IV. Organelles Unique to Plants

1-Plastids

Plastids are double membrane-bound organelles in plants. They contain their own DNA (in nucleoid region) and ribosomes. They are semi-autonomous and reproduce by fission similar to the division process in prokaryotes. The DNA carries several genes including the large subunit of rubisco and those for resistance to some herbicides. The chemistry of the membranes differs from the plasma membrane - plastid membranes are comprised of glycosylglycerides rather than phospholipids (the phosphate in the polar head group in glycosylglycerides is replaced with galactose or a related sugar).

There are several types of plastids including:

1. Proplastids - small, precursors to the other plastid types, found in young cells, actively growing tissues.

2. Chloroplasts - sites of photosynthesis (energy capture). They contain photosynthetic pigments including chlorophyll, carotenes and xanthophylls. The chloroplast is packed with membranes, called thylakoids. The thylakoids may be stacked into pancake- like piles called grana (granum, singular). The "liquidy" material in the chloroplast is the stroma. A chloroplast is from 5-20μm in diameter and there are usually 50- 200 per cell. The chloroplast genome has about 145 Kbase pairs; it is smaller than that of the mitochondria (200 kbases). About 1/3 of the total cell DNA is extranuclear (in the chloroplasts and mitochondria).

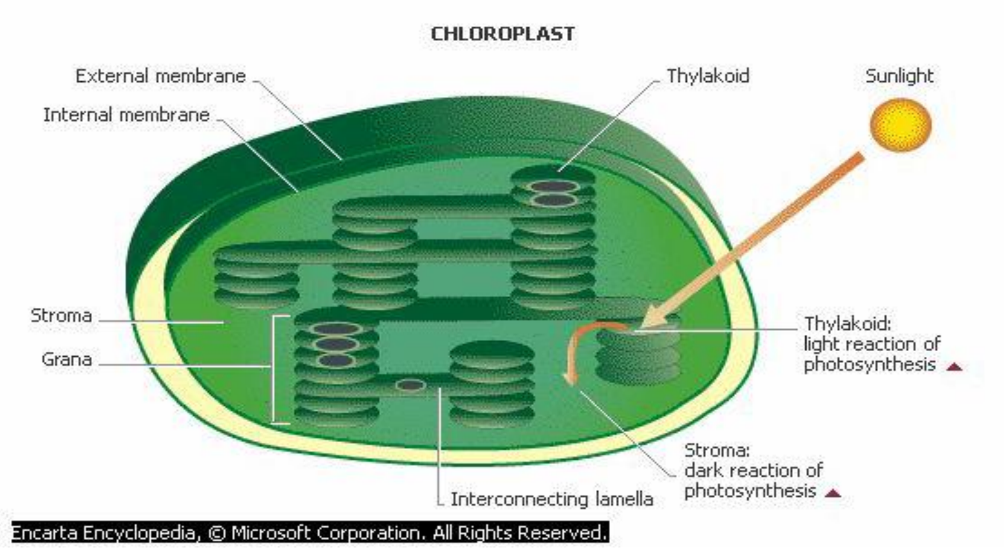
3. Chromoplasts - non-photosynthetic, colored plastids; give some fruits (tomatoes, carrots) and flowers their color.

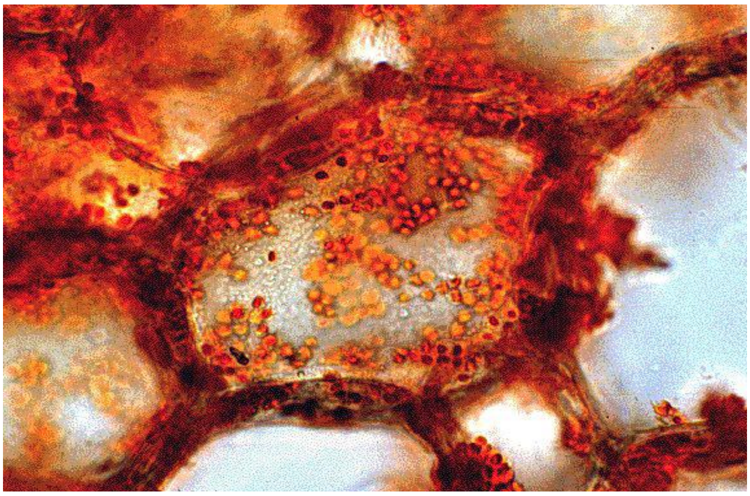
4. Amyloplasts - colorless, starch-storing plastids.

5. Leucoplast - another term for amyloplast.

6. Etioplast - plastid whose development into a chloroplast has been arrested (stopped). These contain a dark crystalline body, prolamellar body, which is essentially a cluster of thylakoids in a somewhat tubular form.

Plastids can dedifferentiate and convert from one form into another. For example, think about the ripening processing in tomato.





Chromoplast

2-Vacuoles

This is the large, central cavity containing fluid, called cell sap, found in plant cells. The vacuole is surrounded by a membrane (tonoplast). This water balloon is a separate entity that can be physically removed from the cell. The vacuole is penetrated by strands of cytoplasm - transvacuolar strands. Every plant cell has a large, welldeveloped vacuole that makes up to 90% or more of the cell volume. Meristematic and embryonic cells are exceptions. Young tissues have many small vacuoles. As the cell grows the vacuoles expand and eventually coalesce. These small vacuoles appear to be derived from the Golgi.

The central vacuole contains water, ions, organic acids, sugars, enzymes, and a variety of secondary metabolites. Among the hydrolytic enzymes are proteases (digest protein), ribonucleases (digest RNA) and glycosidases (break links between monosaccharides). These enzymes are typically not used for recycling cellular components but rather leak out on cell senescence. There are smaller lytic vacuoles, which contain digestive enzymes that are used for this purpose. Another type of vacuole, protein bodies, is vacuoles that store proteins.

Important roles of the vacuoles are:

1- Energetically efficient means to increase surface to volume ratio in the growth form. Since 90% of the cell volume is vacuole, therefore 90% of the cell is water, which is relatively cheap in metabolic terms.

2. Water storage: Probably a minor role; mostly in succulents.

3. Waste disposal: It contains many secondary metabolites including a variety of hydrolytic enzymes. In this regard, the vacuole is analogous to the lysosome. Let's consider differences between plants and animals in terms of wastes. Plants have little waste. Their nutrients are in dilute form, they use them efficiently and hence, there is little left over. The minimal wastes plants produce can be stored in the cells in the vacuoles (or disposed of in other ways - released as a gas into the air, leached out of roots or leaves).

4. pH regulation: The vacuole is a pool to dump excess protons. There is an active proton pump in the tonoplast. The cell sap has a pH of 2- 5.7, whereas the cytosol is 7.0.

5. Storage of essential ions: Ions are pumped into the vacuole for water balance. Potassium and calcium, in particular, are stored in the vacuole.

6. Cell enlargement: Cell growth requires some force to allow for the cell to increase in size. Water pressure provides the force and it moves into the vacuole. For example, root hair enlargement is due entirely too vacuolar enlargement.

7. Facilitates diffusion.

8. Structural support: The vacuole helps to maintain turgor pressure in plant cells.

Central vacuoles and turgor pressure

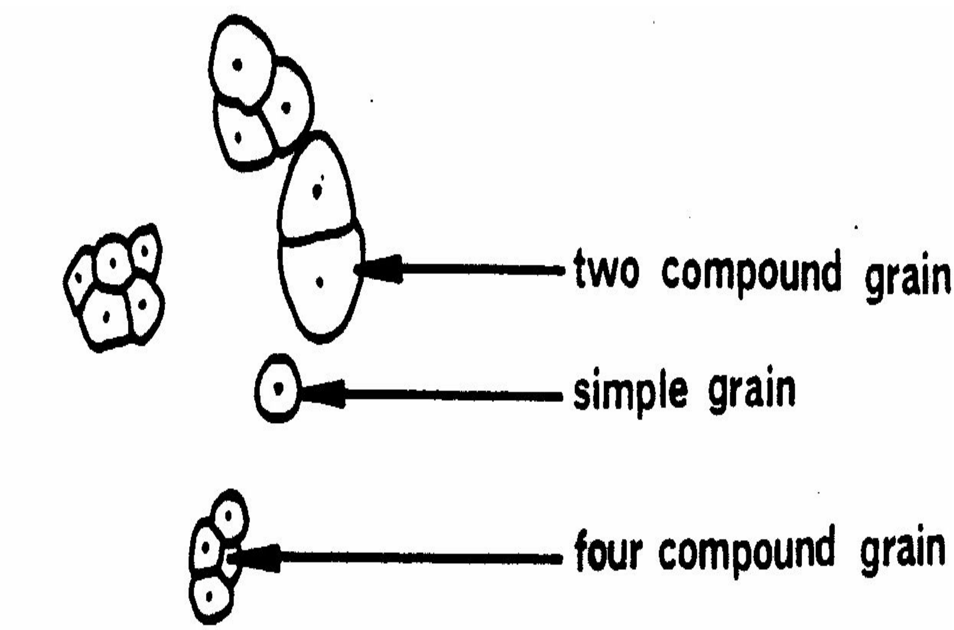
Tannin vacuole

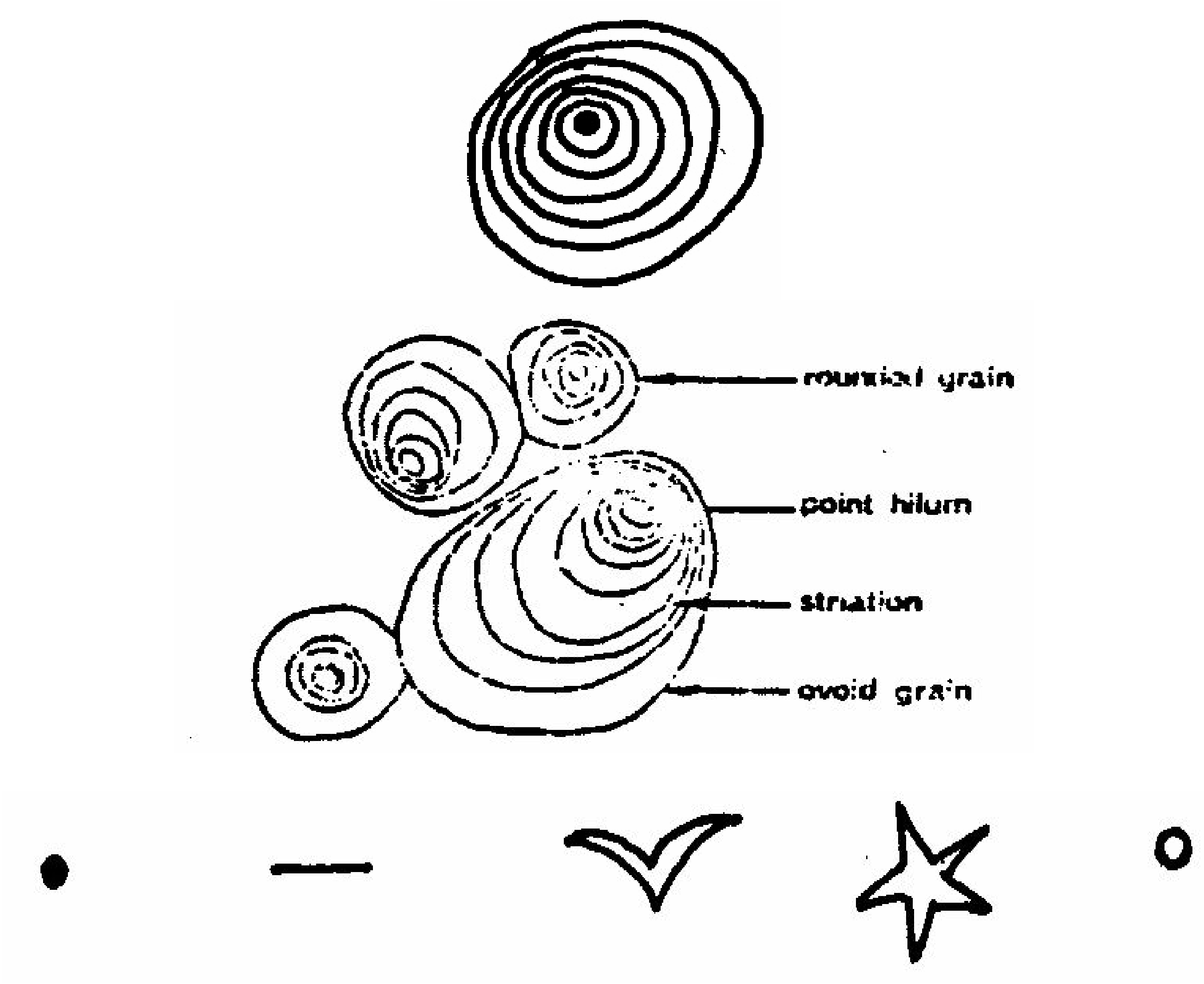
Ergastic cell contents

Carbohydrates, proteins, fixed oil and fats, alkaloids, glycosides, gums mucilage, volatile oil and resins, tannins, Calcium oxalate, these by-products of the plant cell metabolism, being nonliving they are referred to as **ergastic**.

1- Starch grains

Starch is the typical form of carbohydrate used for energy storage in plants and formed in special cells called chloroplasts. It is a polymer of glucose unites occurs in two forms of different size: Amylose (un-branched glucose units) and Amylopectin (branched chain) around a point 'hilum'. Found in parenchyma of pith, cortex, vascular tissues, fruits, cotyledons & seed endosperms.



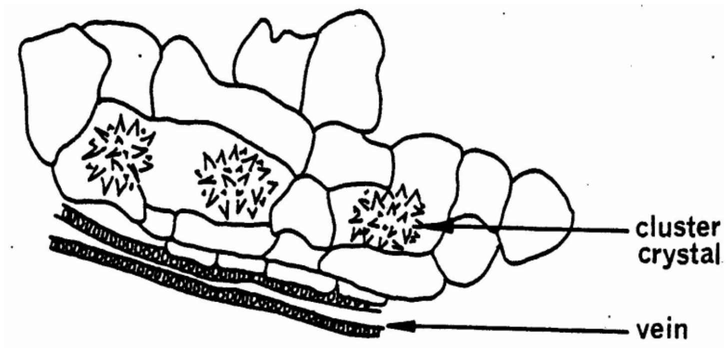


Hilum shapes

2- Crystal

a- Calcium oxalate

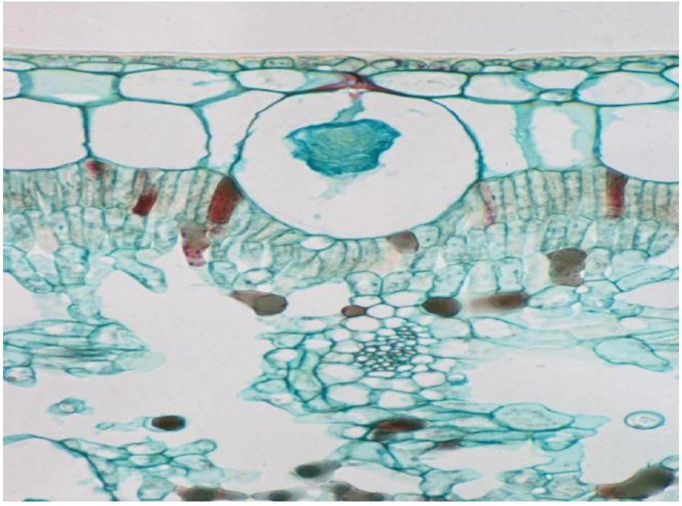
Very common content in the plant kingdom. It is formed in the cell as a result of the reaction of calcium salts absorbed from the soil and oxalic acid produced in the plant as a result of the metabolic process. Since the formed calcium oxalate is insoluble in water and in the mild acid cell-sap, it is deposited in crystalline form. Different forms of calcium oxalate; i-Prisms crystals ii-Druses crystals iii-Raphides or needle- shape iv-Sandy crystals.



Druses crystal of Calcium oxalate in *Datura* leaf

b- Calcium Carbonate

As Cystolith in Ficus leaf has cellulose stalk and body of $CaCO_3$ and lithocyte.



Cystolith in *Ficus* leaf

2- Aleurone grain:

Consists of a mass of protein surrounded by a thin membrane, embedded in the ground protein are a rounded bodies (globoids) and angular bodies (crystalloid).