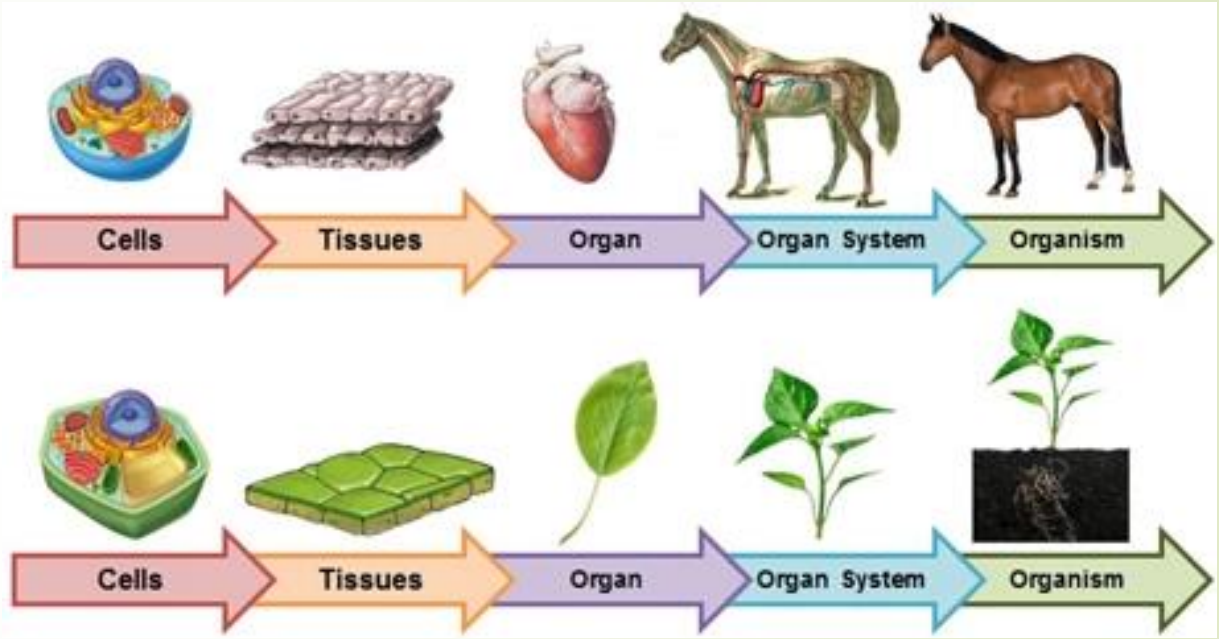
Anatomy

-Dr. Archana ER

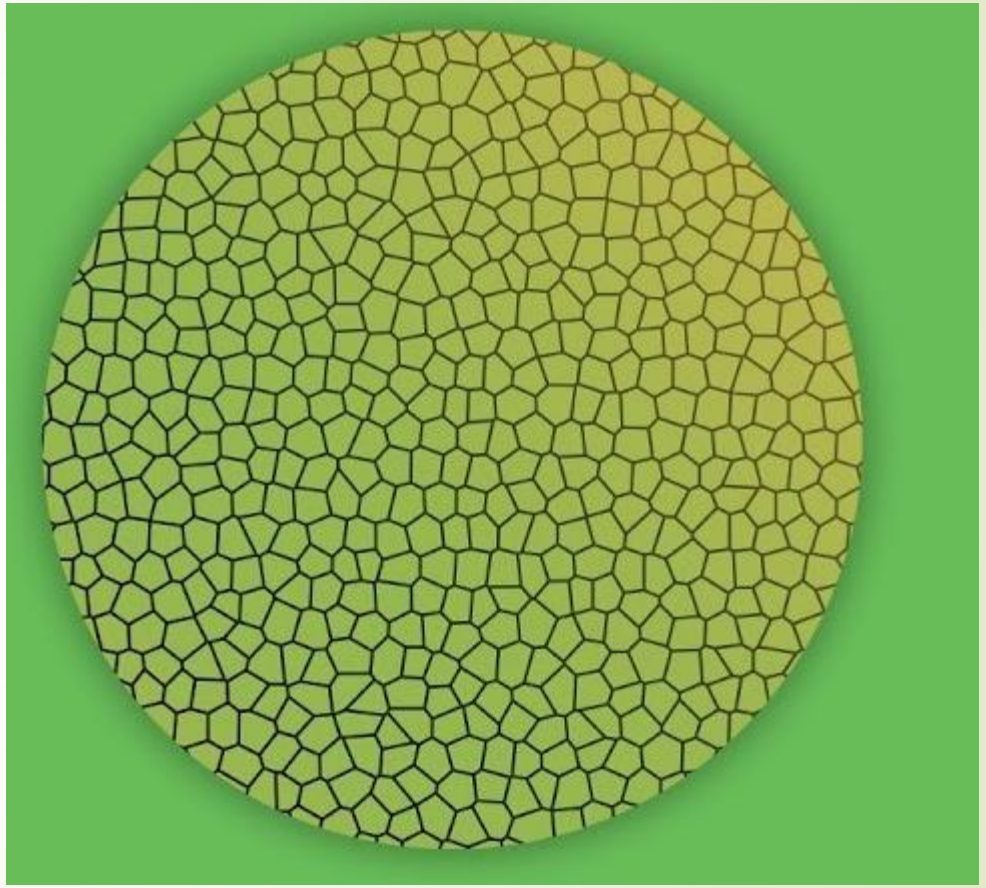
Introduction

- Study of internal organization
- Cells- Tissues– organ – Organ system – Organism
- Root system and shoot system
- Meristematic tissue
- Permanent tissue



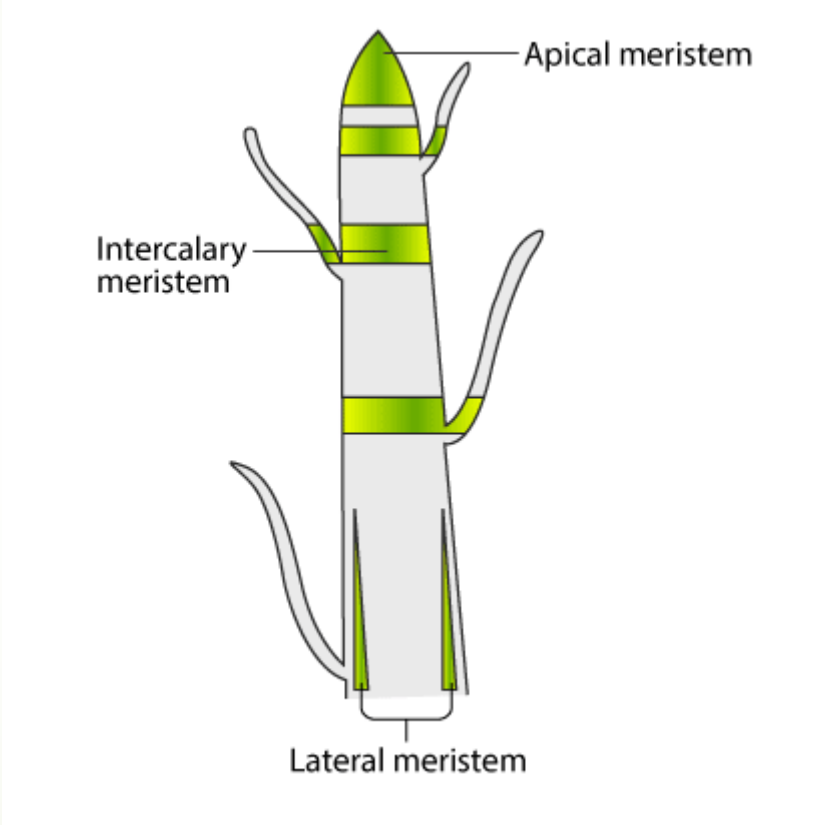
Meristematic tissue

- Immature, undifferentiated
- Continuously dividing
- Formative tissue
- Thin walled, isodiametric
- Protoplasm dense
- No stored food
- Vacuoles small or absent
- Cellulosic cell wall



Classification- based on position

- Apical meristem: Growing tips
- Intercalary meristem: Internodal
- Lateral meristem: Periclinal division



Classification – Based on origin and development

- **Promeristem:** Embryonic, located in plumule and radicle
- **Primary meristem:** originates from promeristem – protoderm, procambium
- **Secondary meristem:** develops from non-meristematic primary permanent tissue

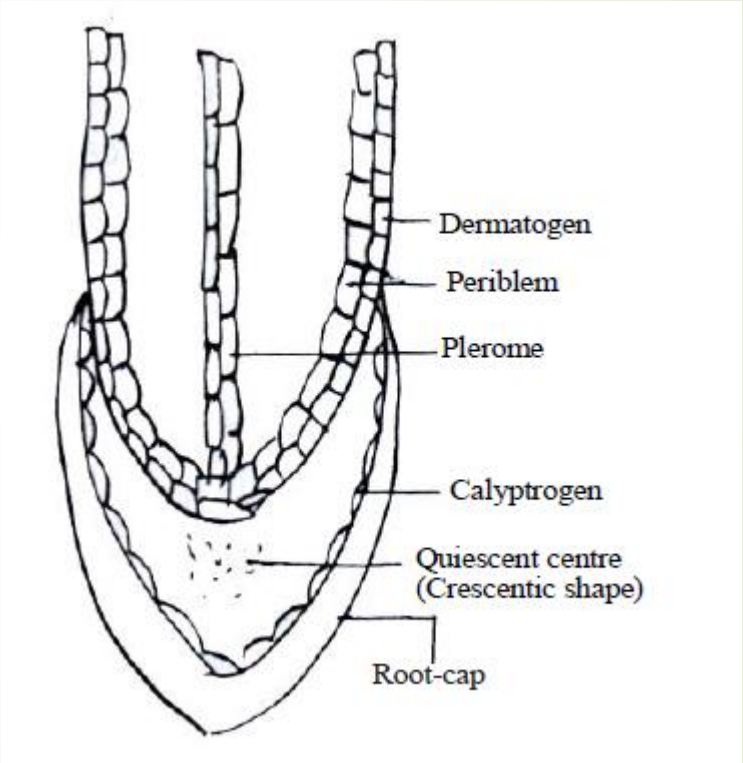
Classification- Based on plane of division

- **Rib meristem:** anticlinal division – for rib and cork development Eg. Pith
- **Plate meristem: P**ericlinal division Eg. Epidermis
- **Mass meristem:** divides in all planes – early development of endosperm, sporangia etc.

ROOT APEX

- Shorter than the shoot apex
- No leaf or branch primordia
- Nodes and internodes absent
- Root cap for protection
- Parts:

1. **Root cap (calyptra)**
2. **Calyptrogen**
3. **Quiescent center**
4. **Meristematic regions**

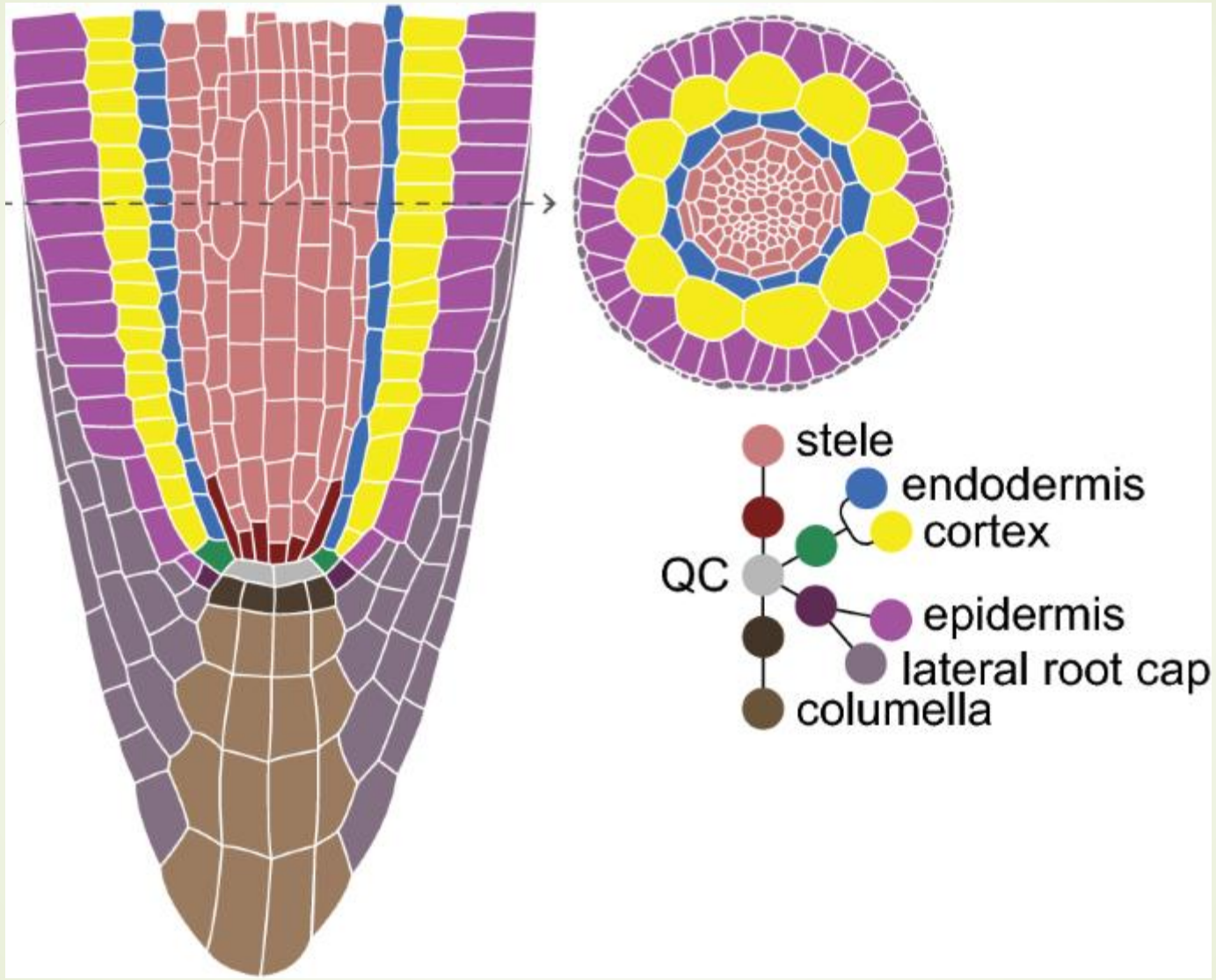


Calyptra

- Protective covering
- parenchyma cells
- Secretes mucilage to protect from desiccation and harmful soil particles
- Gravity perception – statoliths
- Positive geotropism

Quiescent center

- Central part of the promeristem
- Disc like
- Fewer Mt and ER
- No active division until the active initials are viable



HISTOGEN THEORY

- **Hanstein (1968)**
- Explains the growing points of the seed plants
- 3 layer concept

1. **Dermatogen** (outermost uniseriate) - **Epidermis**
2. **Periblem** (middle, isodiametric cells) - **Cortex**
3. **Plerome** (central mass of cells) – **Stele, Medullary ray and Pith**

Calyptrogen – Root cap

Root apices in dicots – Cap and dermatogen have common origin

Root apices in monocots – three group of initials gives rise to 4 zones

Histogen theory was rejected for shoot apex because:

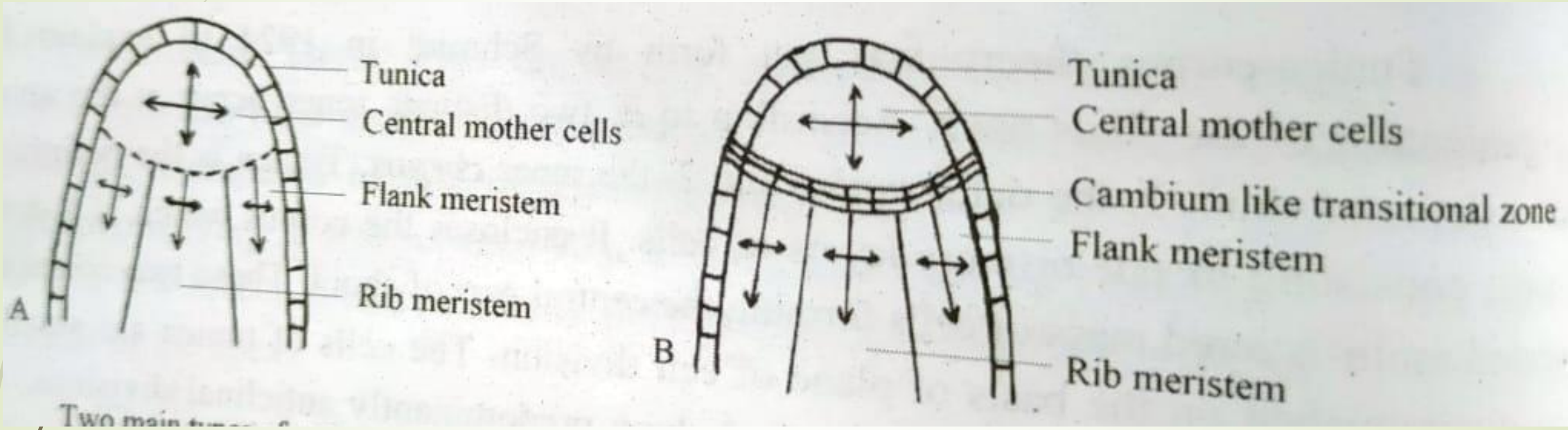
1. No clear distinction between periblem and plerome in angiosperms
2. Origin from different regions cannot be differentiated sharply

TUNICA CORPUS THEORY

- By Schmidt in 1924
- Explains the shoot apex
- Outer Tunica – Anticlinal division – Outer layer gives rise to epidermis and inner layers forms the cortex
- Inner Corpus – larger cells with irregular arrangement, divides in different planes
- Zones of Corpus – Usual Angiosperm Type

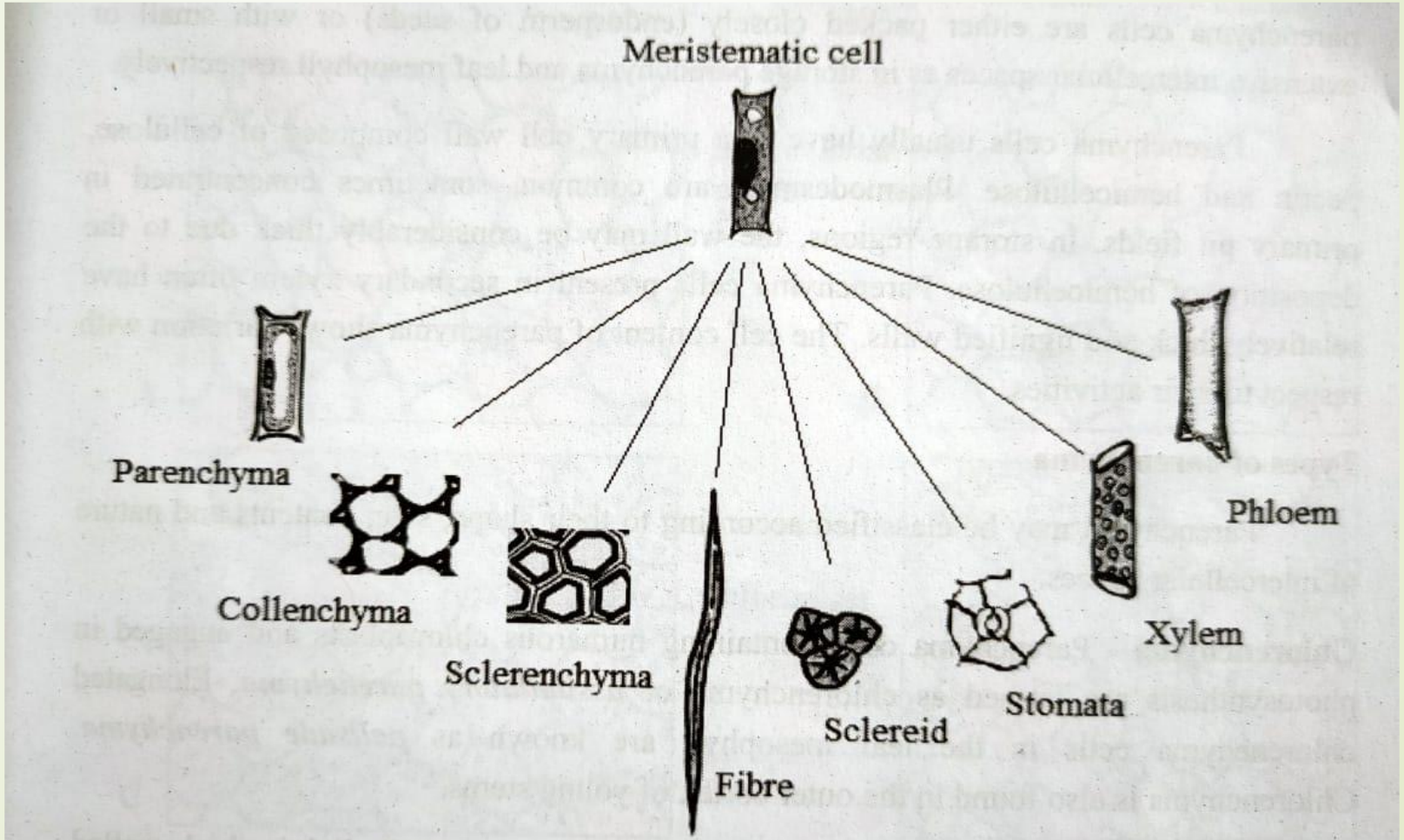
1. Central mother cells
2. Rib meristem – cortex, procambium and leaf primordia
3. The flank – Pith

Opuntia type: Cambium like transitional zone



A. Usual Angiosperm type, B. Opuntia type

PERMANENT TISSUES



Differentiation of various tissues from meristem

Simple tissues

1. Parenchyma:

- Active protoplast
- Precursor of all other tissues
- Most primitive one
- Nearly isodiametric
- Thin primary wall – cellulose, pectin, hemicellulose
- Plasmodesmata common

Types of Parenchyma

1. **Chlorenchyma:** with chloroplast, assimilatory in function, eg. Palisade in leaves
2. **Prosenchyma** – elongated with pointed ends, mechanical support
3. **Aerenchyma** – In aquatic, air filled cavities, for buoyancy
4. **Storage parenchyma** – reserve food materials
5. **Idioblastic parenchyma** – store tannins, oils, calcium oxalate crystals

Functions:

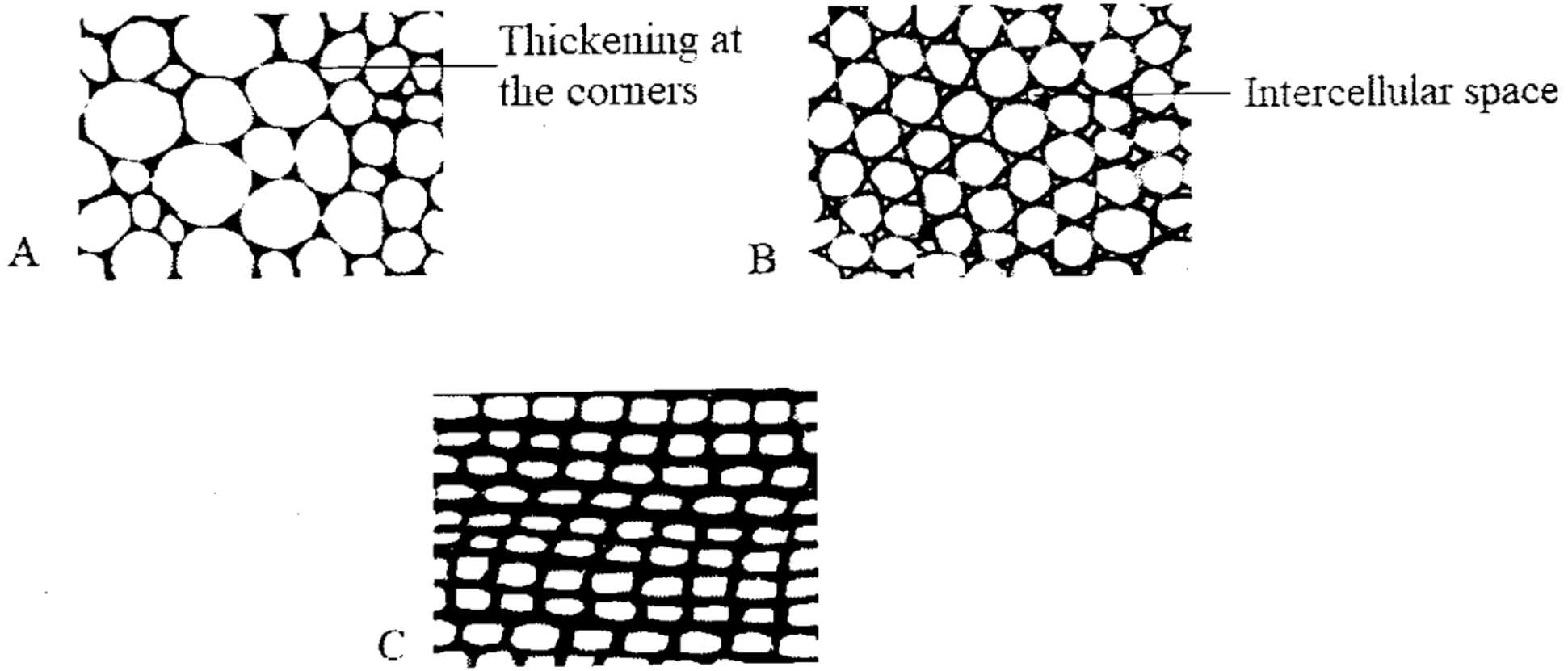
- Active protoplast – Photosynthesis, respiration, storage, secretion, and excretion
- **Store** food
- **Conduction** in VB
- Mature ones regain the power of **division** and becomes meristematic
- Turgid parenchyma gives **mechanical support**
- **Secretory** organs
- **Water storage** in succulents
- **Gaseous exchange** in air spaces
- Wound healing
- Cutinized ones are **protective**

2. Collenchyma

- The only living mechanical tissue
- Unevenly thickened walls
- Thick protoplast
- Cellulose, pectin and hemicellulose
- Found on the rapidly elongating organs like young stem, petioles, floral stalks and leaves
- Absent in underground parts and in monocots

Types of Collenchyma – based on the pattern of thickening

- **Angular (Annular)** – deposition on the junctions of the cell, no air space
- **Lacunar (tubular)** – thickening on the walls bordering the intercellular space
- **Lamellar (Plate-like)** – thickening on the opposite walls (inner & outer tangential walls), cells appear like plates



Types of collenchyma. A. Angular. B. Lacunar. C. Lamellar.

Functions

- Mechanical support with considerable elasticity for the growing parts
- High tensile strength provides flexibility without breaking
- Withstand mechanical stress due to heavy winds
- Chloroplast possessing ones carry on photosynthesis
- Cells regaining meristematic activity can produce new cells

3. Sclerenchyma

- Adapted for mechanical support
- Dead cells – no protoplast
- Thick walled, highly lignified with pits on their walls
- Based on size and shape – two types

1. Fibres – elongated cells
2. Sclereids – short, isodiametric cells

Fibres

- Elongated with pointed ends
- Looks angular in CS
- Thick lignified walls
- Tips overlap for the max. mechanical support
- Abundant in cortex, pericycle, xylem and phloem
- In roots, stems, leaves and fruits
- Based on position –

1. Xylary – forms the xylem elements (Libriform and fibre tracheids)
2. Extra-xylary – occurs in tissues other than xylem (Phloem fibres, cortical fibres, pericycle fibres)

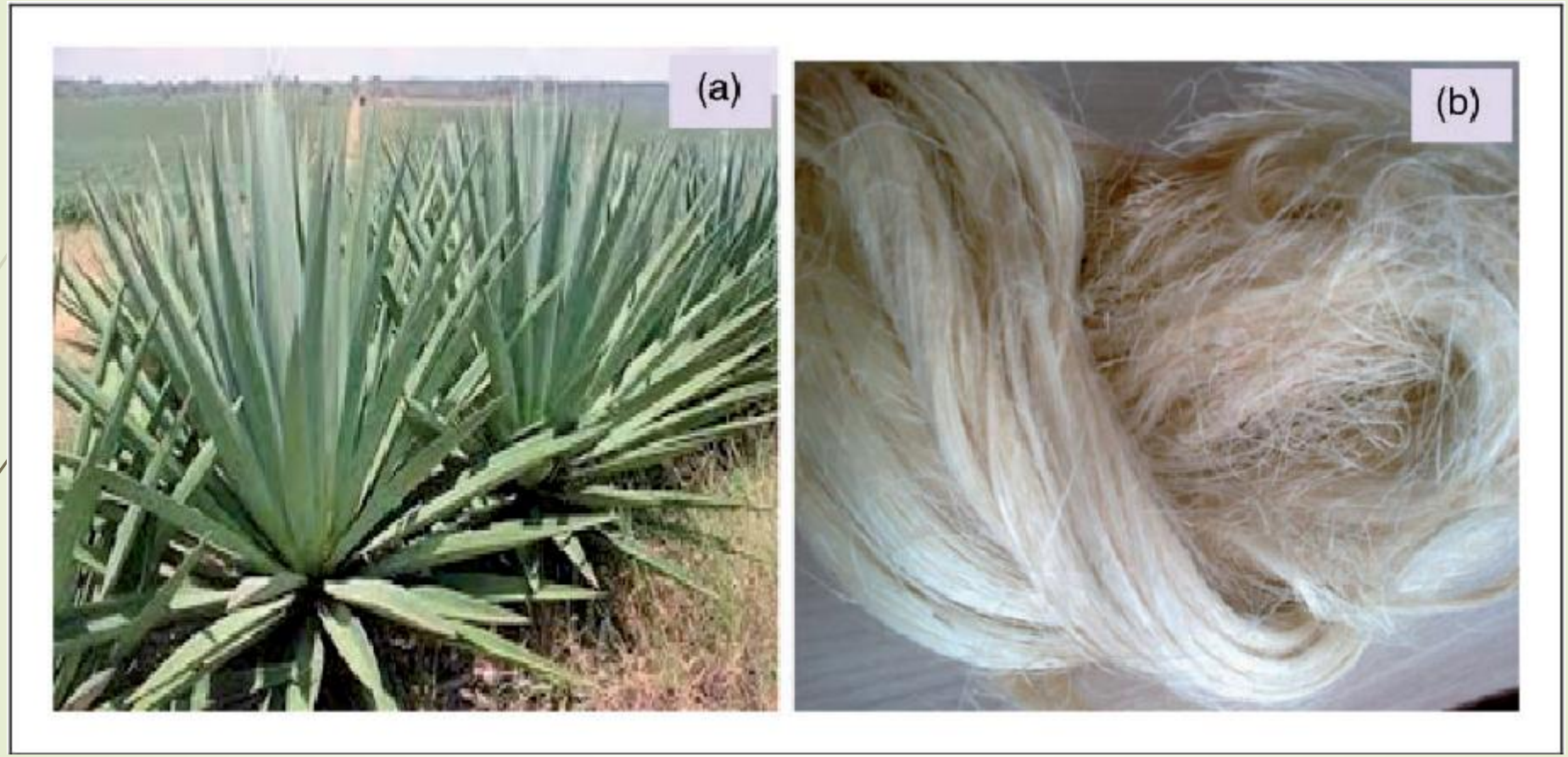
Economically important fibres: Extraction process - Retting

Hard fibres:

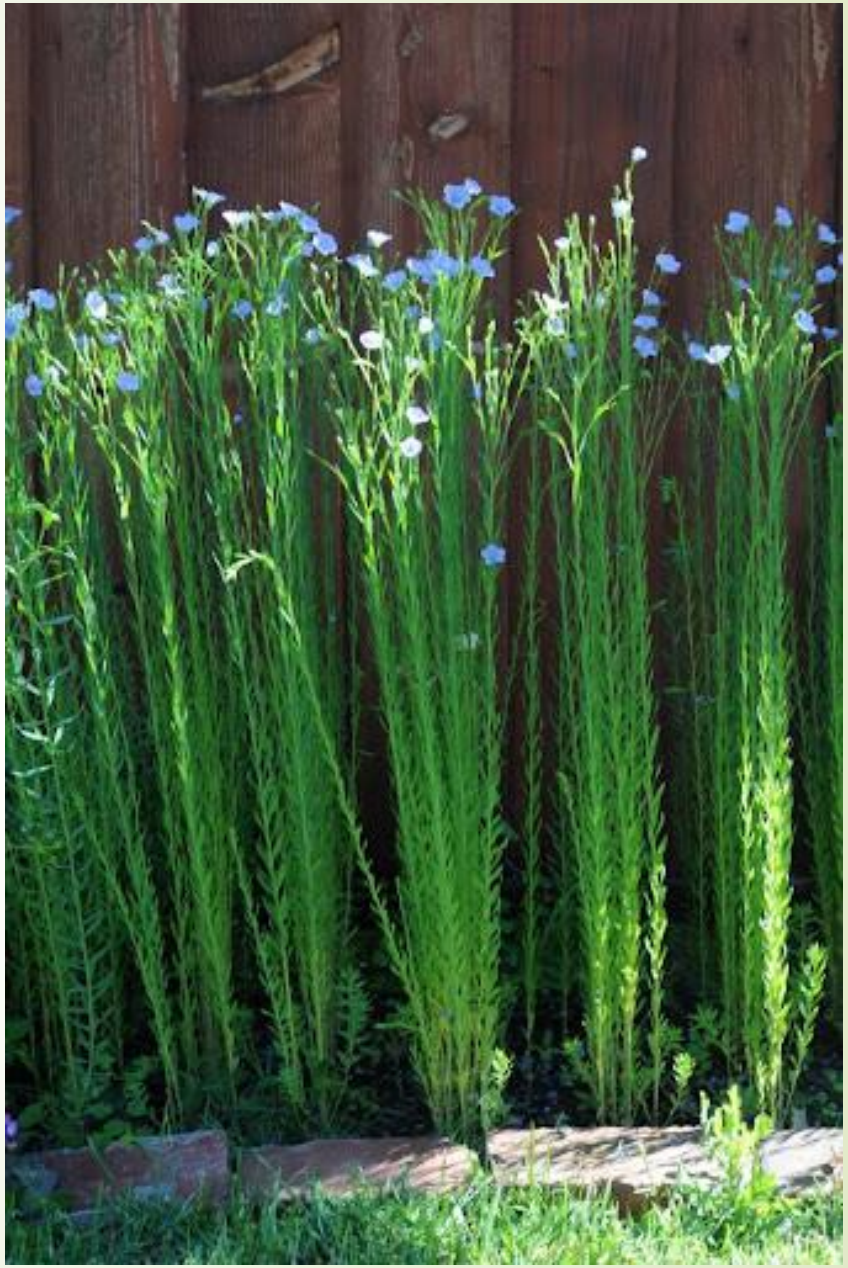
1. Manila hemp (*Musa textilis*)
2. *Yucca*
3. *Agave*

Soft fibres:

1. Hemp *(Cannabis sativa)*
2. Jute (*Corchorus capsularis*)
3. Flax *(Linum utilatissimum)*


(a)
(b)

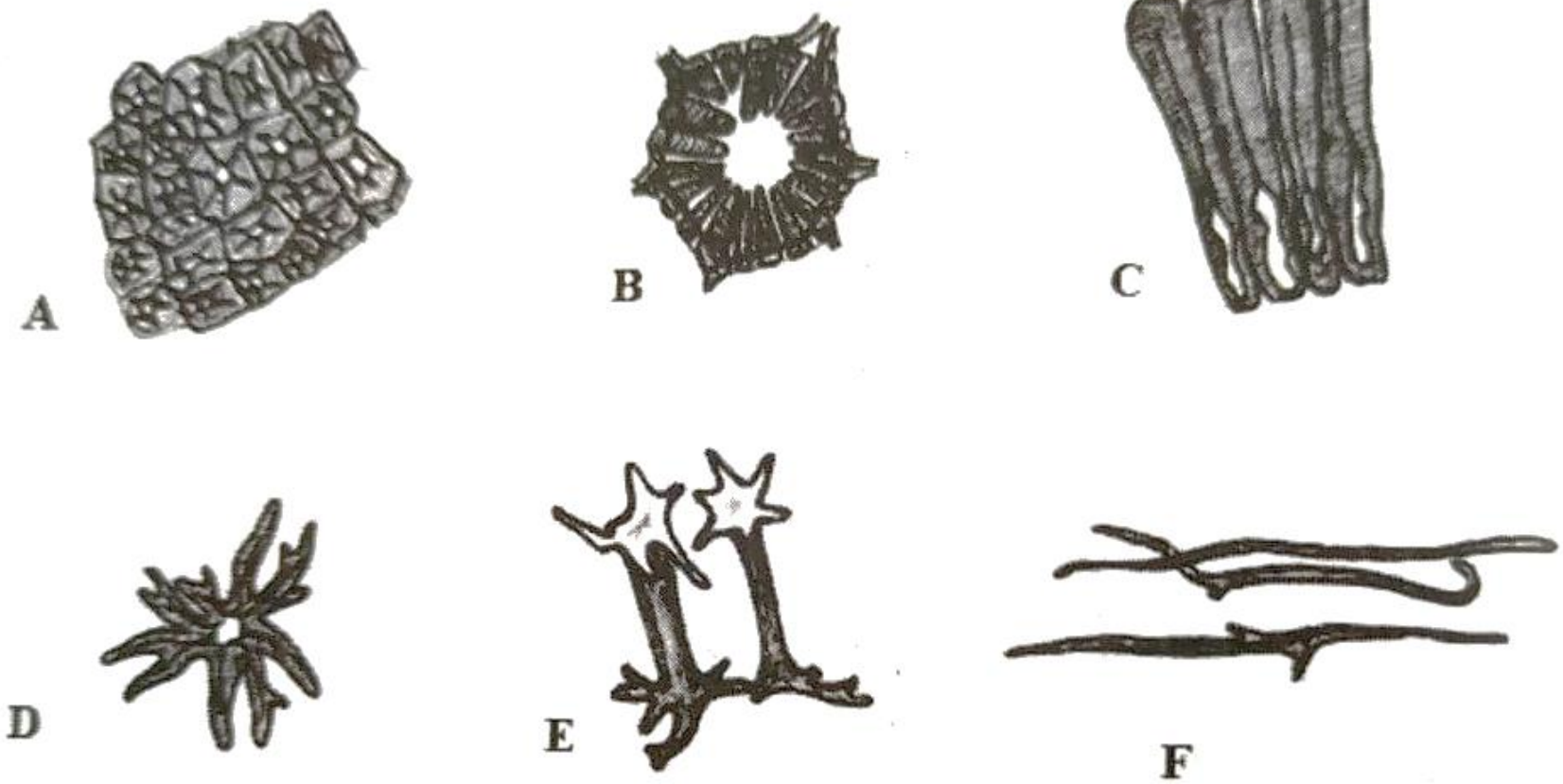

lonelyplanetimages.com



Sclereids

- Short, various shapes
- Dead with small lumen, highly thickened wall
- Secondary wall concentrically laminated
- Types:

1. Brachysclereids: Stone cells – Gritty texture of pears
2. Macrosclereids: Rod shaped, elongated – Seed coat of Phaseolus, pulses family
3. Osteosclereids: dumb-bell shaped – leaves of monocots
4. Asterosclereids: Star- like, Eg. Nymphaea
5. Trichosclereids: Hair- like, Eg. Leaves of Olea



Different types of sclereids

A&B. Brachysclereids
C. Macrosclereids
D. Asterosclereid
E. Osteosclereids
F. Trichosclereids

Functions :

- Most effective mechanical tissue
- Withstand various strains
- Xylary fibres helps in conduction
- Phloem tracheids helps in physiological functions
- Sclereids provides firmness
- Sclereids in seed coat protects internal parts
- Fibres in seeds and fruits helps in dispersion

COMPLEX TISSUES

- Made of cells with different morphology and structure but perform a common function
- Xylem and phloem

XYLEM

- Two cell types – Axial and radial
- Axial system components –

1. Tracheary elements (Tracheids and vessels)
2. Fibres (Fibre tracheids and libriform fibres)
3. Parenchyma cells

- Radial system components –

1. Parenchyma cells
2. Ray tracheids (in some conifers only)

Tracheary elements:

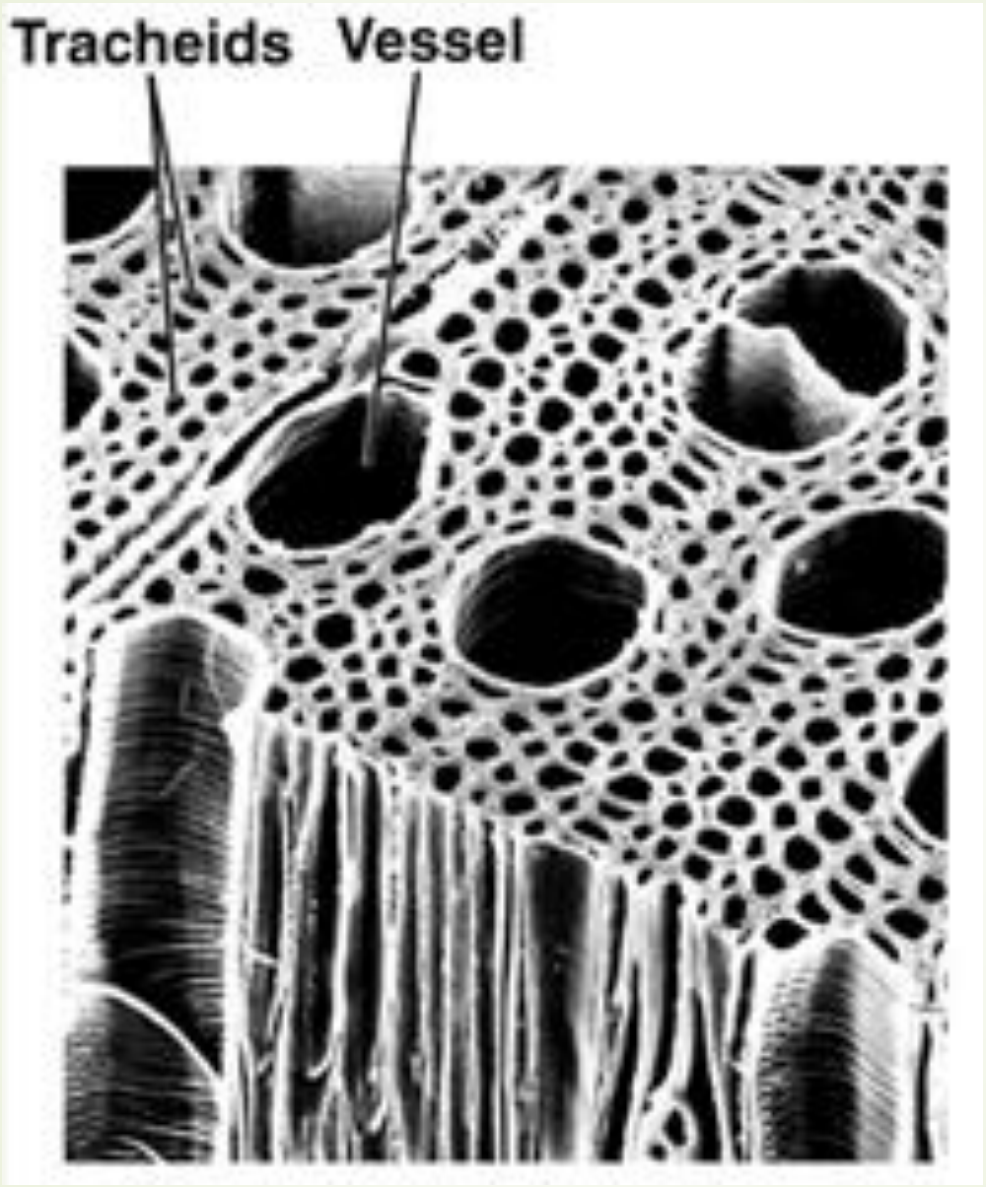
- Elongated, lignified with secondary thickening and pits
- Conduction of water and minerals

1. Tracheids:

- Elongated with tapering ends
- No perforations
- But pits present (primary wall present)
- Only elements in pterido and gymno
- Secondary wall thickening patterns – Annular, Spiral, Scalariform, Reticulate and Pitted

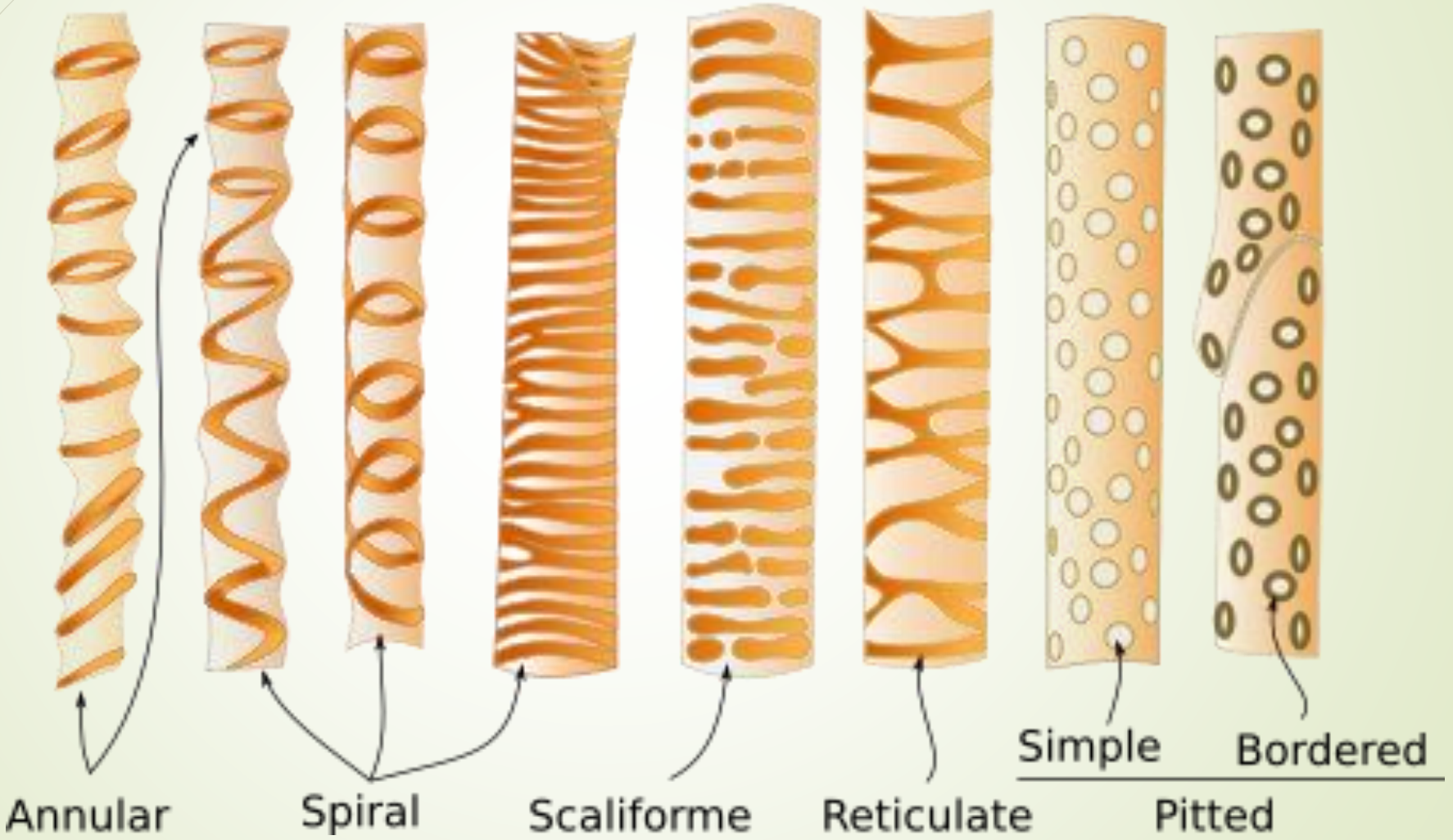
Vessels or Trachea

- Non- living
- Larger in diameter
- Vessel members
- Perforation plates – end walls – simple and multiple
- Oblique end (primitive) or transvers end (advanced)
- Secondary wall thickenings
- Protoxylem – first formed – annular or spiral
- Metaxylem – later formed – scalariform mostly, or reticulate & pitted
- Vessels absent in Winteraceae, Yucca, etc.
- Present in Selaginella, Marsilea, Gnetum


Tracheids
Vessel

TRACHEIDS y TRACHEAS

Cell wall modifications



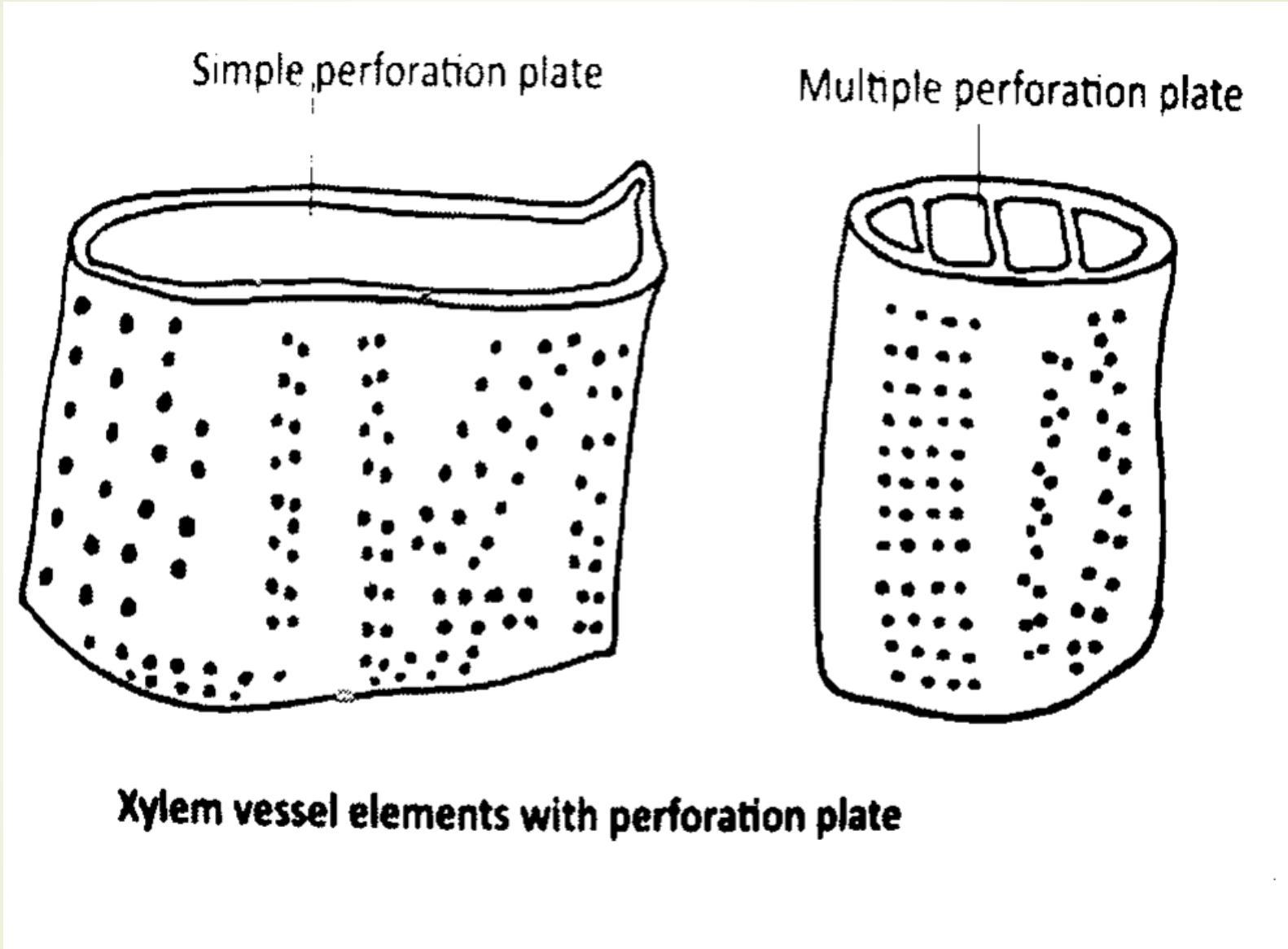
Xylem Fibres

- Elongated sclerenchyma
- 2 types – fibre tracheids and Libriform fibres

Xylem parenchyma

- living, thin walled
- No lignin
- Storage
- Types- Axial and radial

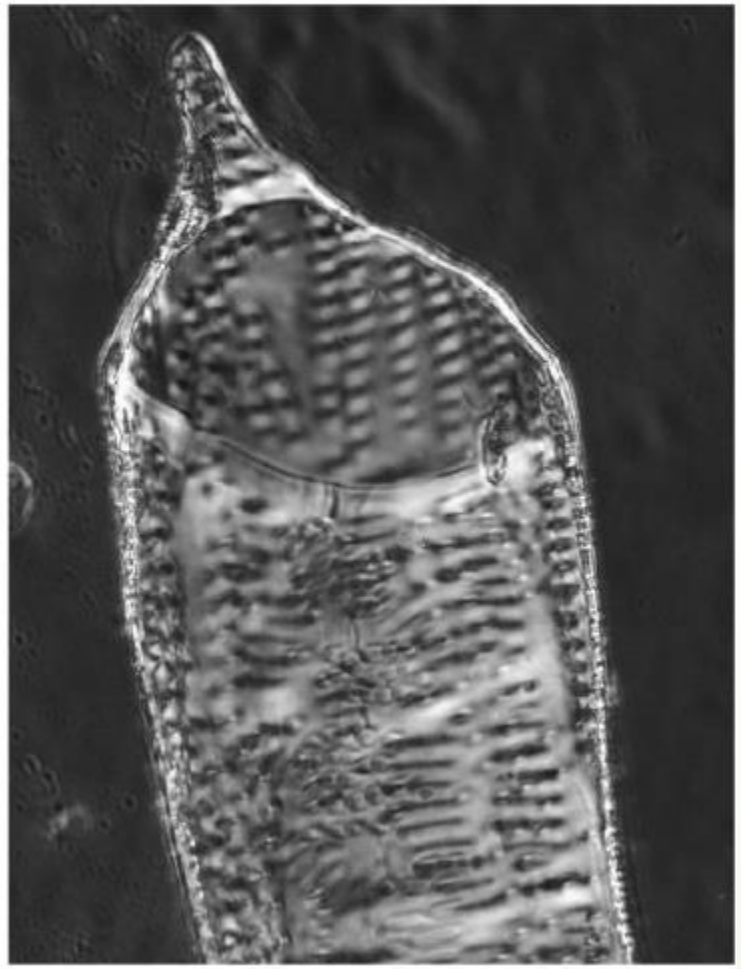
Axial from fusiform initials, Radial from radial initials

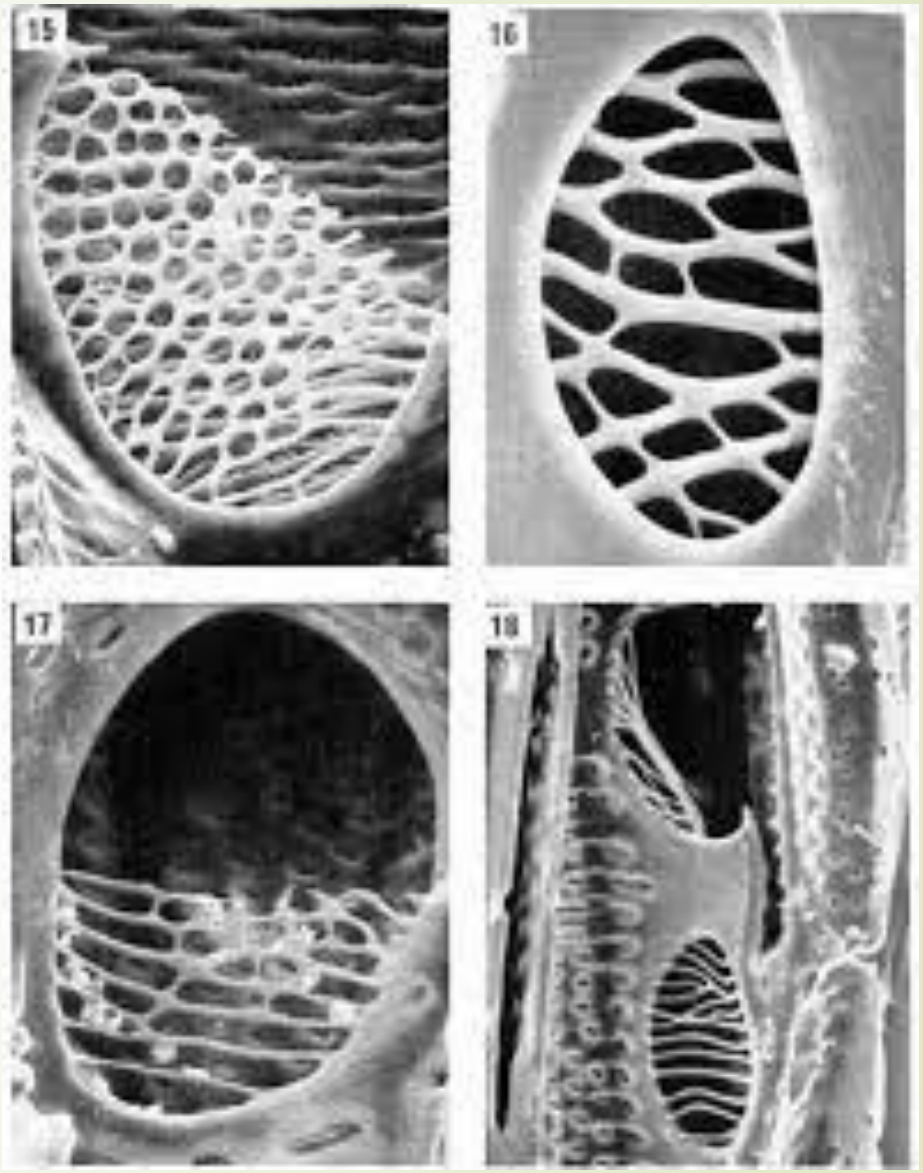


Xylem vessel elements with perforation plate

Simple
Perforation Plate

C





Xylem fibre

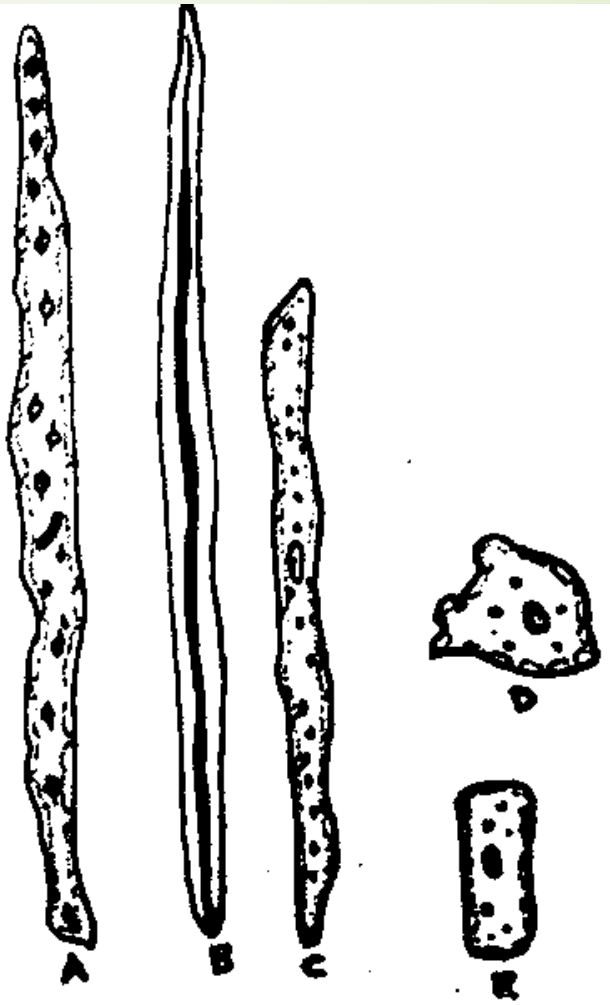


Fig. A-E Xylem fibres and parenchyma cells
A. Fibre tracheid. B. libriform fibre. C. axial parenchyma cell. D,E. ray parenchyma cells

Functions of Xylem

- Tracheary elements conduct water and minerals
- Provide mechanical support
- Provide rigidity and mechanical support
- Storage in parenchyma
- Ray – radial conduction

PHLOEM

- Food conduction
- Primary and Secondary phloem
- Primary from pro-cambium
- Secondary from vascular cambium
- Primary – only axial
- Sec – Both axial and radial

Axial components

1. Sieve elements – Living, conduction
2. Companion cells – narrow, thin walled, closely associates to sieve cells
3. Phloem fibres and sclereids - dead, narrow, elongated
4. Phloem parenchyma – living, storage

Sieve elements

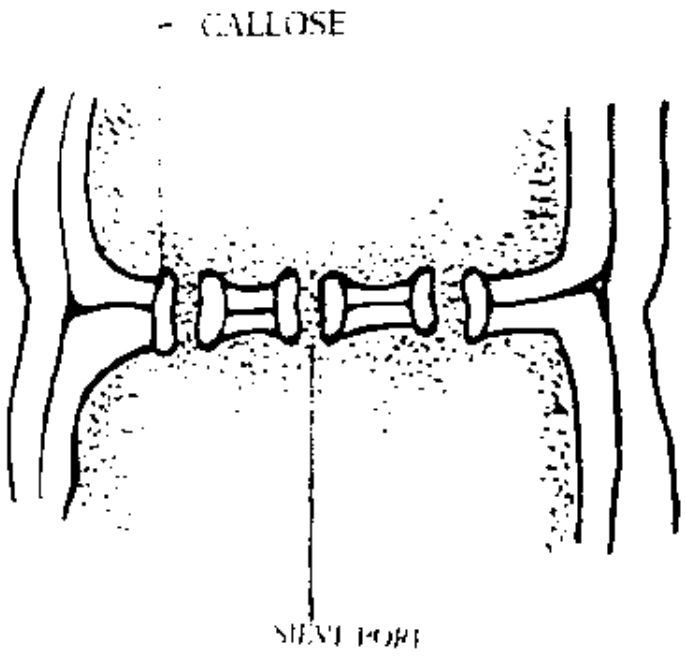
1. Sieve cells: Primitive, less specialized

Occurs in pteridophytes and gymnosperms

2. Sieve tubes: composed of many sieve tube elements

- Cytoplasm vacuolates and nucleus disappears at maturity
- Sieve tube is the only non-nucleated living cell in plants
- Cross-wall – sieve plate (cucurbita) – simple or compound (vitis)

On maturation, vacuole ruptures – mixes with cytoplasm – MYCTOPLASM – P-protein released to cytoplasm – along with callose – complex to form slime plugs during injury – loss of materials is prevented



Sieve plate - Side view

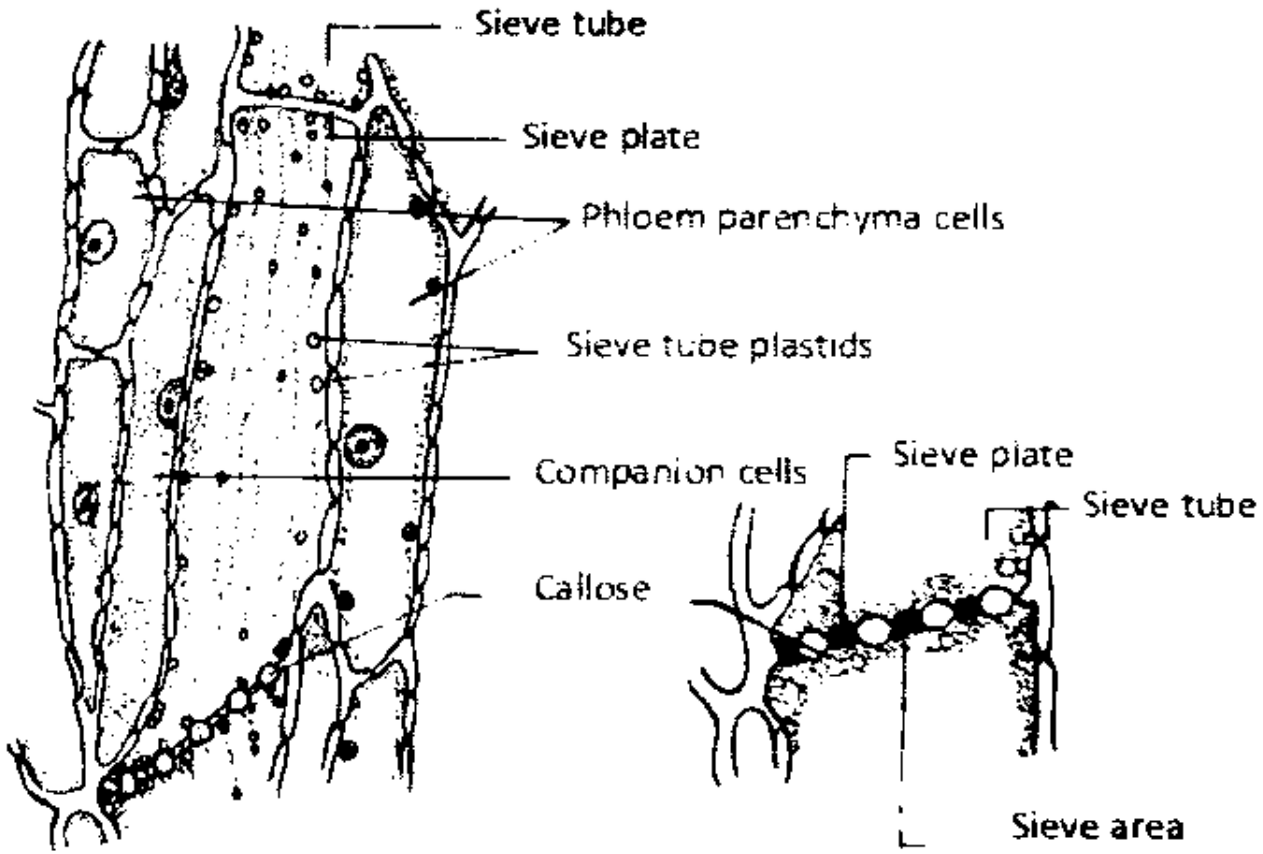
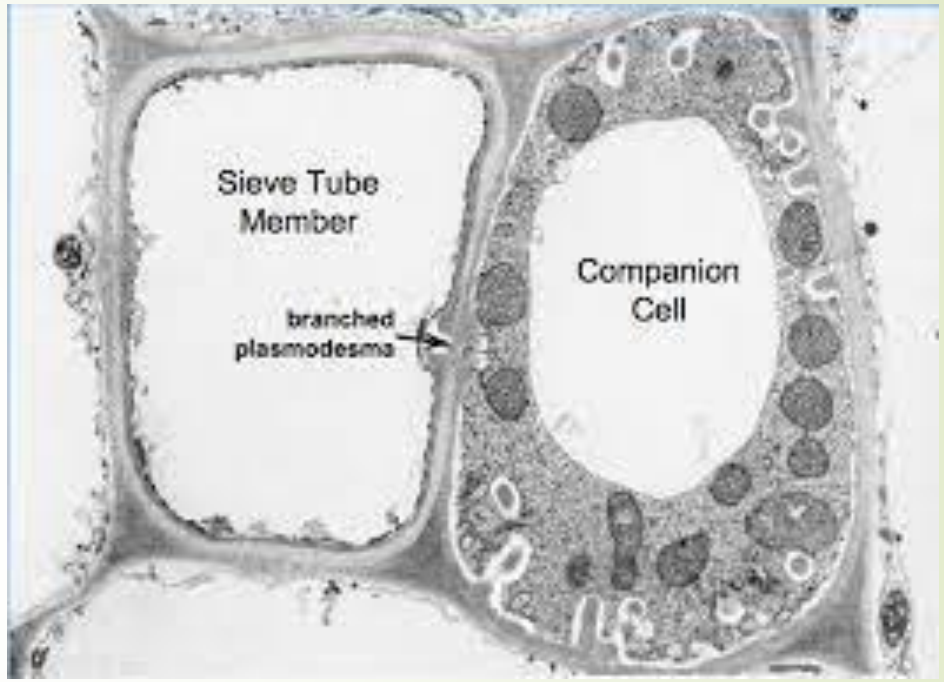


Fig.A
Phloem tissue

Fig.B
Magnified view of sieve plate

Companion cells

Companion cells



- Elongated thin walled narrow
- Associated with sieve cells
- Has nucleus and thick cytoplasm
- Absent in gymnosperm – instead they have albuminous cells

Phloem fibres and Sclereids

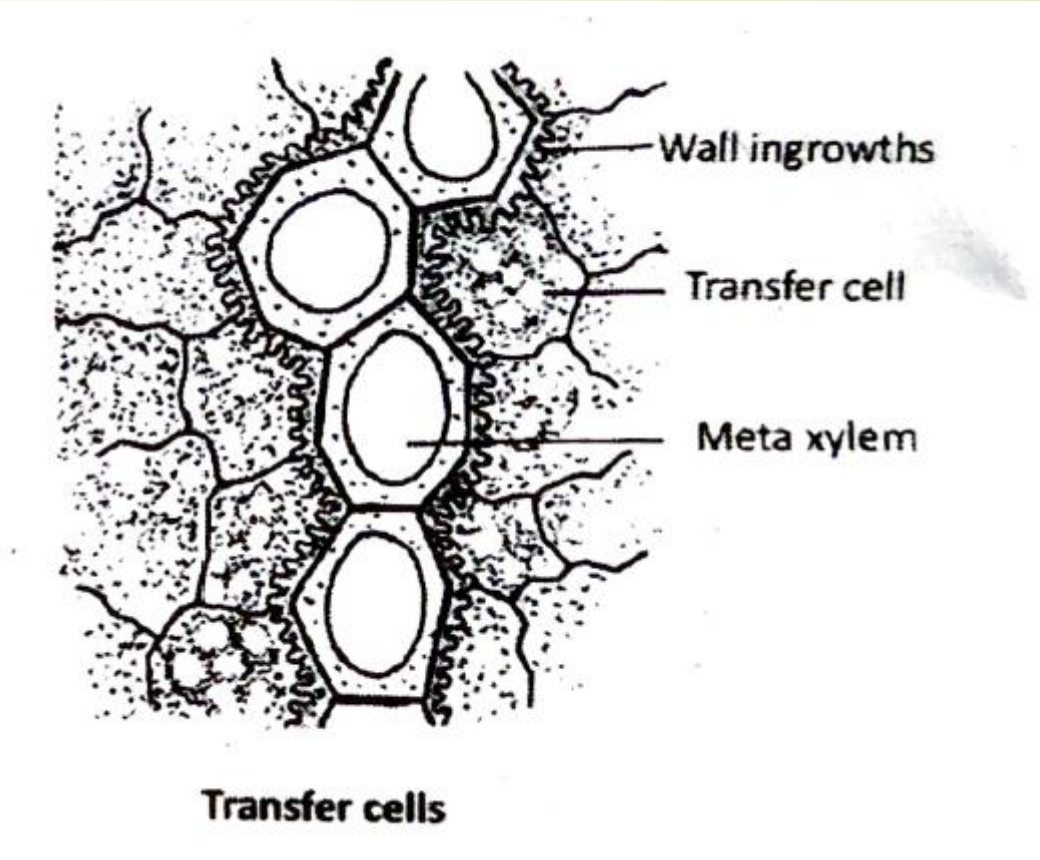
- Dead, narrow, elongated with tapering ends
- Also called bast fibres

Phloem parenchyma

- thin walled, living
- Storage of starch, fat, mucilage, resin etc.
- Axial and radial

Transfer cells

- Specialized cells in the minor veins of herbs
- Has outwards projection
- In both xylem and phloem
- Concerned with conduction among mesophyll cells and transpiration stream



Transfer cells

Functions of phloem

- Sieve elements namely sieve cells and sieve tubes are mainly concerned with conduction of food
- Companion cells supply metabolic products to the sieve tube elements
- Companion cells regulate the rate of flow through the sieve tube
- Phloem fibres provide mechanical support and protection
- Phloem parenchyma is concerned with storage and translocation of carbohydrates, amino acids *etc*.
- Phloem rays are concerned with radial conduction of food materials.

Secretory tissues

- Transfer or certain intermediate or end products of metabolism from cells – secretion
- Cells involved in secretion – secretory cells
- Eg. Water, salt, nectar, resin, tannin, latex, hormones etc.

Classification- based on location:

1. External – Glandular hairs, digestive glands, nectaries and hydathodes
2. Internal – Lysigenous ducts, Schizogenous ducts, resin ducts and laticifers

Types:

I. External Secretory tissues

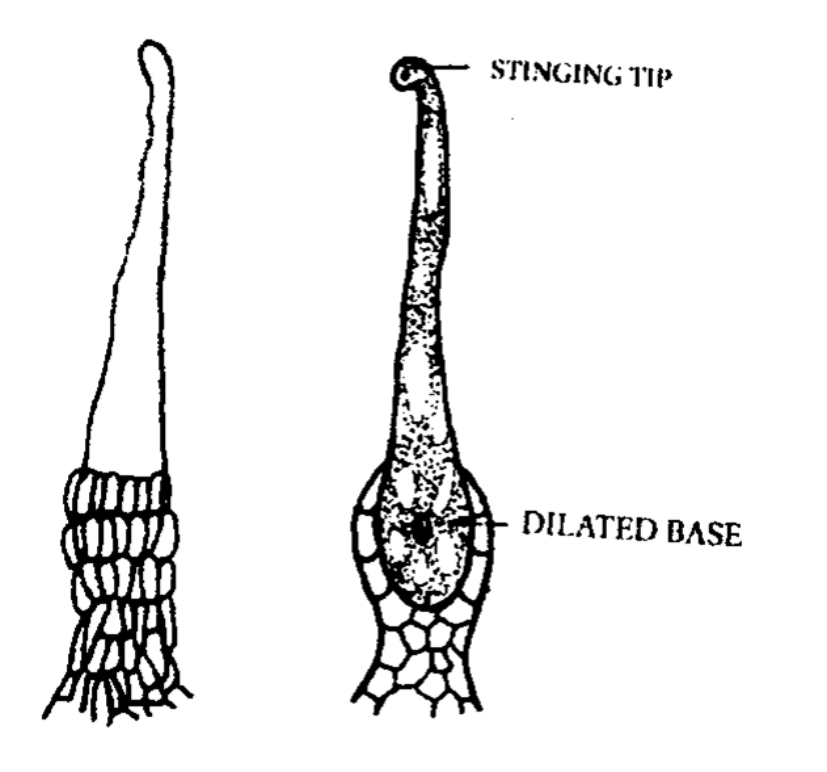
- Glandular hairs
- Digestive glands
- Nectaries
- Hydathodes

II. Internal Secretory tissues

- Schizogenous ducts
- Lysigenous ducts
- Resin ducts
- Laticifers

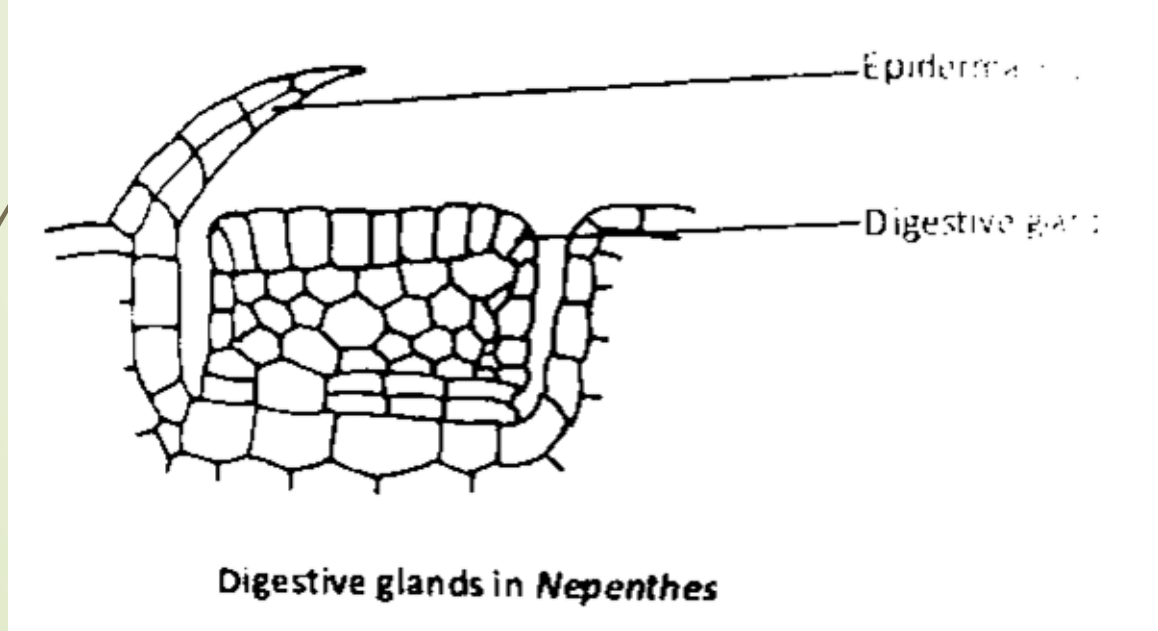
Glandular Hairs

- Trichomes
- Uni/multi-cellular
- Base and stalk



Digestive glands

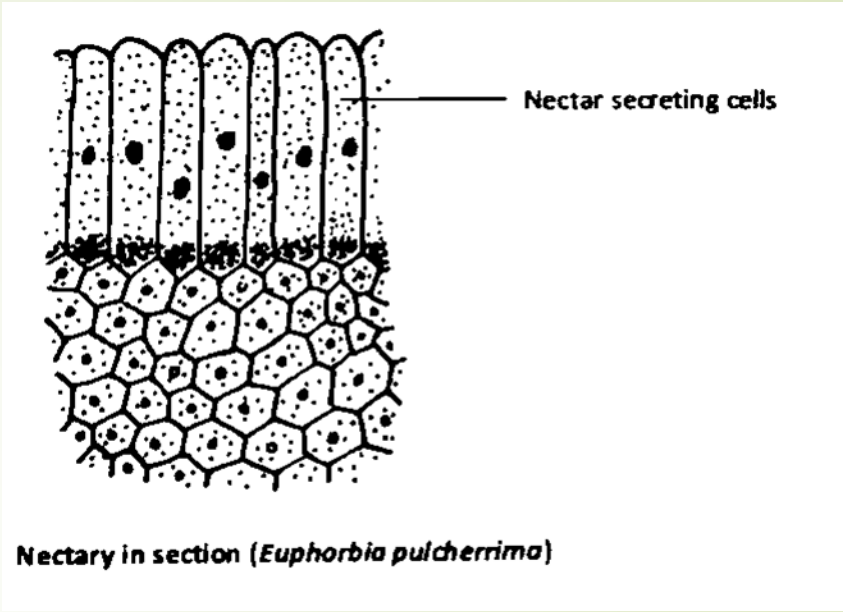
- Insectivorous plants
- Protein digestives
- Multicellular mass of tissue



Digestive glands in ***Nepenthes***

Nectaries

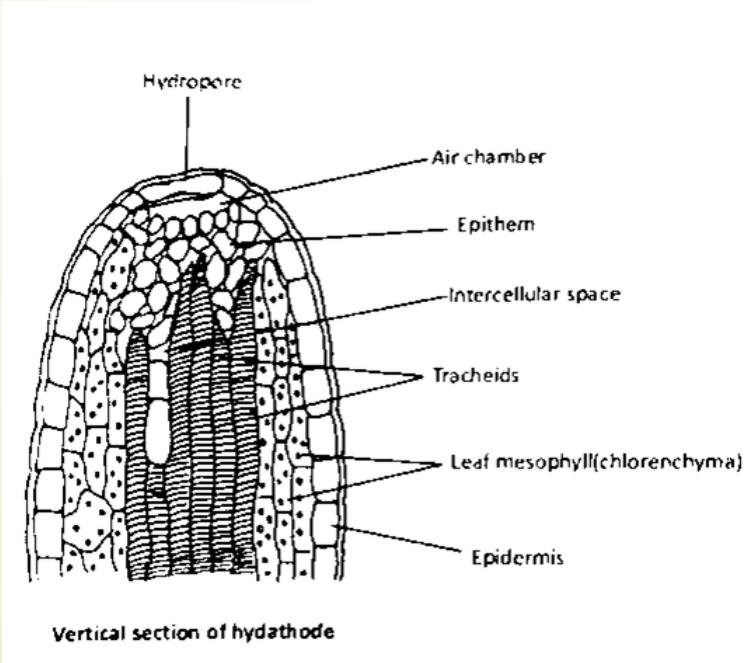
- Specialized nectar producing structures
- Nectar – solution of sugar and various other compounds
- Insect/ bird pollinated flowers
- Floral/Extrafloral



Nectary in section (*Euphorbia pulcherrima*)

Hydathodes

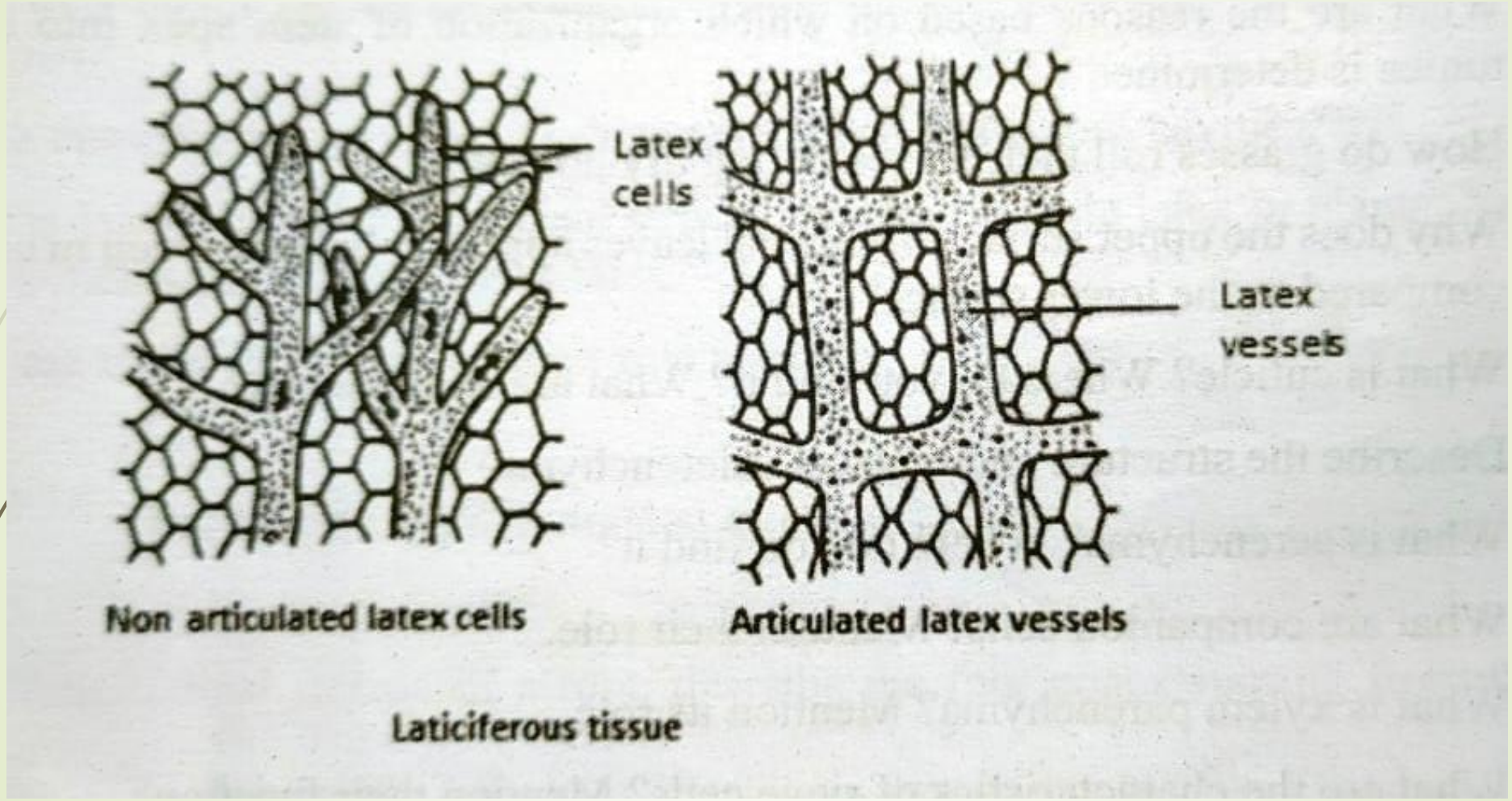
- For the exudation of excess water in liquid form
- Water stomata
- Guttation
- Leaf margin tips

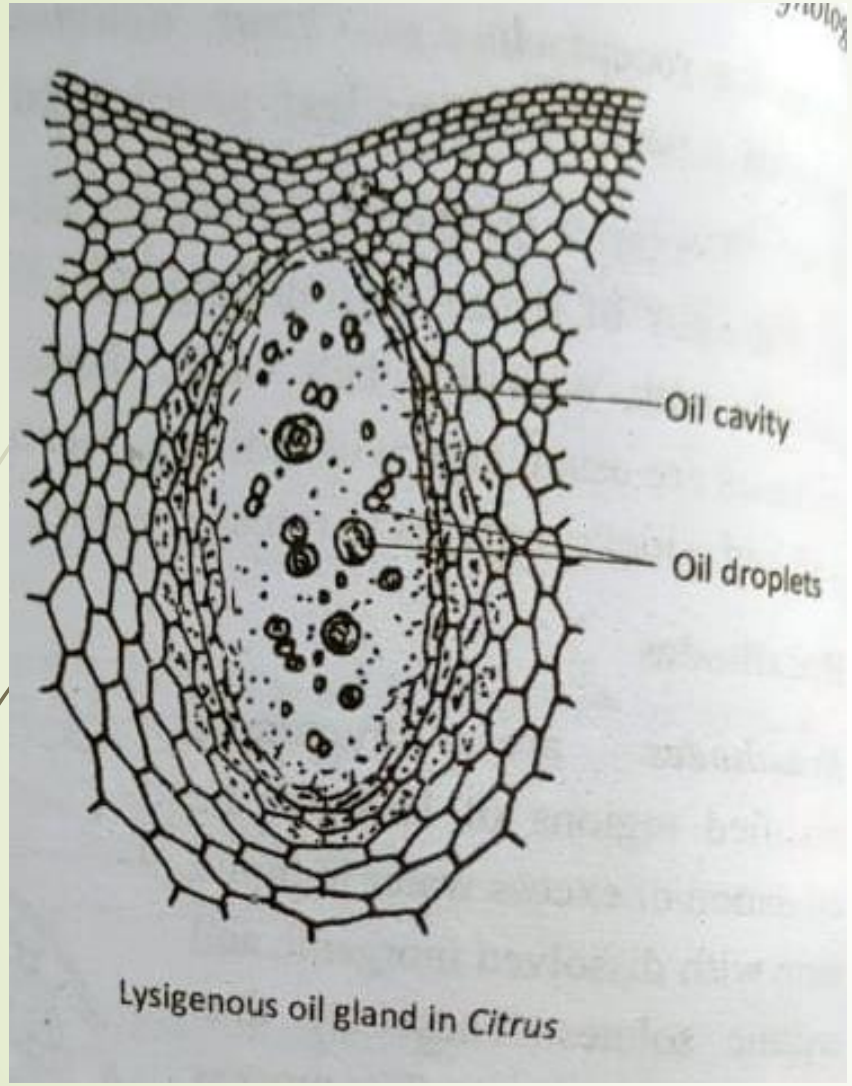


Vertical section of hydathode

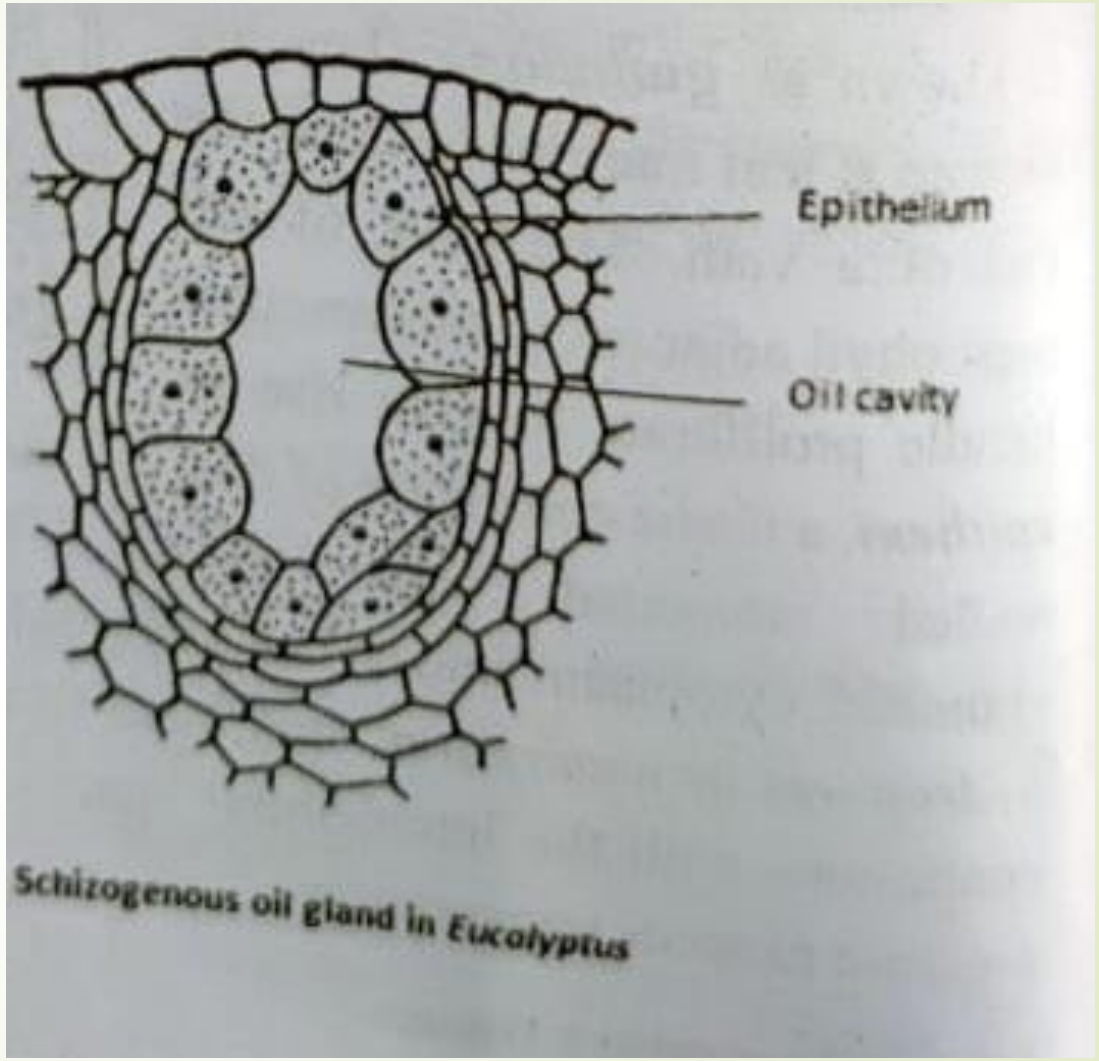
Lysigenous cavity

- Cavity formed by the complete disintegration of the cells
- Substances released to the cavity
- Eg. Oil glands in Citrus

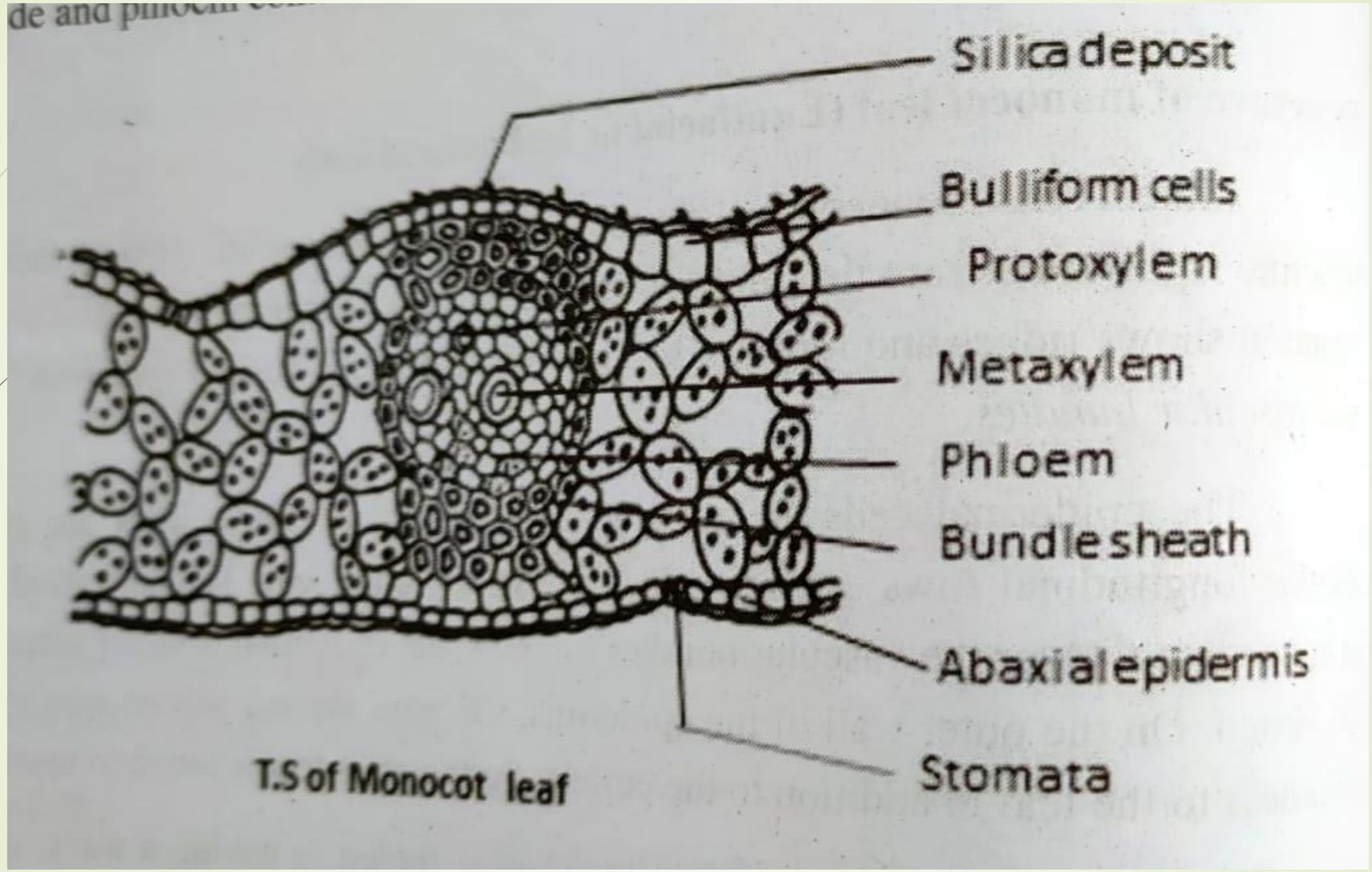

Latex cells
Latex vessels
Non articulated latex cells
Articulated latex vessels
Laticiferous tissue

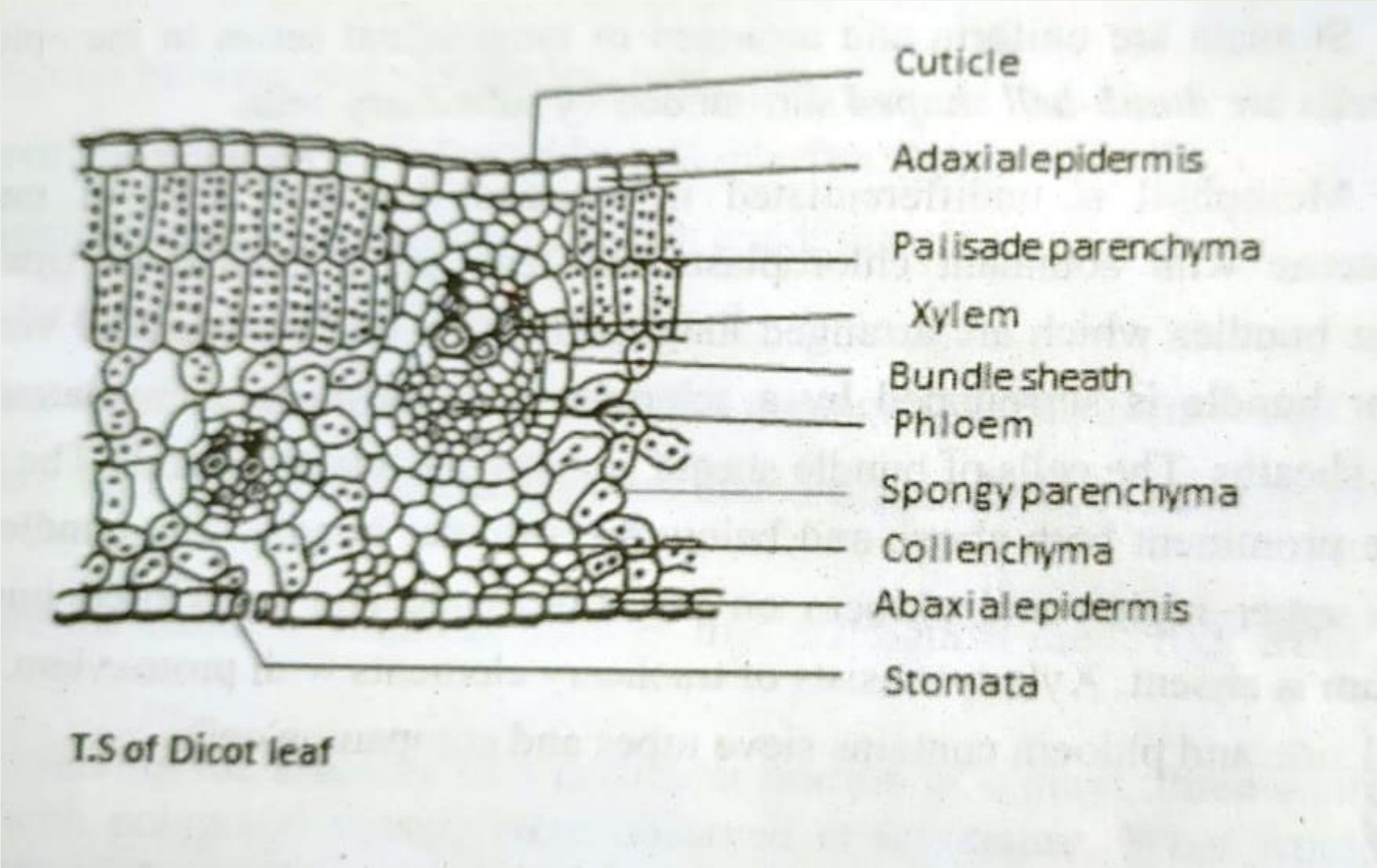


Lysigenous oil gland in *Citrus*



Schizogenous oil gland in *Eucalyptus*


Silica deposit
Bulliform cells
Protoxylem
Metaxylem
Phloem
Bundle sheath
Abaxial epidermis
Stomata
T.S of Monocot leaf



T.S of Dicot leaf