

I. Concept of Tissues

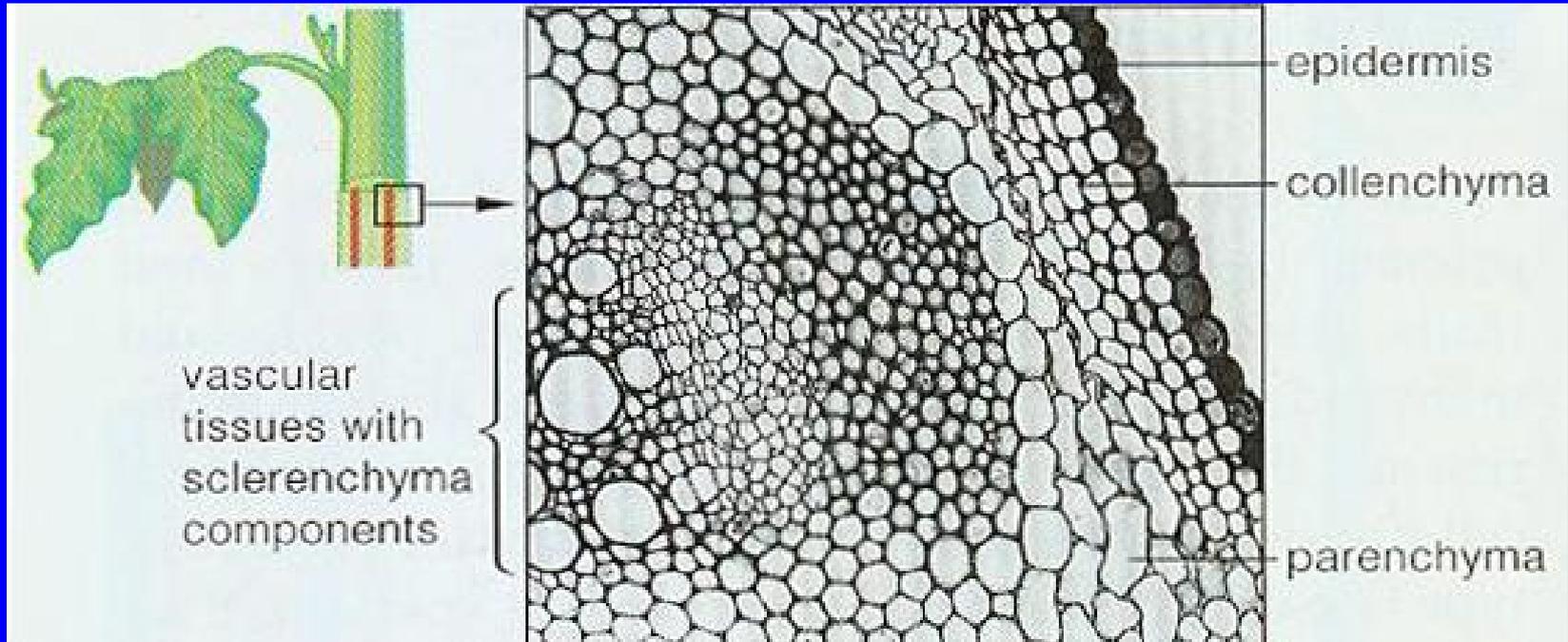
Tissue can be defined as a structural and functional unit composing of same type of cells or different types of cells from the same origin throughout plant development.

Simple tissues: tissues composed of only one type of cells are referred to as simple tissues.

Complex tissues: tissues composed of more than one type of cells are referred to as complex tissues.



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The location of simple tissues and complex tissues in one kind of plant stem.



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II. Types of Tissues

(I) Meristematic tissues

1. Concept: tissues where cells are constantly dividing are called meristematic tissues.

2. Types

(1) On the basis of their **position** in the plant body, meristematic tissues are of following types :

① Apical meristem

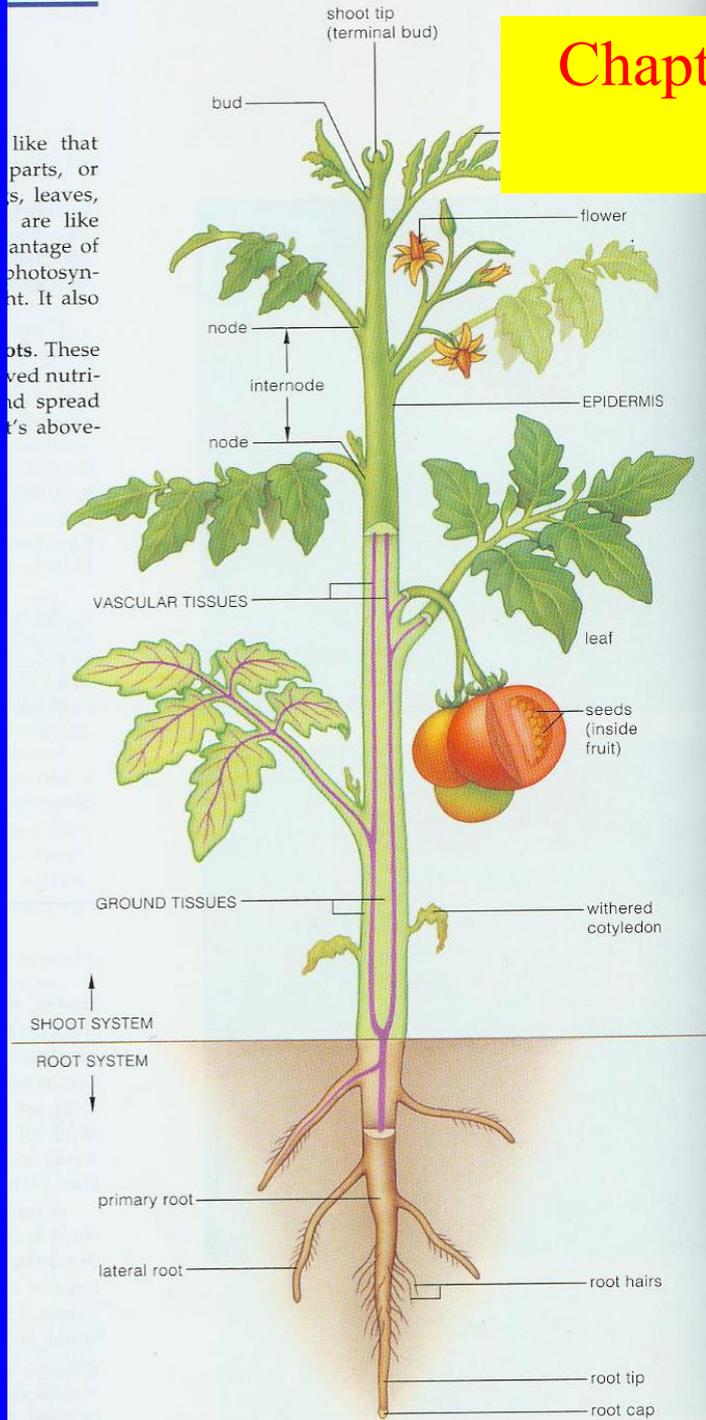
It is found at the tips of stems, roots and shoots, which is responsible for the lengthening of roots and stems, and gives rise to side branches (lateral shoots), leaves and reproductive organs on the stems.

Cell characteristics: meristem cells are small cells, the diameters of which are about equal, and have very thin cell walls, well-centralized nucleus with having large spaces, small and scattered vacuoles, dense protoplasm and lack of ergastic substances usually.

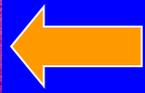
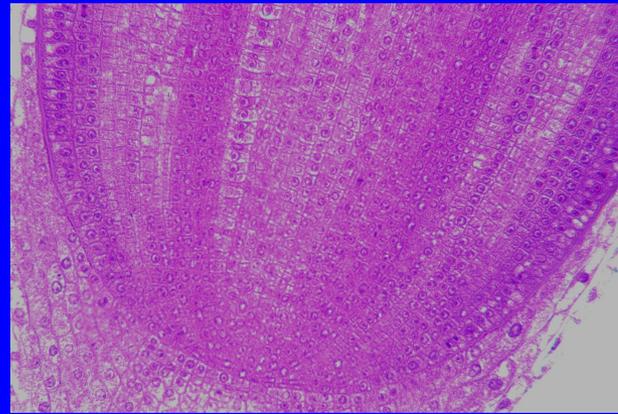


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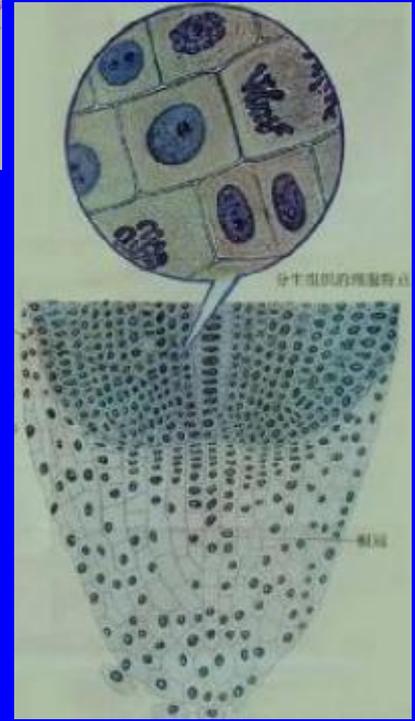


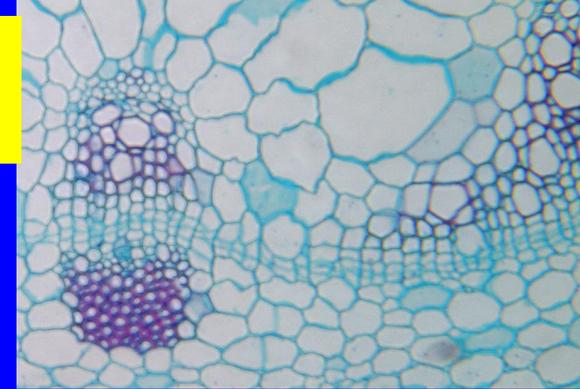
← **Body plan for one type of flowering plant, showing its shoot and root systems.**



Apical meristem in the tip of corn root.

Apical meristem in the tip of onion root.





② Lateral meristem

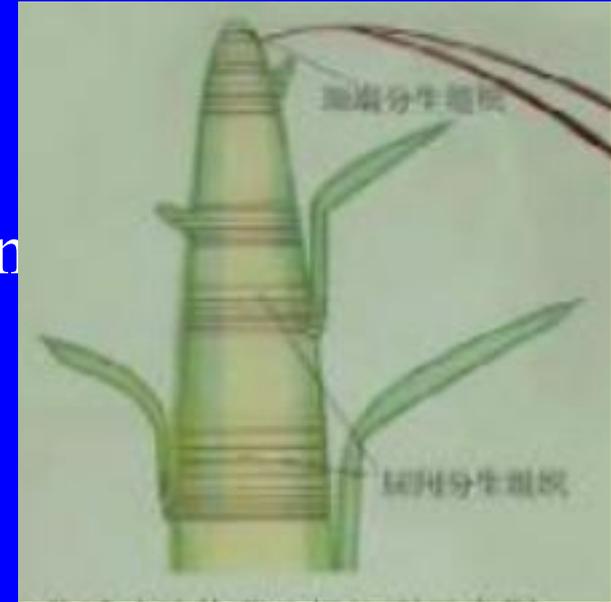
It encircles the roots and stems , close to the edge of organs. It includes the cambium and the cork cambium, which thicken the roots and stems or produce new protective tissues. It is mainly found in gymnosperms and woody dicotyledons.

Cell characteristics: cells are almost long fusiform in shape and highly vacuolated for protoplasts. They have not dense protoplasm and their activities are periodic.

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③ Intercalary meristem

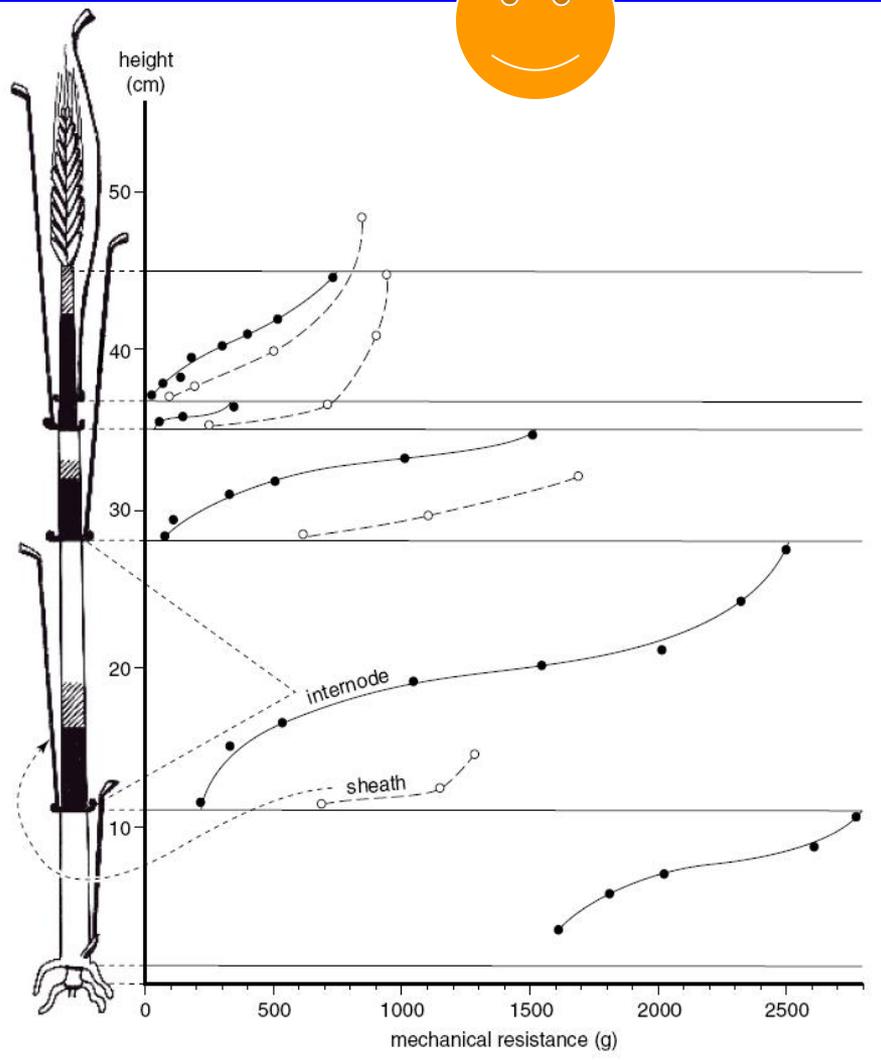
It is located between more or less differentiated tissues, and is the one that the apical meristem is remained in local regions of certain organs. It is mainly found in stems and leaves of monocotyledons, which extends stems, leaves, etc.



Cell characteristics: cells are continuously active for a short period of time. After division for a while, they are completely converted into mature tissues.



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Distribution of growth regions in a culm of rye plant. The plant has five internodes and a spike. The leaf sheaths are represented as extending upward from each node and terminating where leaf blades (shown only in part) diverge from them. The youngest tissue in internodes (intercalary meristems) is represented in black, somewhat older tissues is hatched, and the most mature is left white. Curves to the right indicate mechanical resistance of internodal tissues (solid lines) and of sheaths (broken lines) at the various levels of shoot. Resistance was equated with the pressure, expressed in grams, necessary to make a transverse cut through the internode or sheath. (After Prat, 1935. ?Masson, Paris.)

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- (2) On the basis of their origins, meristematic tissues are of following types:
- ① Promeristem: directly retained in the embryo, with long-lasting and strong ability to divide, located at foremost tips of roots or stems.
 - ② Primary meristem: it is composed of cells that are derived from promeristem, and differentiated in morphology initially, but still has strong ability to divide (in which cell division and cell differentiation happen).
 - ③ Secondary meristem: these are cells from mature tissues, develop from mature, primary tissues, and transformed into a meristem.

(II) Permanent tissues

1. Concept: it is also known as mature tissue, most cells of which are derived from meristematic tissues have lost the ability to divide gradually and it has formed other various of tissues via further growth and division.
2. Types: on the basis of functions

(1) Protective tissue

It is present in the outermost layer of the plant body. Such protection will reduce water transpiration, control gas exchange, prevent pests and diseases and mechanical damage.

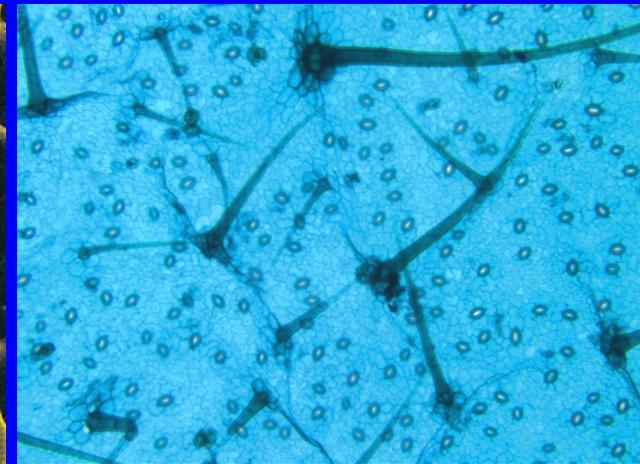
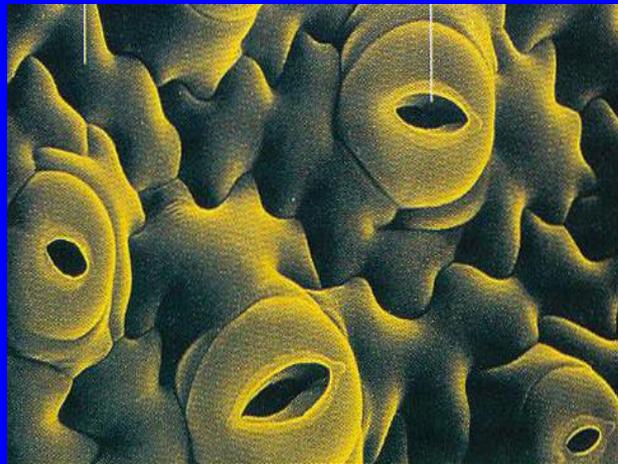
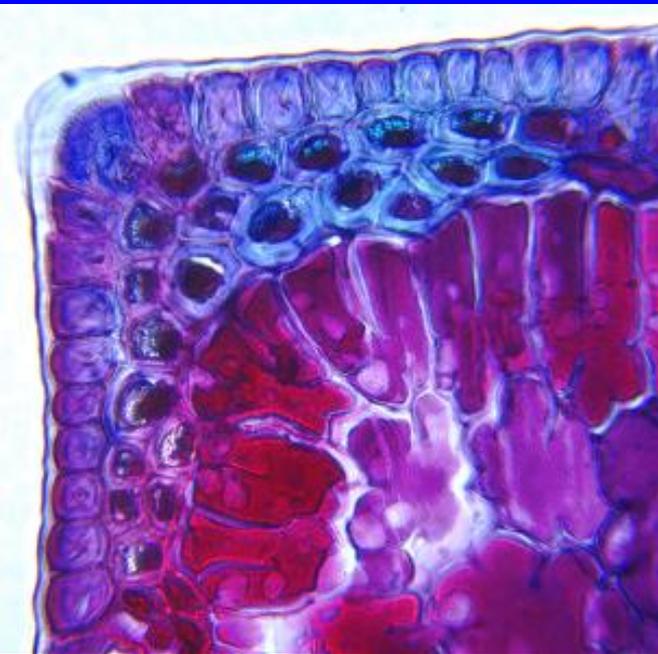
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① Epidermis

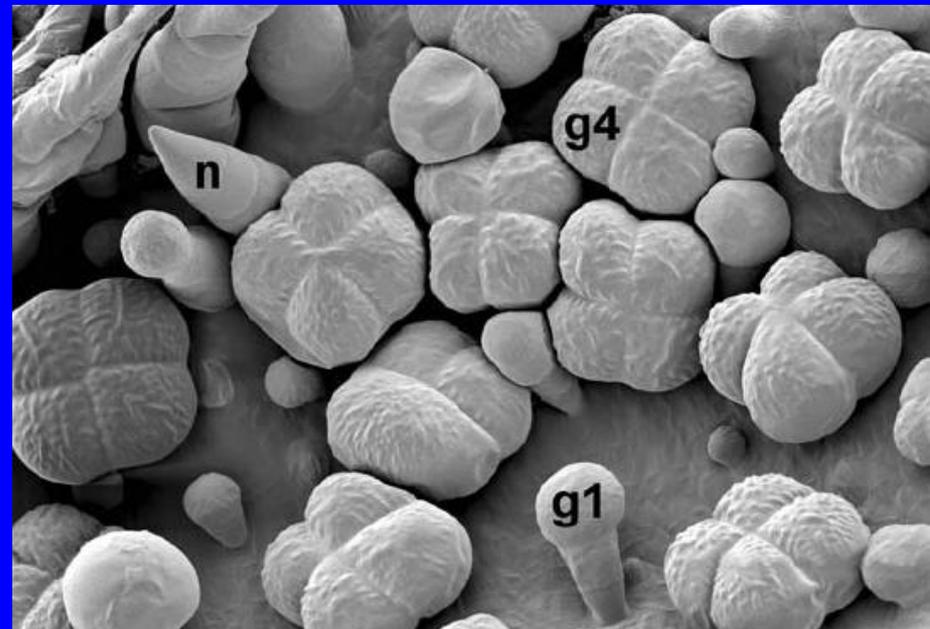
- ♣ The epidermis is a single layer of cells that covers young organs of plants, and it contains a variety of different features and functions of cells.
- ♣ Cell characteristics: Cells in various shapes of plate-like, cell-free space, are living cells, and chloroplasts are not found in them. They often contain leucoplasts, chromoplasts, starch granules and pigments, tannins, crystals and other metabolites. The outer tangential walls are thicker and keratinized, and some of them have epicuticular wax layers.



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Epidermis and its accessory.



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♣ Cutin membrane

{ Cuticle (outer layer): cutin and waxes

{ Cuticular layer (inner layer): cutin and cellulose

♣ Stoma: it is surrounded by two special guard cells in kidney-shape or dumbbell-shape, and chloroplasts are found in them. The nonuniform thickening of the guard cell wall causes the stomata to open or close and helps to regulate air flow across the stomatal pore and transpiration.

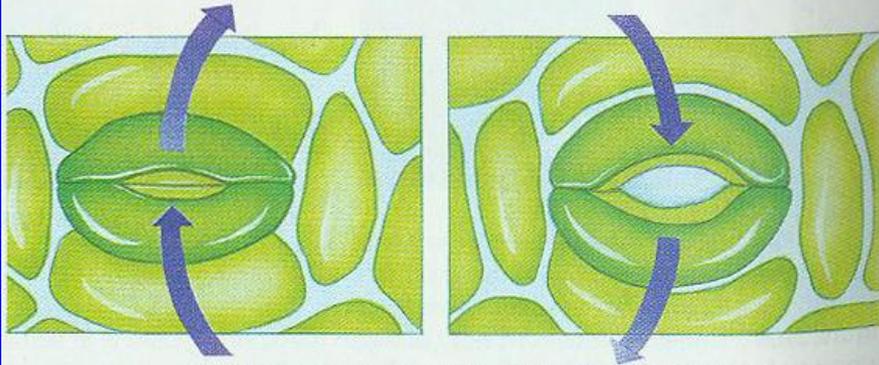
♣ Epidermal appendages: epidermal hairs from the seed coats, epidermal hairs with secretion function.

♣ Root hairs: The thin outer walls of the root epidermal cells extend outward to form elongated tubular projections.

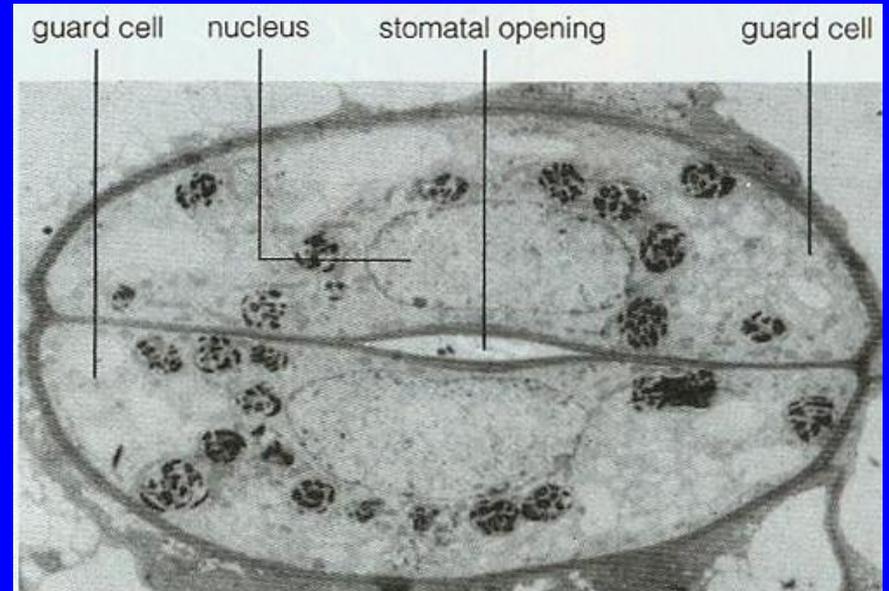
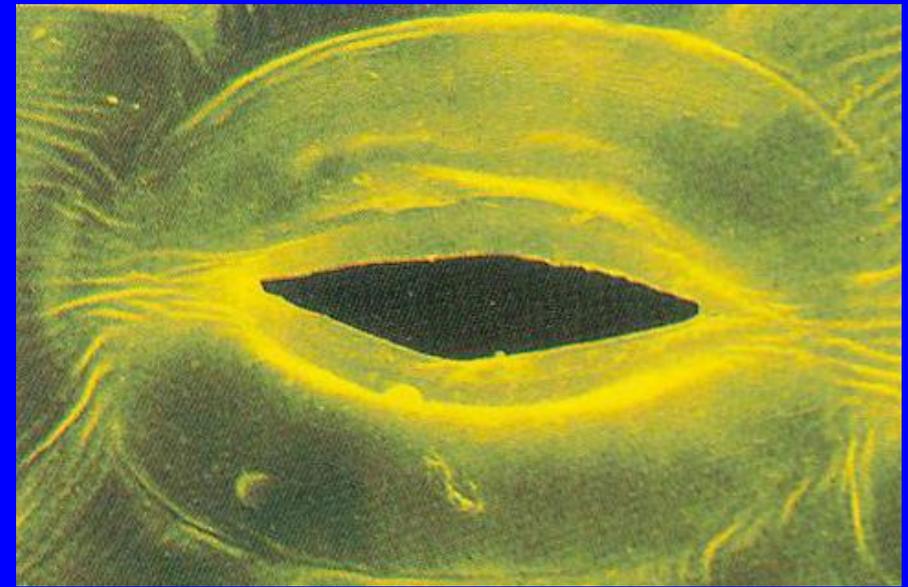


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Stomatal closure. Water leaves the swollen guard cells, which collapse against each other and so close the gap (stoma) between them.



Stomatal opening. Water enters collapsed guard cells, which swell (under turgor pressure) and move apart, thus forming the stoma.



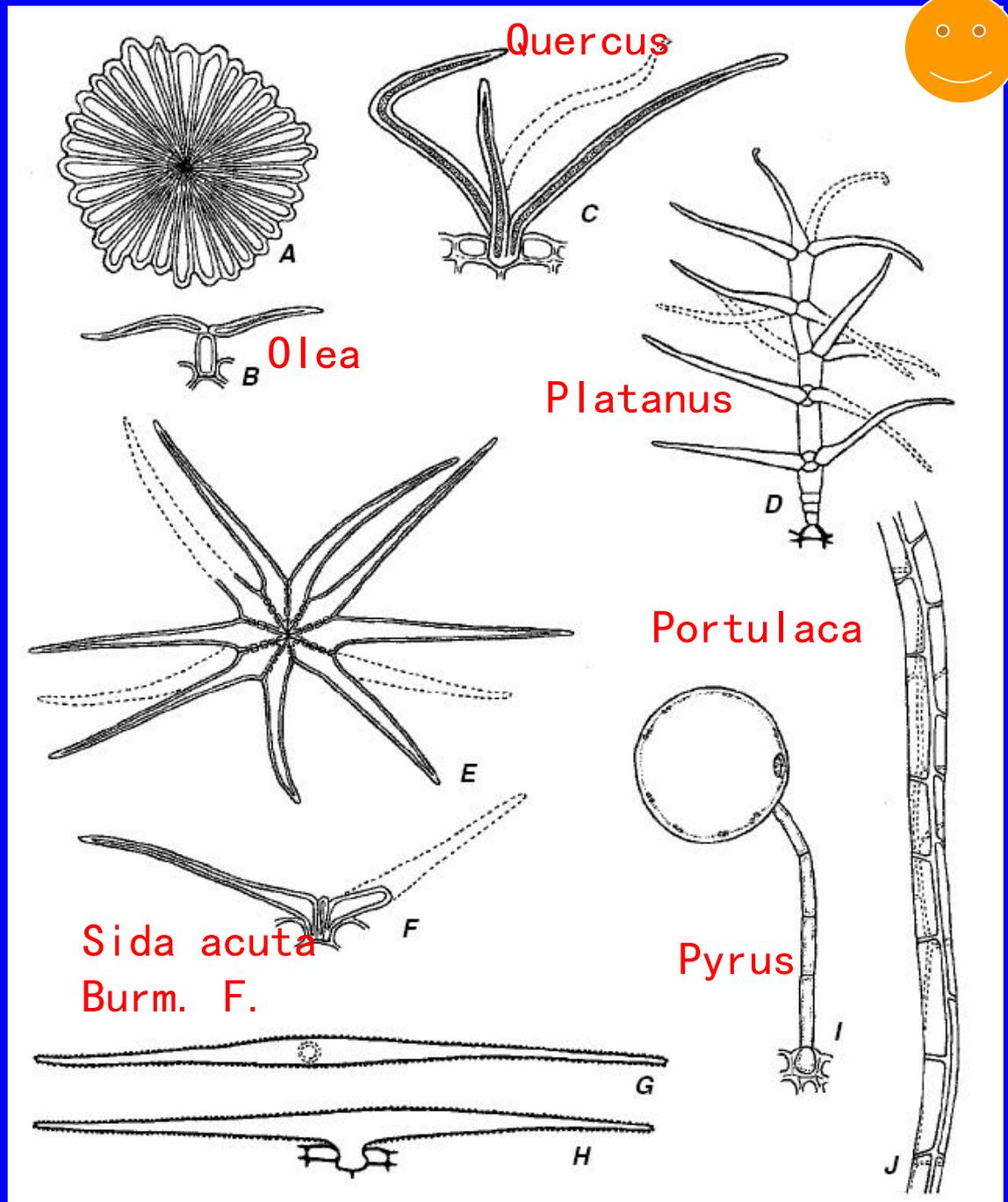
SEM and TEM of an open stoma, and the stomatal action.



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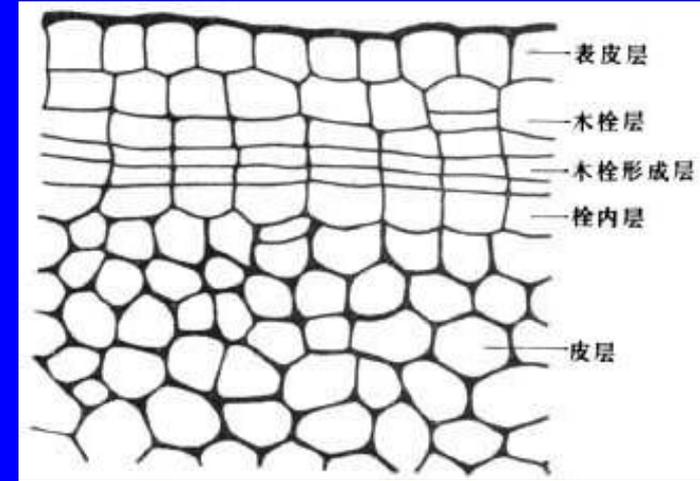
Trichomes. A, B, peltate scale of *Olea* in surface (A) and side (B) views. C, tufted, stellate hair of *Quercus*. D, dendritic hair of *Platanus*. E, F, stellate hair of *Sida* in surface (E) and side (F) views. G, H, two-armed, T-shaped unicellular hair of *Lobularia* in surface (G) and side (H) views. I, vesiculate hair of *Chenopodium*. J, part of multicellular shaggy hair of *Portulaca*. (A-C, I, $\times 210$; D-H, J, $\times 105$)



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② Periderm

♥ The periderm is a secondary protective tissue that replaces the epidermis and resides on the surface of roots or stems for thickening. Cork cambium cells make periclinal divisions. The outer cells differentiate into cork while the inner cells differentiate into phelloderm. Collectively, the cork, cork cambium, and phelloderm make up the periderm.



♥ Cork: rectangular in shape, compactly arranged in radial rows, thick wall and strong suberization, protoplast disintegration (dead at maturity), filled with air. Cork: impermeable to moisture, compressive, heat insulation, insulation, light in texture, flexible, resistance to organic solvents.



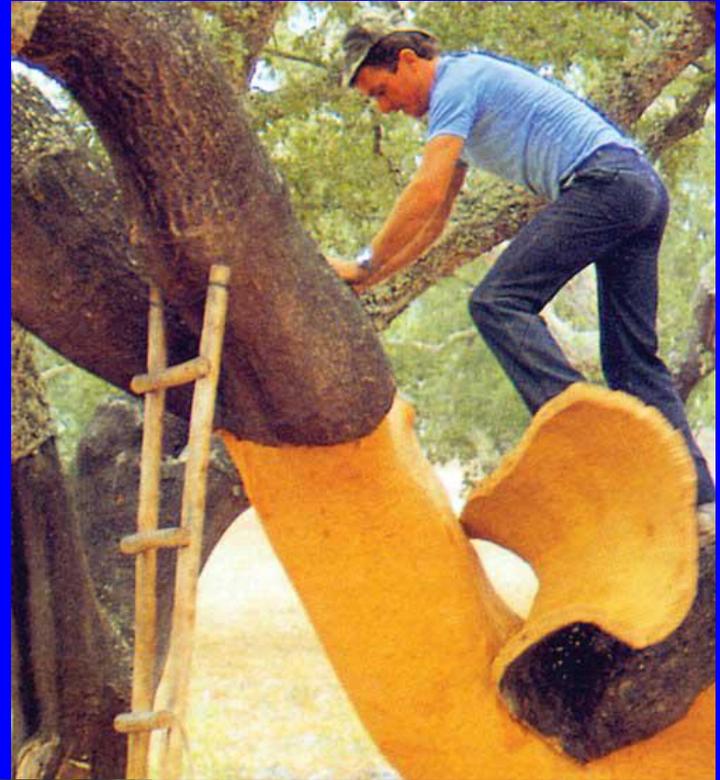
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Phellodendron amurense



Quercus suber



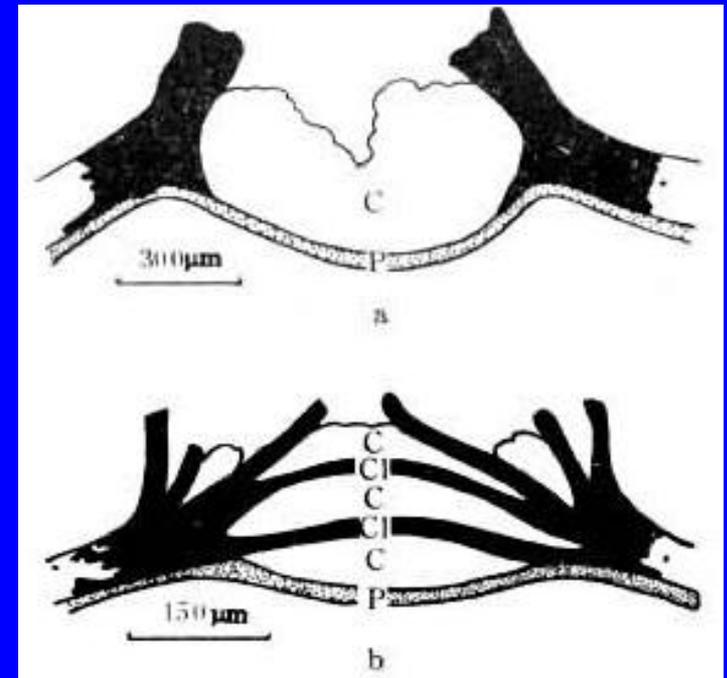
Quercus variabilis



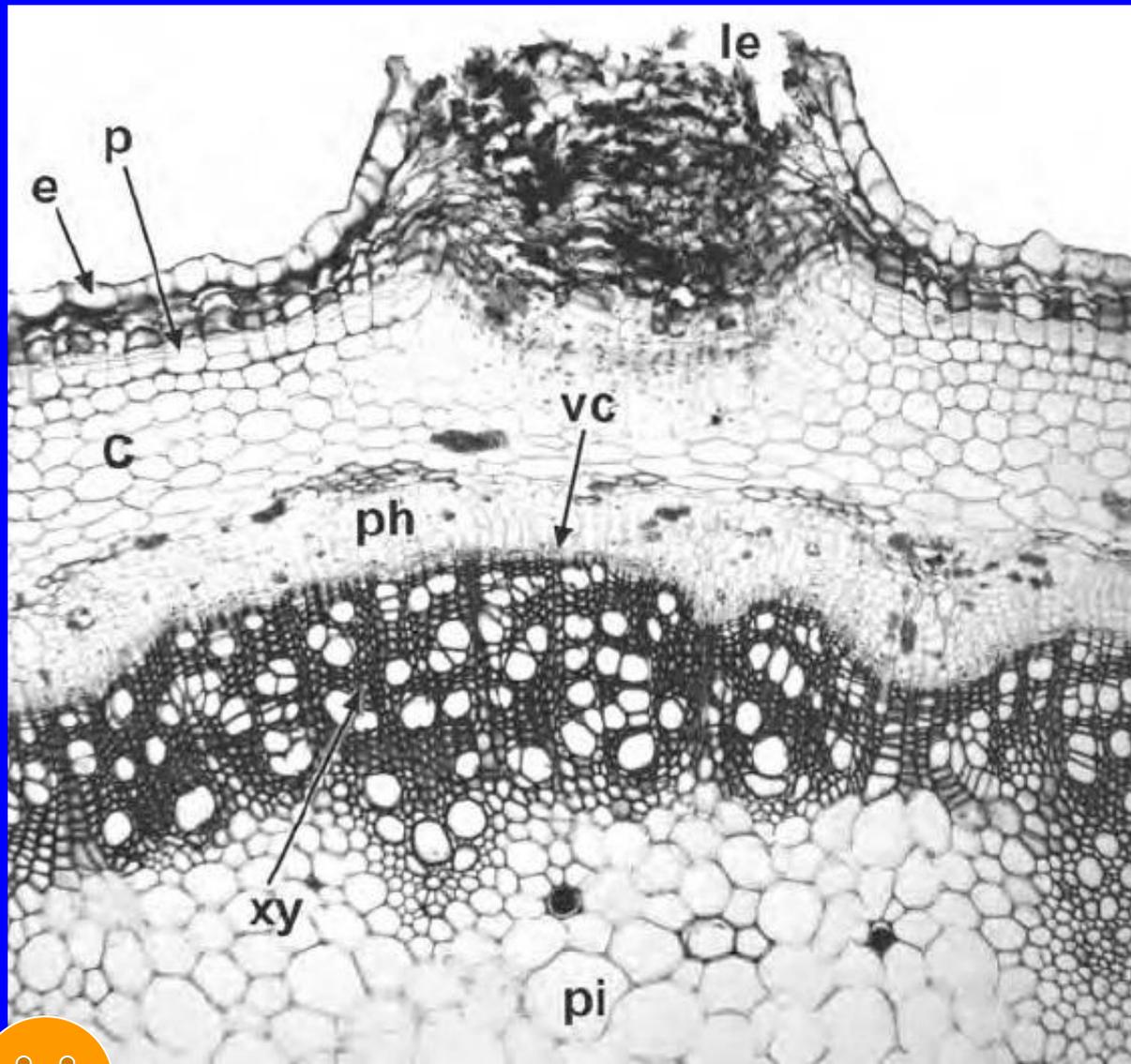
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♥ Phelloderm: living, thin-walled cells , generally only having one layer.

♥ Lenticel: it is a porous tissue that in certain limited parts of the periderm, cells of cork cambium are more active, outward develop into a tissue with well-developed cell space, and break the periderm, , thus to form small protrusions of various shapes.



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Sambucus nigra
(Caprifoliaceae).
Transverse section of stem
surface, showing periderm
forming in outer cortical
layers. c=cortex,
e=epidermis, le=lenticel,
p=periderm,
ph=secondary phloem,
pi=pith, vc=vascular
cambium, xy=secondary
xylem. Scale=100 μm.

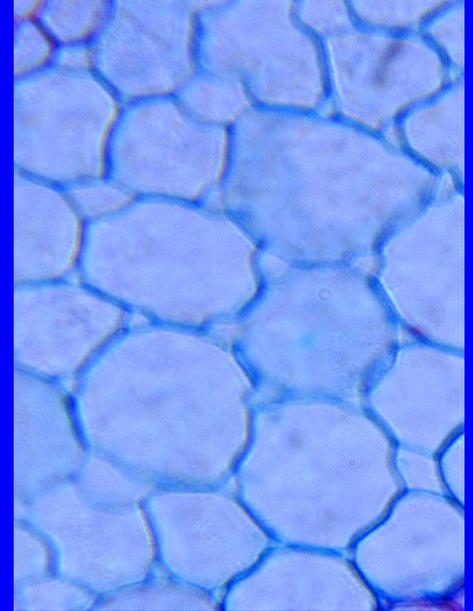


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(2) Parenchyma

① Features:

- ♣ It is a tissue for various metabolic activities, accounting for the most part of the plant. It is the basis of plant composition.
- ♣ It is composed of cells that are thin-walled, less specialized and close to the meristem in structure. Cells have living protoplasts, the diameters of which are about equal.
- ♣ Cells also undergo limited division and may form adventitious roots, adventitious buds or lateral meristems during wound healing or grafting, with strong meristematic potential.
- ♣ Cell plasticity can be further developed into higher specialized tissues.
- ♣ Cells have more developed intercellular spaces.



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② Types

Assimilation tissue: it is able to perform photosynthesis, and protoplasts develop numerous chloroplasts.

Storage tissue: store many nutrients, exist in various types of storage organs.

Water-storing tissue: it is composed of cells that store abundant water. Cells are large, and the vacuole contains lots of sticky sap, which can be found in psucculent xerophytes.

Ventilation tissue: it has lots of intercellular spaces and exists in aquatic and wet plants that allow O₂ to enter the roots and it is also associated with buoyancy and support in water.

Transfer cells: cell walls can form inwardly-directed projections or antler-shaped projections.



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Agave americana



Sedum spurium



Aloe vera

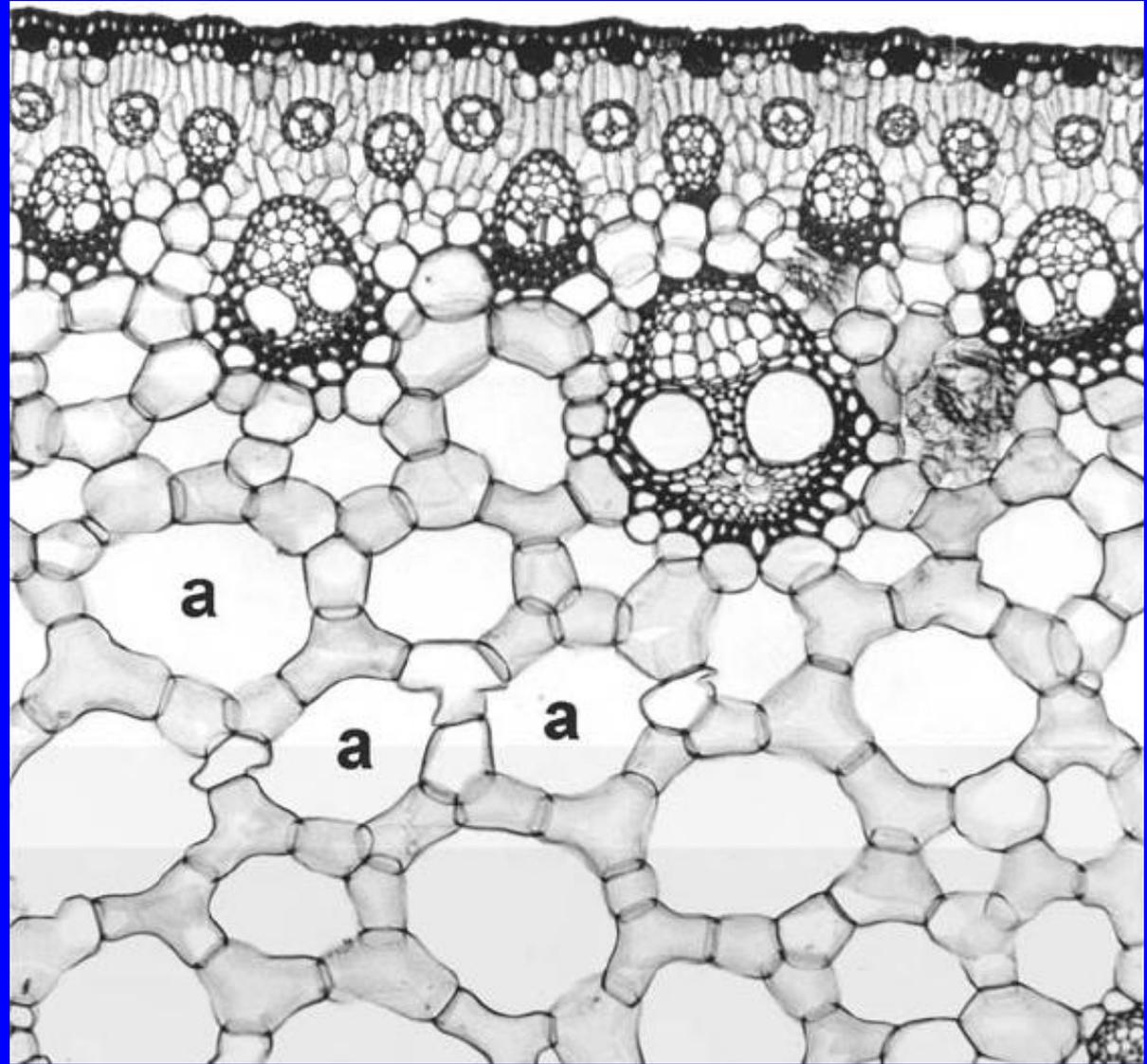


Sedum anglicum

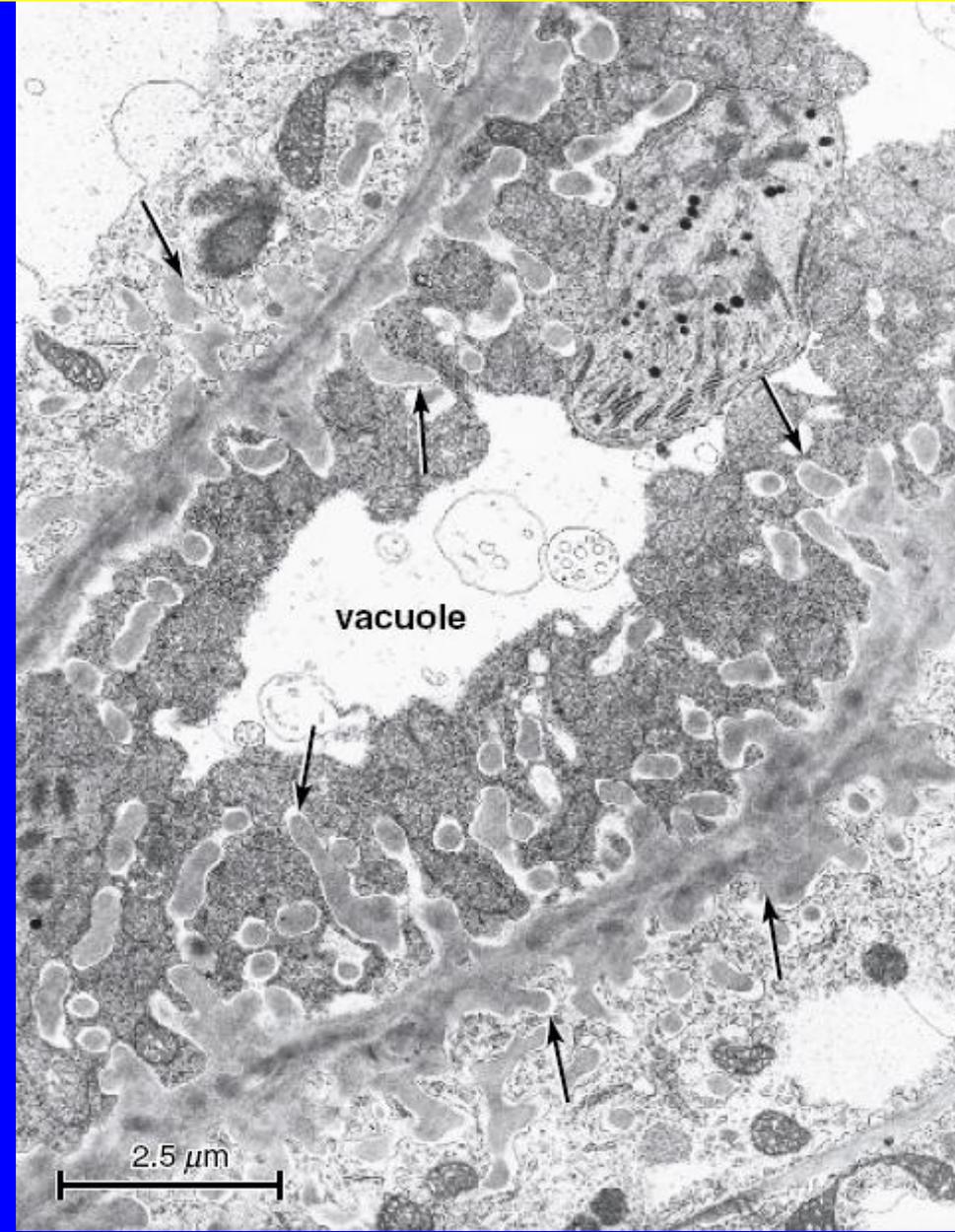
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Cyperus papyrus
(Cyperaceae),
longitudinal section of
leaf showing
aerenchyma. a=air
space. Scale=100 μm .



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Longitudinal section of a portion of the phloem from a small vein of a *Sonchus deraceus* (sow thistle) leaf. The cell, with the dense cytoplasm, in the center of this electron micrograph is a companion cell. Phloem parenchyma cells occur on both sides of the companion cell. All three cells contain wall ingrowths (arrows); all three cells are transfer cells.

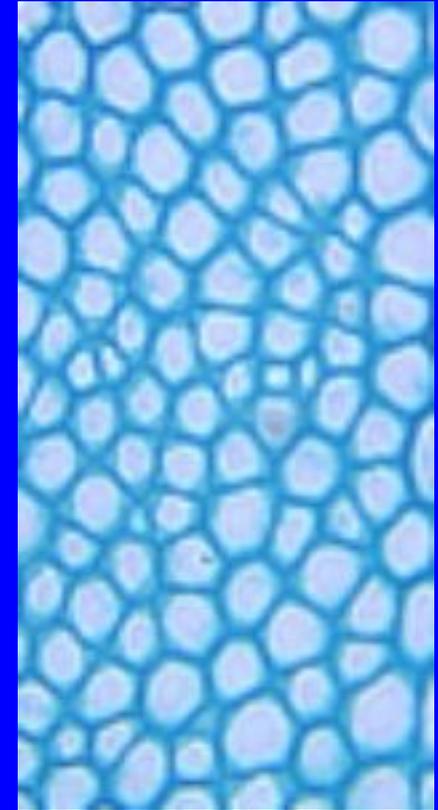
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(3) Mechanical tissue

It is a tissue that plays a major supporting role and has strong resistance to compression, tension and flexion.

① Collenchyma tissue

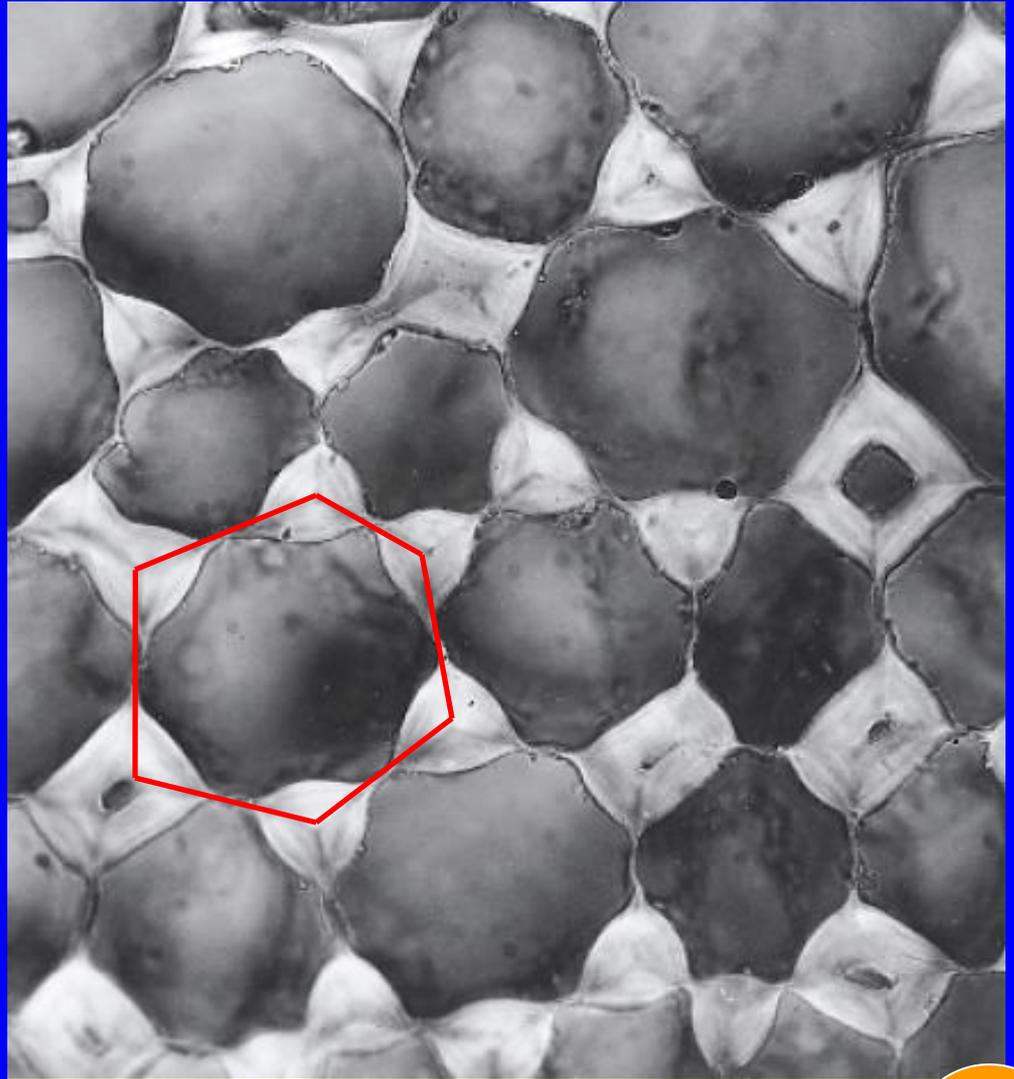
- ❖ Collenchyma cells have unevenly thickened primary walls, and typically cell walls are thicker in the corners where they connect with other cells.
- ❖ Chemical composition: cellulose, pectin, hemicellulose, lignin-free.



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Transverse section of collenchyma tissue from a petiole in rhubarb (*Rheum rhabarbarum*). In fresh tissue like this, the unevenly thickened collenchyma cell walls have a glistening appearance. (×400)

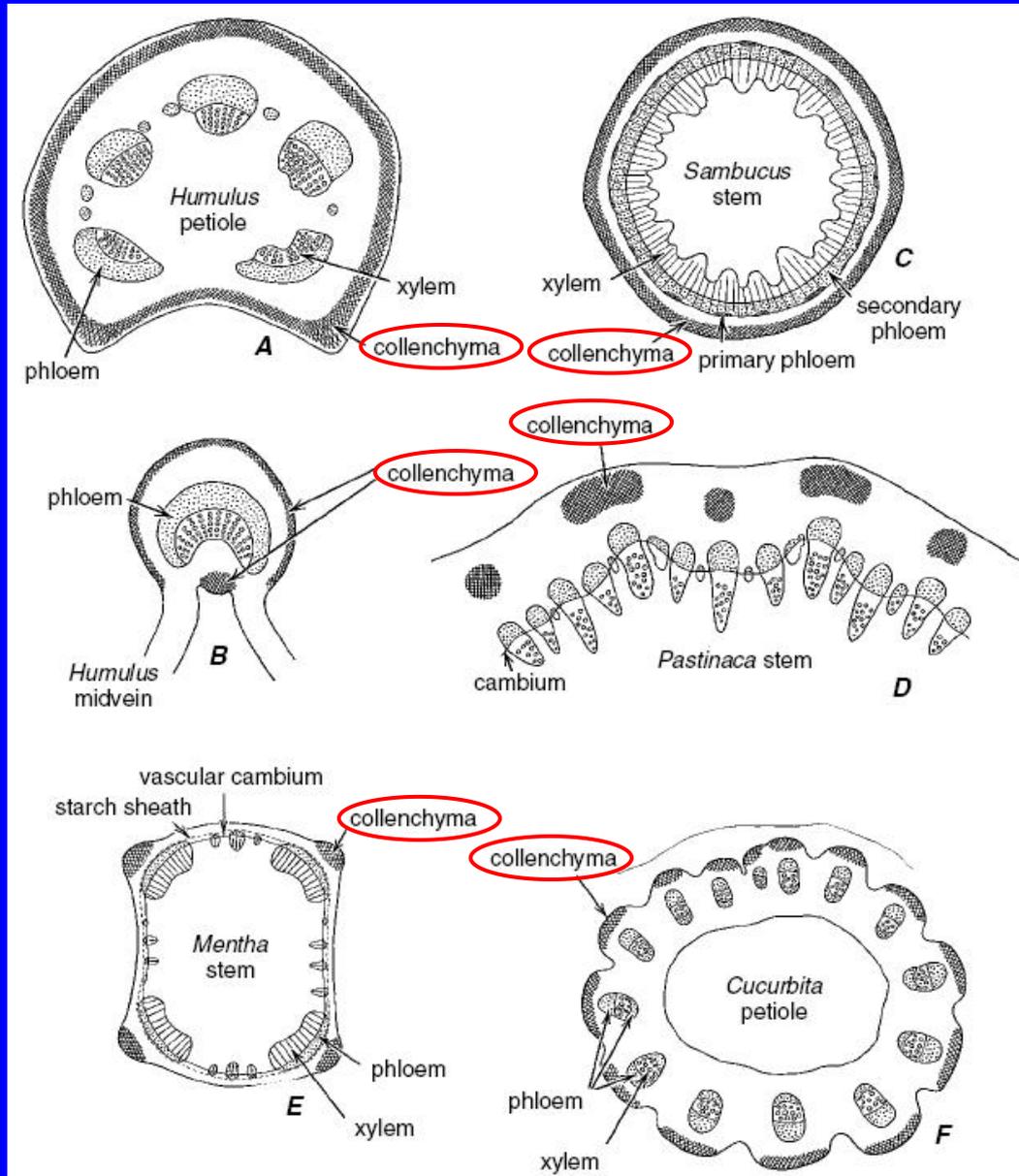


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- ❖ Nature: primary wall, living cells, chloroplasts always, with the potential for division (involved in the formation of cork cambium).
- ❖ Distribution: distributed in stems, petioles, leaves, flower stalks and other parts, with continuous cylinders or separated into bundles, exist in the periphery of the organ or epidermis, or with the epidermis separated only a few layers of parenchyma cells, especially concentrated in the edges.
- ❖ Function: as a supporting tissue, it doesn't inhibit the growth of young organs and further develops into the sclerenchyma.



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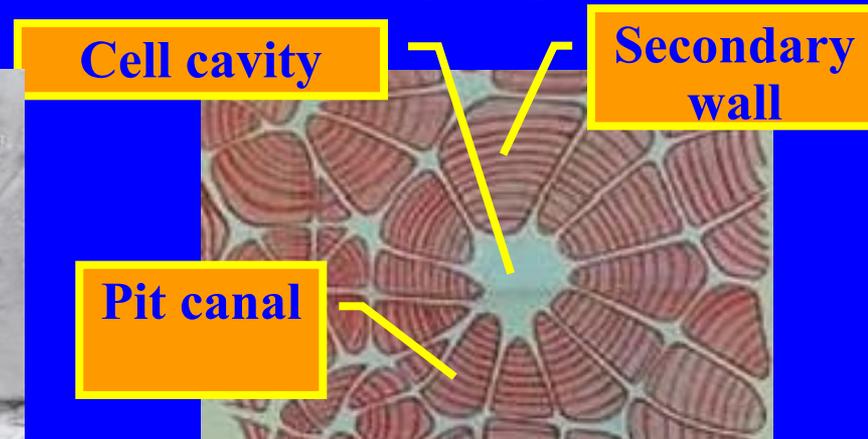
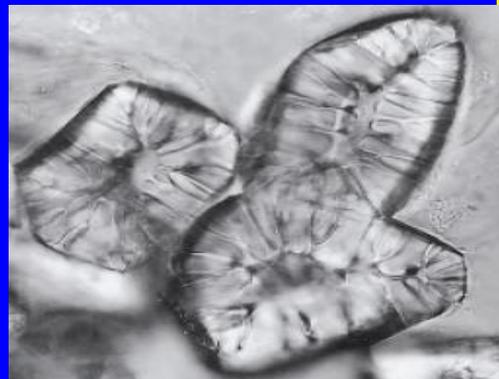
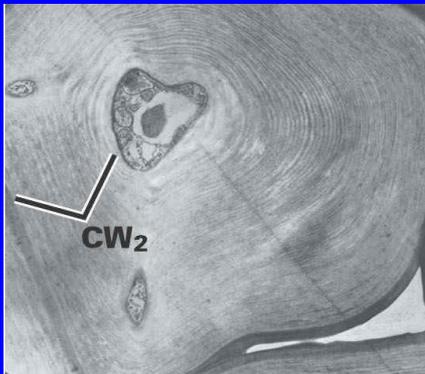


Distribution of collenchyma (crosshatched) and vascular tissues in various plant parts. Transverse sections. (A, B, $\times 19$; C-F, $\times 9.5$)



② Sclerenchyma

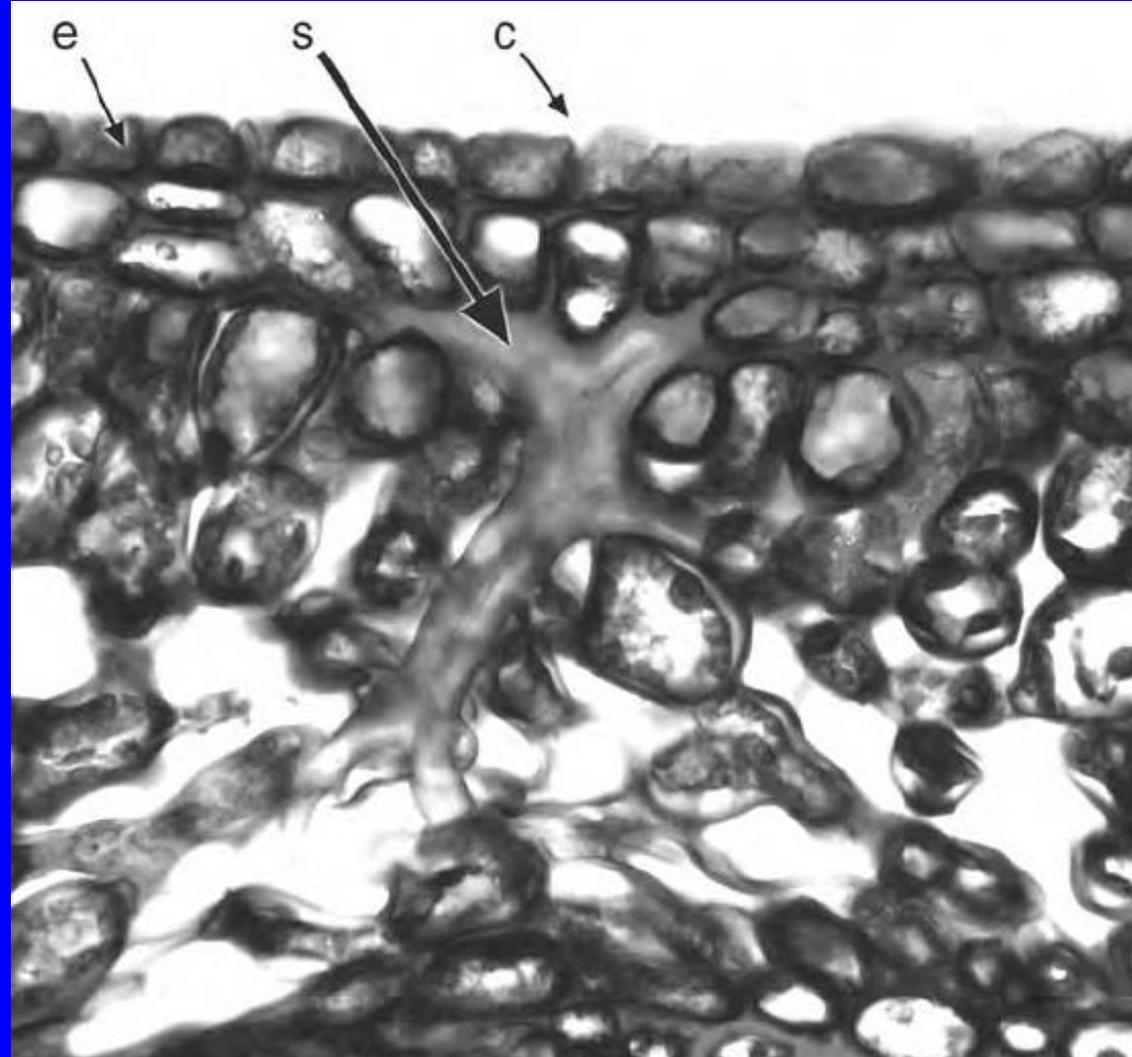
- ♣ Cells have evenly-thickened, lignified secondary walls. At mature, protoplasts are usually dead and decomposed, only leaving the dead cells with cell walls.
- ♣ **Sclereids**: they often have thick, strongly lignified secondary walls, on which, numerous round simple pits are formed, frequently with tubular, branching pit canals. They are widely distributed in plant stems, leaves, fruits and seeds, and able to enhance the hardness and support the organs. They are scattered throughout the parenchyma as single cells or small groups of cells.



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Camellia japonica
(Theaceae), transverse section of leaf midrib showing branched sclereid (s) in ground parenchyma. c=cuticle, e=epidermis, s=sclereid. Scale=100 μm .



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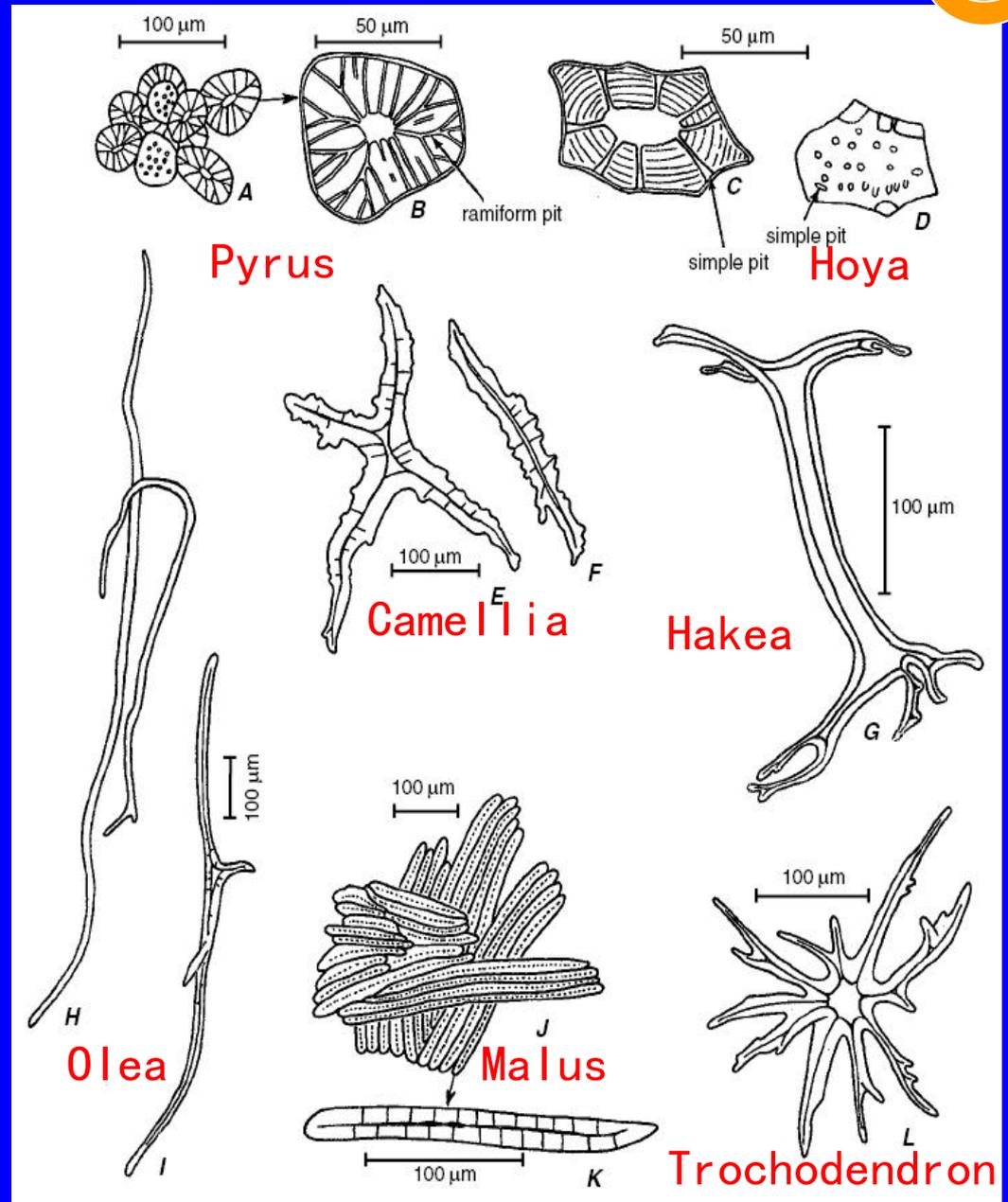
Branched sclereid from a leaf of the water lily (*Nymphaea odorata*) as seen in polarized light.

Numerous small angular crystals are embedded in the wall of this sclereid.

($\times 230$)

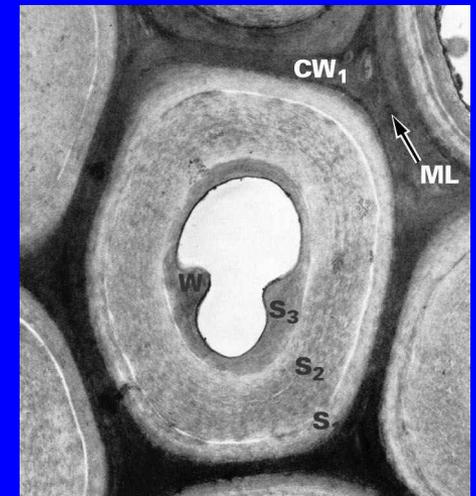
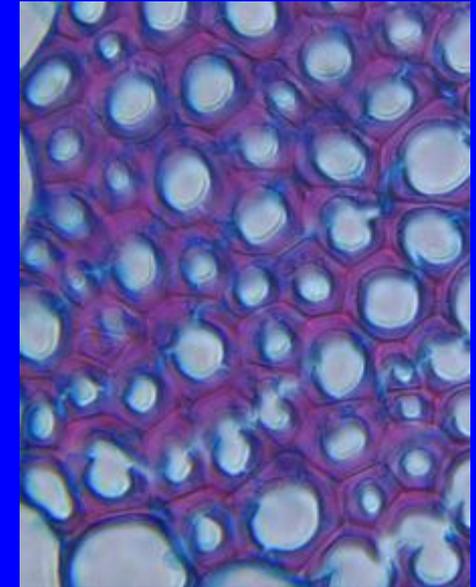


Sclereids. A, B, stone cells from fruit flesh of pear (*Pyrus*). C, D, sclereids from stem cortex of wax plant (*Hoya*), in sectional (C) and surface (D) views. E, F, sclereids from petiole of *Camellia*. G, columnar sclereid with ramified ends from palisade mesophyll of *Hakea*. H, I, filiform sclereids from leaf mesophyll of olive (*Olea*). J, K, sclereids from endocarp of fruit of apple (*Malus*). L, astrosclereid from stem cortex of *Trochodendron*. (From Esau, 1977)

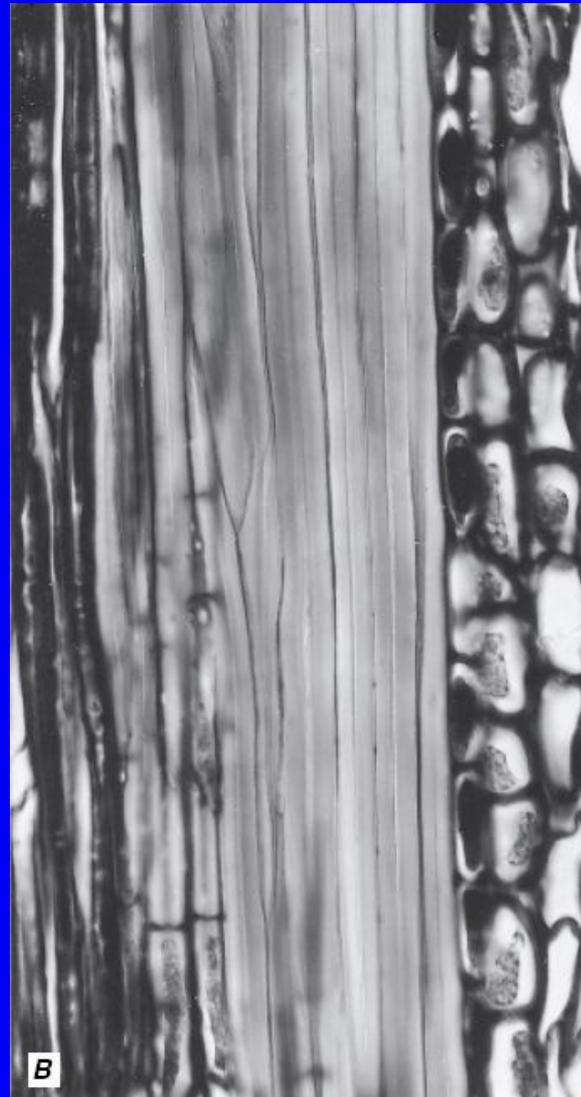
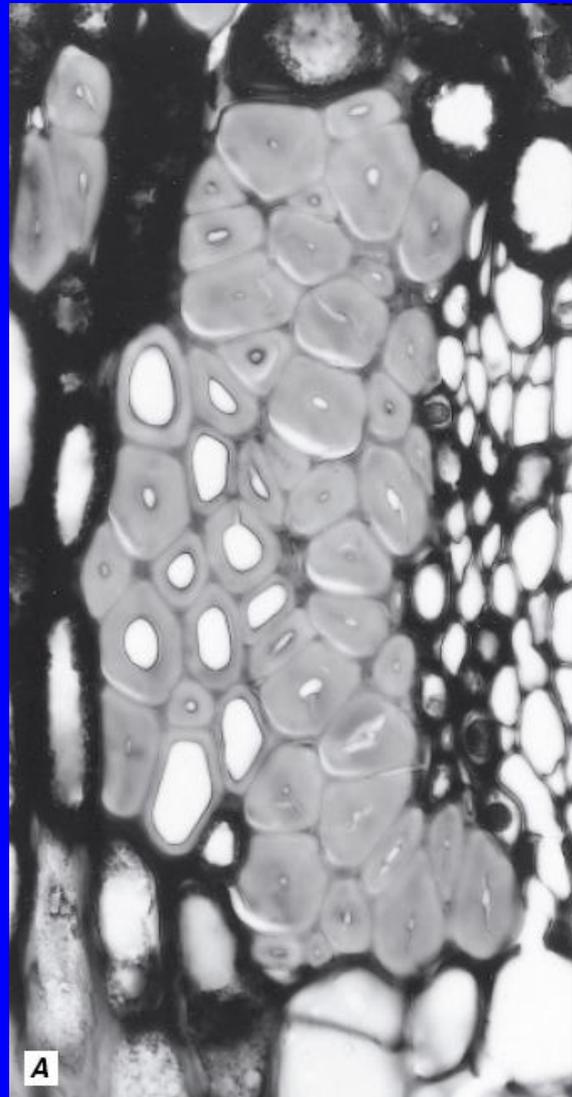


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♣ Fibers: they are slender cells, many times longer than they are wide, with obvious secondary cell wall thickening. Cells that normally never lignify and strongly lignify are found. They have fewer pits in slit-like shape. Fibers are widely distributed in various parts of mature plants, overlapping with each other, closely collected into bundles. They have high compressive strength and elasticity.



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Primary phloem fibers from the stem of basswood (*Tilia americana*), seen here in both (A) transverse and (B) longitudinal views. The secondary walls of these long, thick-walled fibers contain relatively inconspicuous pits. Only a portion of the fibers can be seen in (B). (A, $\times 620$; B, $\times 375$)

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1. In the evolution of the system, what kind of tissues are formed by cactus and other psucculent xerophytes to ensure that they can tolerate the arid environment?
2. What kind of tissues are found in the “grit ” of pear pulp? What are the characteristics of such tissues?