VACUOLES AND MERISTEMS

4 LECTURES

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Study material for M.Sc Botany Second semester

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Non-living components of plant cell

1-Vacuoles:

Vacuoles are organelles bounded by a single membrane, the **tonoplast**, or **vacuolar membrane**. They are multifunctional organelles and are widely diverse in form, size, content, and functional dynamics. A single cell may contain more than one kind of vacuole. Some vacuoles function primarily as storage organelles, others as lytic compartments, vacuoles are involved with the breakdown of macromolecules and the recycling of components within the cell. Entire organelles, such as senescent plastids and mitochondria, may be engulfed and subsequently degraded by vacuoles containing large numbers of hydrolytic and oxidizing enzymes. Many meristematic plant cells contain numerous small vacuoles. In the mature cell as much as 90% of the volume may be taken up by the vacuole, with the rest of the cytoplasm consisting of a thin peripheral layer closely pressed against the cell wall. Being a selectively permeable membrane, the tonoplast is involved with the regulation of osmotic phenomena associated with the vacuoles.

Components of vacuoles:

The principal component of the non–protein-storing vacuoles is water, with other components varying according to the type of plant, organ, and cell and their developmental and physiological state. In addition to inorganic ions such as Ca2+, Cl−, K+, Na+, NO3, such vacuoles commonly contain sugars, organic acids, and amino acids, and the aqueous solution commonly is called **cell sap**.

Ergastic or stored compounds

All compounds stored by plants are products of metabolism. These compounds may appear, disappear, and reappear at different times in the life of a cell. Most are storage products, some are involved in plant defenses, and a few have been characterized as waste products.

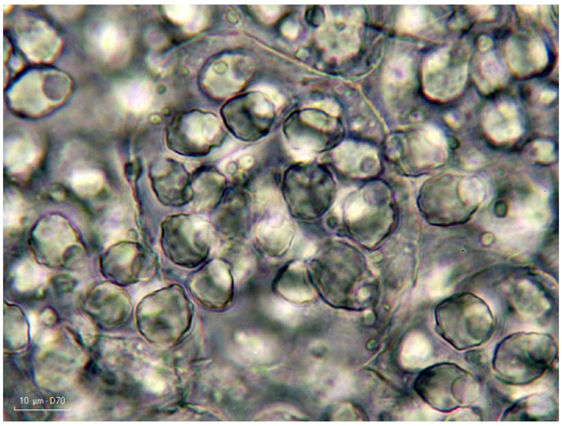
1- Starch grains: A starch is the most abundant carbohydrate in the plant world. Moreover it is the principal storage polysaccharide in plants. During photosynthesis assimilatory starch is formed in chloroplasts. Later it is broken down into sugars, transported to storage cells, a re-synthesized as storage starch in amyloplasts. As mentioned previously, an amyloplast may contain one (simple) or more (compound) starch grains. If several starch grains develop together, they may become enclosed in common outer layers, forming a complex starch grain. Starch grains, or granules, are varied in shape and size and commonly show layering around a point, the ***hilum***, which may be the center of the grain or to one side. The layering of starch grains is attributed to an alternation of these two polysaccharide molecules. The layering is accentuated when the starch grain is placed in water because of differential swelling of the two substances: amylose is soluble in water, and amylopectin is not. Storage starch occurs widely in the plant body. It is found in parenchyma cells of the cortex, pith, and vascular tissues of roots and stems; in parenchyma cells of fleshy leaves (bulb scales), rhizomes, tubers, corms, fruits, and cotyledons; and in the endosperm of seeds.

2- Storage proteins:

Storage proteins may be formed in different ways, depending in part upon whether they are composed of salt-soluble globulins or alcohol-soluble prolamins, globulins are the major storage proteins in legumes, and prolamins in most cereals. Typically globulins aggregate in protein storage vacuoles after having been transported there from the rough ER via the Golgi apparatus. Protein bodies also contain a large number of enzymes and fair amounts of phytic acid, a cation salt of myo-inositol hexaphosphoric acid, which usually is stored in the globoids. Phytic acid is an important source of phosphorous during seedling development. Some protein bodies contain calcium oxalate crystals (Apiaceae).

Aleurone grains:

It is storage proteins that found in wheat, which considerable part of the prolamins aggregate directly into **it** within the rough ER and then are transported in distinct vesicles to the vacuoles without Golgi involvement. Structurally consist of an amorphous proteinaceous matrix surrounded by a bounding membrane. Other protein bodies may contain one or more non-proteinaceous globoids or one or more globoids and one or more protein crystalloids, in addition to the proteinaceous matrix.



3- Oil bodies: are more or less spherical structures that impart a granular appearance to the cytoplasm of a plant cell when viewed with the light microscope. Oil bodies are widely distributed throughout the plant body but are most abundant in fruits and seeds. Approximately 45% of the weight of sun flower, peanut, and sesame seed is composed of oil. The oil provides energy and a source of carbon to the developing seedlin

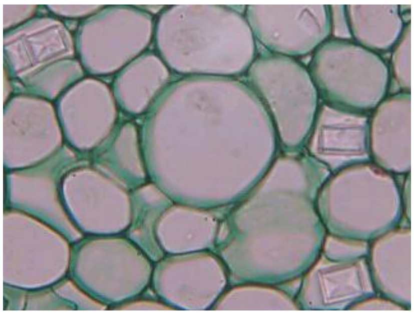
4- Crystals:

Inorganic deposits in plants consist mostly of calcium salts and anhydrides of silica. Among the calcium salts, the most common is calcium oxalate**.**

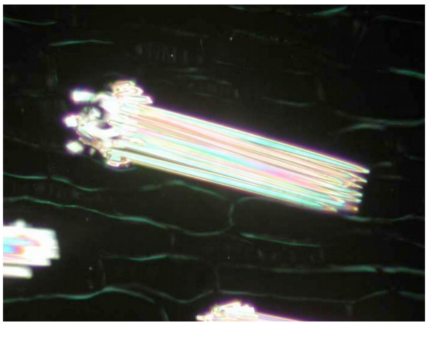
Calcium oxalate:

It occurs in the majority of plant families, notable exceptions being the Cucurbitaceae and some families of Liliales, Poales, and all Alismatidae . Calcium oxalate occurs as mono- and dihydrate salts in many crystalline forms. The monohydrate is the more stable and is more commonly found in plants than is the dihydrate. The most common forms of calcium oxalate crystals are:

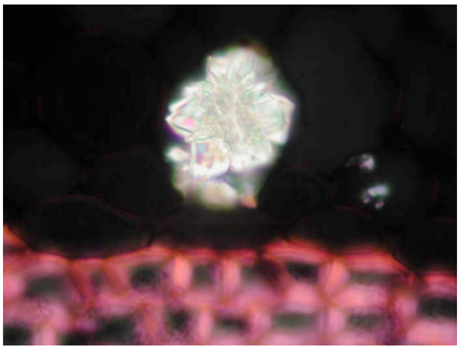
(1) **Prismatic crystals**, variously shaped prisms, usually one per cell.



(2) **Raphide,** needle-shaped crystals that occur in bundles.



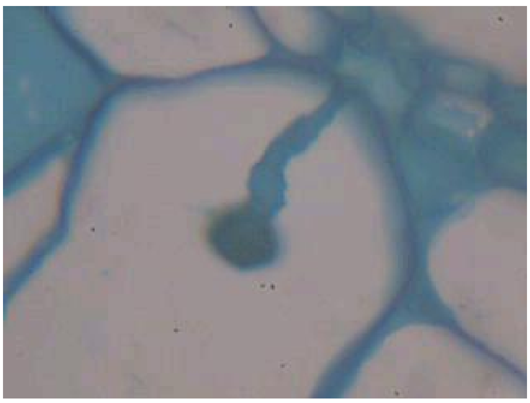
(3) **Druses**, spherical aggregates of prismatic crystals.



(4) **Styloids,** elongated crystals with pointed or ridged ends, one or two to a cell; and (5) **crystal sand,** very small crystals, usually in masses. In some tissues calcium oxalate crystals arise in cells that resemble adjacent, crystal-free cells. In others, the crystals are formed in cells called **crystal idioblasts** specialized to produce crystals. Crystal idioblasts contain an abundance of ER and Golgi bodies. Most crystal cells are probably alive at maturity. The location and type of calcium oxalate crystals within a given taxon may be very consistent and, hence, useful in taxonomic classification. Calcium oxalate crystals usually develop in vacuoles.

2- **Calcium carbonate crystals:**

They are not common in seed plants. The best known calcium carbonate formations are **cystoliths**, which are formed in specialized enlarged cells called **lithocysts** of the ground parenchyma and epidermis. The cystolith develops outside the plasma membrane in association with the cell wall of the lithocyst. Callose, cellulose, silica, and pectic substances also enter into the composition of cystoliths, which are confined to a limited number (14) of plant families.



Tissues:

Plant tissues can be either meristems or permenant tissues.

Meristems or (Meristematic tissues)

The term meristem emphasizes cell division activity as a characteristic of a meristematic tissue. some of the products of cell division in the meristems do not develop into adult cells but remain meristematic. Those cells that maintain the meristem as a continuing source of new cells are referred to as the **initiating cells**, or **meristematic initials**, or simply **initials**. Their products, which after a variable number of cell divisions give rise to the **body cells**, are the **derivatives** of the initials. The concept of initials and derivatives should include the qualifi cation that the initials are not inherently different from their derivatives.

Classification of Meristems

A common classification of meristems is based on their position in the plant body**,** there are **apical meristems**, that is, meristems located at the apices of main and lateral shoots and roots, and **lateral meristems**, that is, meristems arranged parallel with the sides of the axis, usually that of stem and root. The vascular and cork cambia are lateral meristems. The third term based on the position of a meristem is **intercalary meristem**. This term refers to meristematic tissue derived from the apical meristem and continuing meristematic activity some distance from that meristem.
The best known examples of intercalary meristems are those in internodes and leaf sheaths of monocots, particularly grasses. Meristems are also classifiedaccording to the nature of cells that give origin to their initial cells. If the initials are direct descendants of embryonic cells that
never ceased to be concerned with meristematic activity, the resulting meristem is called **primary**. If, however, the initials originate from cells that had differentiated, then resumed meristematic activity, the

resulting meristem is called **secondary**.

Characteristics of Meristematic Cells:

Meristematic cells are fundamentally similar to young parenchyma cells, during cell division the cells at the shoot apices are relatively thin-walled, rather poor in storage materials, and their plastids are in proplastid stages. The endoplasmic reticulum is small in amount and mitochondria have few cristae. Golgi bodies and microtubules are present as is characteristic of cells with growing cell walls. Generally, larger meristematic cells have smaller nuclei in proportion to cell size.

Senescence (Programmed Cell Death)

The term **senescence** specifically refers to the series of changes in a living organism that lead to its death. Senescence may affect the whole organism or some of its organs, tissues, or cells. Annual plants that bloom only once in their lifetime (**monocarpy**: fruiting once only) senesce within one season. In deciduous trees the leaves commonly senesce at the end of seasonal growth. Fruits ripen and senesce in a few weeks, isolated leaves and flowers in a few days. Senescing individual cells are root cap cells, which are continuously shed from a growing root. Since senescence occurs in orderly sequences in the life of the plant and is an active degenerative process, it is considered to be genetically controlled, Senescence can be controlled by chemicals, including growth substances, and by environmental conditions.