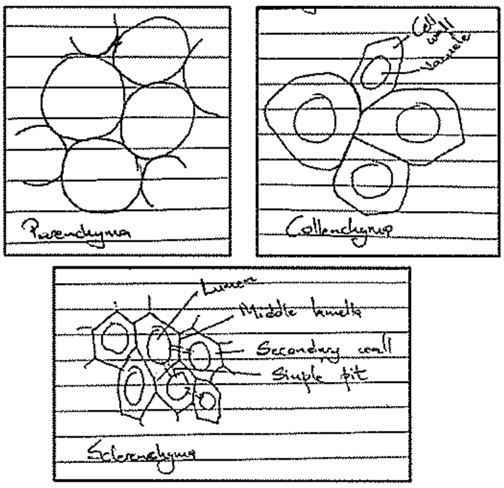
[25 marks]

Question 2

With the aid of well-labelled diagrams, write elaborative notes on tissues produced by the meristems. **[25 marks]**

Meristematic tissues are composed of actively dividing cells, which are responsible for the production of cells. Meristems produce simple and complex tissues. Simple tissues are made up of one type of cell *only, whereas complex tissues are made up of a mixture of several types of cells. Simple tissues include parenchyma, collenchyma and sclerenchyma tissues.*

Parenchyma	*Collenchyma*	*Sclerenchyma*
Living when mature	*Living when mature*	*Dead when mature*
Primary cell wall is present	*Has primary cell wall*	*Has secondary cell wall*
Cell wall made up of cellulose	*Cell wall made up of cellulose and pectin*	*Cell wall made up of lignin*
Intercellular spaces present between cells	*No or little intercellular space between cells*	*No intercellular space is present between cells*
Photosynthesis, storage of food, gas exchange are the major functions	*Providing mechanical support, resisting bending and stretching are the major functions*	*Providing mechanical support, protection and transportation of water and nutrients are the major functions*

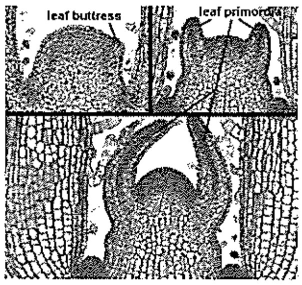


Complex tissues include xylem and phloem. Xylem conducts water and dissolved mineral ions from the root to the shoot system. It is made up of tracheids, vessel elements, xylem fibres and xylem parenchyma. Tracheids are elongated and tapering at their ends, with pits. Vessel elements arranged end to end along the axis of an organ and the cross walls between successive vessel elements are perforated, giving free passage of water from cell to cell. Phloem is responsible for the transport of dissolved organic substances from the source to the sink. Phloem consists of sieve tube elements, companion cells, phloem fibres and phloem parenchyma

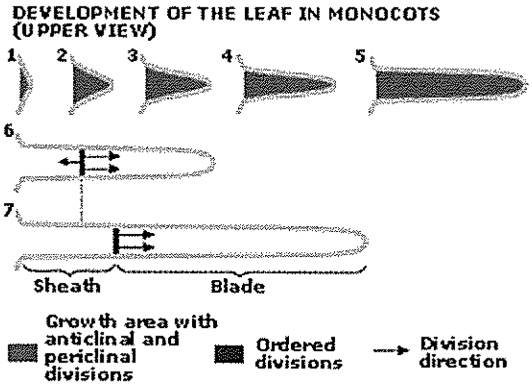
Question 3

Elaborate on the origin and development of the leaf.

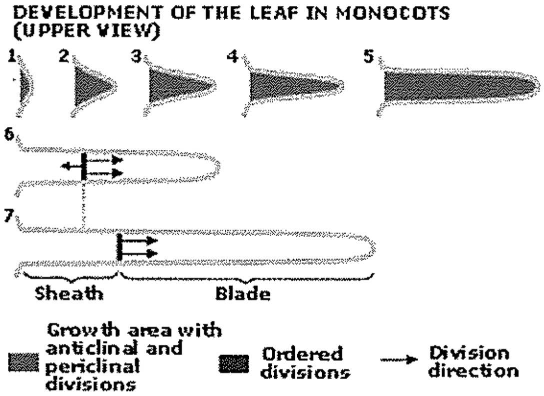
The initiation of leaf commences with a lateral protrusion on the apical meristem. This is leaf buttress. Later leaf primordium develops on leaf buttress. The initial lateral protrusion results from periclinal division. Leaf primordia first appear as transverse ridges on the surface of the apical meristem of the shoot. The shoot apical meristems of gymnosperm and angiosperm consist of two distinct zones — tunica and corpus. Tunica is the surface layer and it encloses the corpus. The tunica and corpus variously participate in the development of leaf primordium. Several meristems are involved in the development and growth of the leaves.



Leaf Initiation – *In dicots, the initially formed bulge further elongates by mitotic cell divisions throughout the bulge. Then, at the top of the extended bulge, cells start to divide a single plane causing the sheath to broaden. Depending on the species, division activity concentrates on certain regions leading to the typical shape of some dicot leaf blades, e.g. serrate of lobbed. The lower part of the extended bulge develops into the leaf stalk or petiole.*



In monocots, the initial bulge further elongates by mitotic cell divisions until a certain size is reached. Then, overall cell division stops. Only cells in a small region at the base of the leaf further divide, i.e. nearly exclusively in parallel to the leaf base. This is how the typical longitudinal arrays of epidermal cells and the parallel venation of monocot leaves arise. Below this division zone, a sheath is formed that surrounds the stem. A leaf stalk is absent. The opposite side develops into the leaf blade. Leaf growth may continue without limitation as long as this meristem exists.



[25 marks]

Question 4

a) Distinguish between the following terms:

i. Exarch and endarch

Exarch refers to the development from the periphery, while endarch refers to the development from the centre.

ii. Centrifugally and centripetally

Centripetal force is towards the centre, while the centrifugal force is away from the centre.

iii. Heartwood and sapwood (6)

The heartwood is the dead central part of the wood, whereas the *sapwood is the living, outermost part of the secondary wood, where sap flows.*

b) Using well-annotated diagrams, show how lateral roots originate. (7)

Both dicot and monocot roots form lateral branches but dicot roots branch more than monocot roots. Lateral roots begin to form just above the region of root hairs. The development of lateral roots commences with the division of the cells of the pericycle. Cell division leads to the formation of a group of meristematic cells in which the layering typical of a normal root apical meristem soon appears. Growth of the new apical meristem leads to the penetration of the endodermis and the rest of the cortex, until the new lateral root bursts through the epidermis and out into the soil. Lateral roots are said to be endogenous in origin because they grow out from within the tissues.

Candidates are to submit hand-drawn diagrams

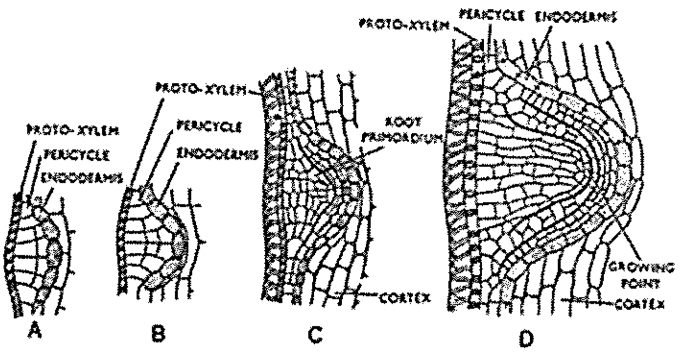
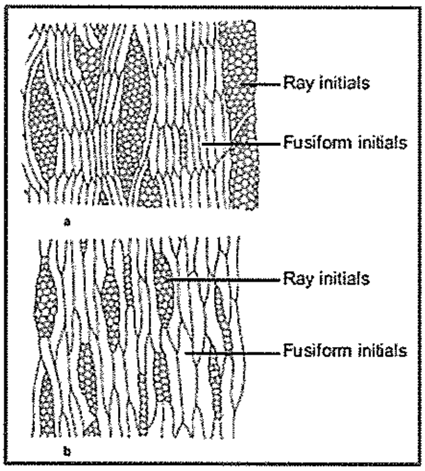


Fig. 610. Formation of a lateral root—stages in longitudinal views.

c) The vascular cambium has two morphologically distinct types of initials. Provide the two types of initial and write notes on them. (7)

The vascular cambium has fusiform and ray initials. Fusiform initials are elongated, spindle-shaped cells that are arranged in vertical row. They arise within vascular bundles and produce new vascular tissues, xylem inside and phloem outside. Fusiform initial divides so that one daughter cell becomes either xylem or phloem. A fusiform initial can also divide to produce two fusiform initials that remain within the vascular cambium. They are aligned lengthwise, together with conducting cells, parallel to the surface of the stem or root. Ray initials are horizontally arranged cells in the vascular cambium. They assist in producing phloem and xylem rays. They arise between vascular bundles and they produce cubical parenchyma cells. Rays are common in dicots, where they are often more than one cell wide. They are visible best on the tangential section of the stem.



d) Using at least one example, write a short note on anomalous secondary thickening in plants. (5)

Anomalous growth is associated with the formation of multiple cambia.

Examples:

In a stem of Bougainvillaea sp., the vascular bundles contain no cambium and are scattered throughout a central ground tissue. Secondary thickening begins when a complete ring of cambium forms in the cortex, immediately outside the vascular bundles. This cambium cuts off secondary tissues towards the centre of the stem. Most of the secondary tissue forms lignified ground tissue, in which are scattered vascular bundles.

Or

The storage roots of Beetroot have an anomalous form of secondary thickening, with the first cambium formed in the usual way but acts for only a short time. When the first cambium becomes inactive, a new cambium is formed outside the previous one in the pericycle or secondary phloem. The process is *repeated several times and the mature beetroot contains many alternating layers of secondary phloem and secondary xylem.*

Or

In the root tubers of Sweet potato, secondary xylem and phloem are formed in the usual way. Both tissues contain a high proportion of parenchyma. Subsequently, cambia are formed in the secondary xylem, each surrounding a large vessel, or a group of large vessels. These produce secondary xylem towards the original vessel and secondary phloem towards the outside.

[25 marks]

OR

Question 5

Compare C3, C4 and CAM plants in terms of the following:

a) Site of dark and light reactions in the leaf,

C3 pathway are mesophyll cells

C4 pathway are mesophyll cell, bundle sheath cells,

CAM follows both C3 and C4 in same mesophyll cells (3)

b) First product of carbon dioxide fixation,

C3 – 3-phosphoglycerate

C4 – Oxaloacetate

CAM – Oxaloacetate (3)

c) Carbon dioxide acceptor,

C3 – Ribulose 1,5-bisphosphate

C4 – Phosphoenol pyruvate

CAM – Phosphoenol pyruvate (3)

d) Re-fixation of carbon dioxide,

C3 plants – CO_2 is fixed at the onset of the Calvin cycle (1)

C4 – CO_2 can be re-assimilated into the C_3-CR cycle/Calvin cycle in the bundle-sheath cells (2)

CAM plants – CO_2 produced during the night is re-assimilated into the Calvin cycle in mesophyll cells (2)

e) Photorespiration,

C3 plants – do not have the anatomic structure (no bundle sheath cells) nor the abundance of the enzyme PEP carboxylase to avoid photorespiration. (2)

C4 plants – no photorespiration (1)

CAM plants – avoid photorespiration (1)

f) Rate of photosynthesis during stress conditions.

C3 – lower photosynthetic rate because of the inability to avoid photorespiriation (2)

C4 plants – exhibit higher photosynthetic rates because of numerous chloroplasts on the mesophyll cells (2)

CAM – high photosynthetic rate because they avoid water loss by opening their stomata at night. (3)

[25 marks]

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