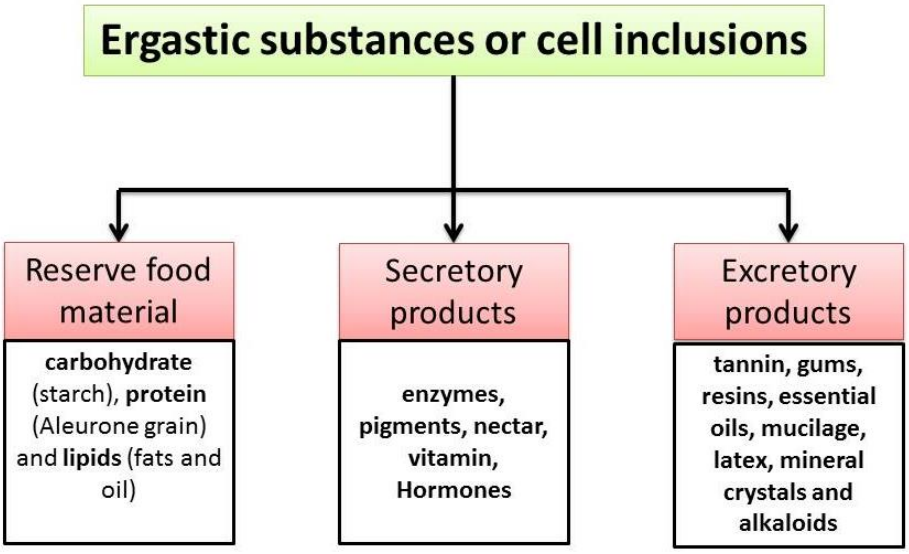
Ergastic substances or cell inclusions

Ergastic substances or cell inclusions are the products of cell metabolism, appearing and disappearing at various stages of cell's life-cycle. In majority of cases they are waste products of simple chemical nature compared to protoplasmic components which are more complex.

These ergastic substances may be present in the cell walls or vacuoles or in the organelles of protoplasm. They may be present in soluble or insoluble state and may be organic or inorganic in nature.

The cell inclusions belong to three main categories:

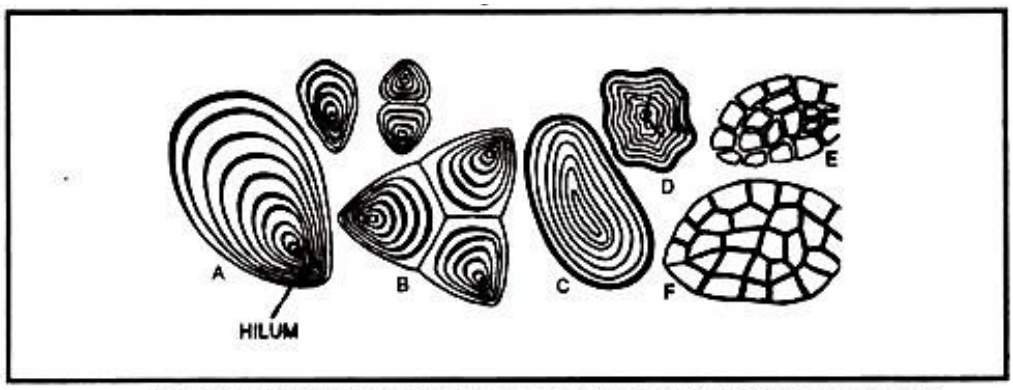


1. Reserve foods are of four main types – (i) Starch (ii) Glycogen (Protein) (iii) Fat droplets (iv) Aleurone grains

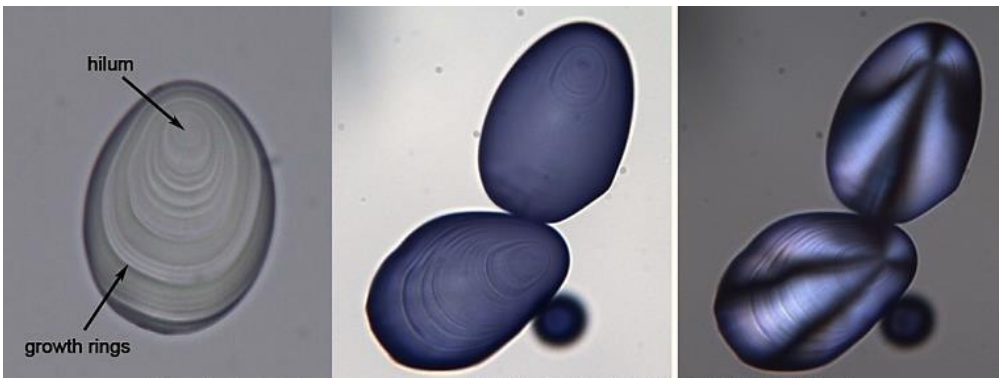
(i) **Starch grains** - The starch grains are found in chloroplasts and amyloplasts of plant cells. Most of the living cells of stem and root contain starch grains. It is a long chain polysaccharide formed of glucose units. Two types of glucose polymers are present –Alpha amylose i.e., unbranched water soluble and Beta amylose (amylopectin) i.e., branched and water insoluble.

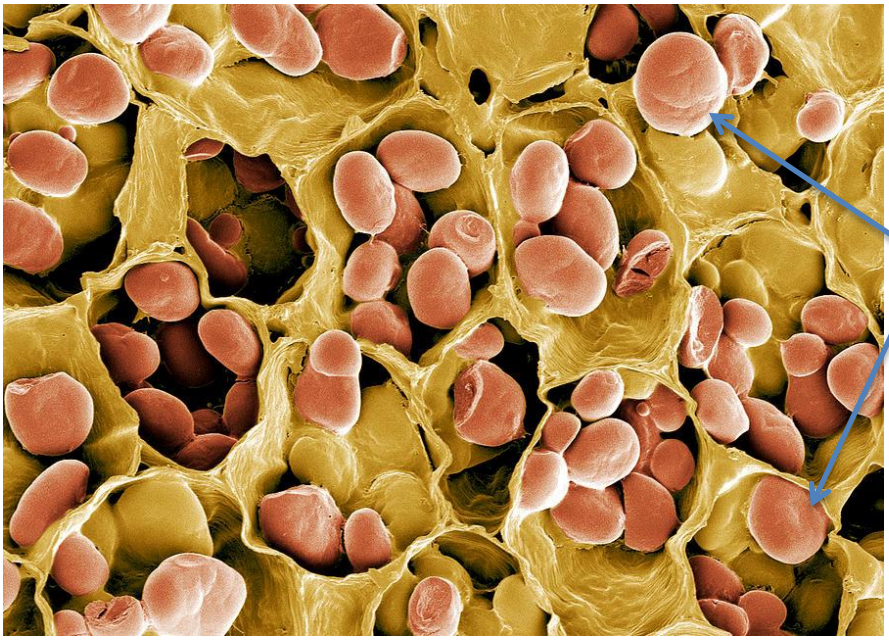
Starch occurs in the form of variously shaped grains. Each starch grain has a central portion called the **hilum**. Starchy materials are arranged around the hilum as various striations. Sometimes they are deposited in the form of concentric rings and hence called **concentric starch** grains. Eg., Rice, Pea, etc. In Potato they are arranged towards one side in the form of eccentric rings and hence called **eccentric starch grains**. The starch grain may have only one hilum (**Simple starch grain**) or may have more than one hilum (**Compound starch grain**). Compound starch grains are formed by fusion of more than two grains. The grains may occur singly when

they are called simple. They are called compound starch grains when two or more of them occur in amyloplasts. Starch grain stains bluish black with iodine.



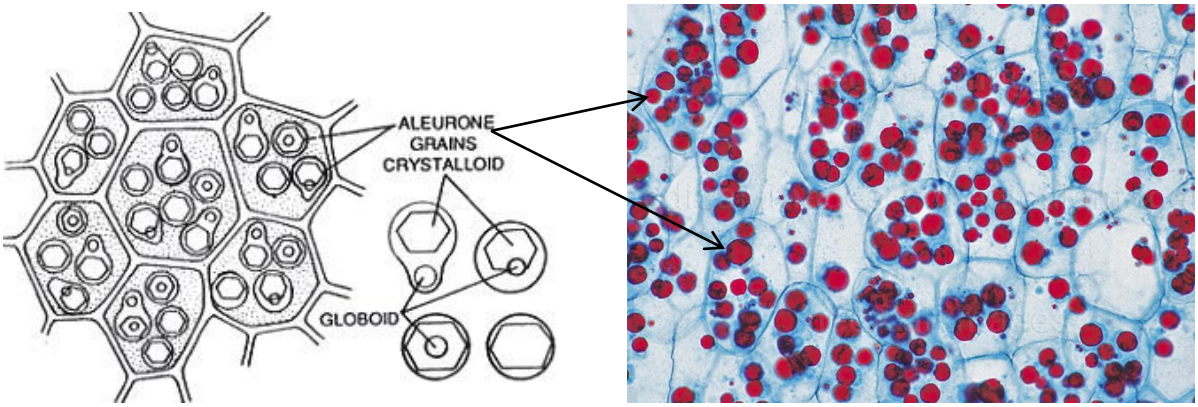
Different types of starch grains : A = Simple eccentric starch grain of potato, B = Compound eccentric type, C = concentric starch grain of wheat, D = Concentric starch grain of maize, E = Compound concentric starch grain of rice, F = Compound concentric starch grain of oat.



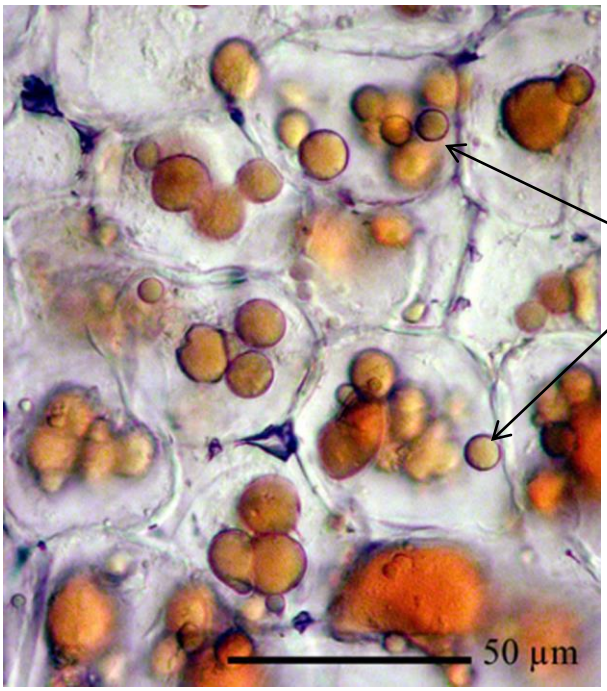


Coloured scanning electron micrograph (SEM) of starch grains (reddish orange) in *Vigna* sp.

(ii) **Proteins-** They are complex nitrogenous compounds containing carbon, hydrogen, oxygen and nitrogen sometimes also containing sulphur. Present either dissolved in the cell sap or in the form of crystal like bodies called **aleurone grains**. **Aleurone grain** is a solid ovate or rounded body usually enclosing a crystal like body called crystalloid and a rounded body called globoid.



(iii) **Lipids (Fats and Oils)**- They are glycerides of fatty acids, insoluble in water, soluble in organic solvents. They occur as minute globules in the protoplasm or in organelles called **elaioplasts** or **sphaerosomes.** Found in fruits and oily seeds like groundnut, coconut, castor seed, sunflower, olive fruits etc. Solid at ordinary temperature-Fats and liquids at ordinary temperature-Oils



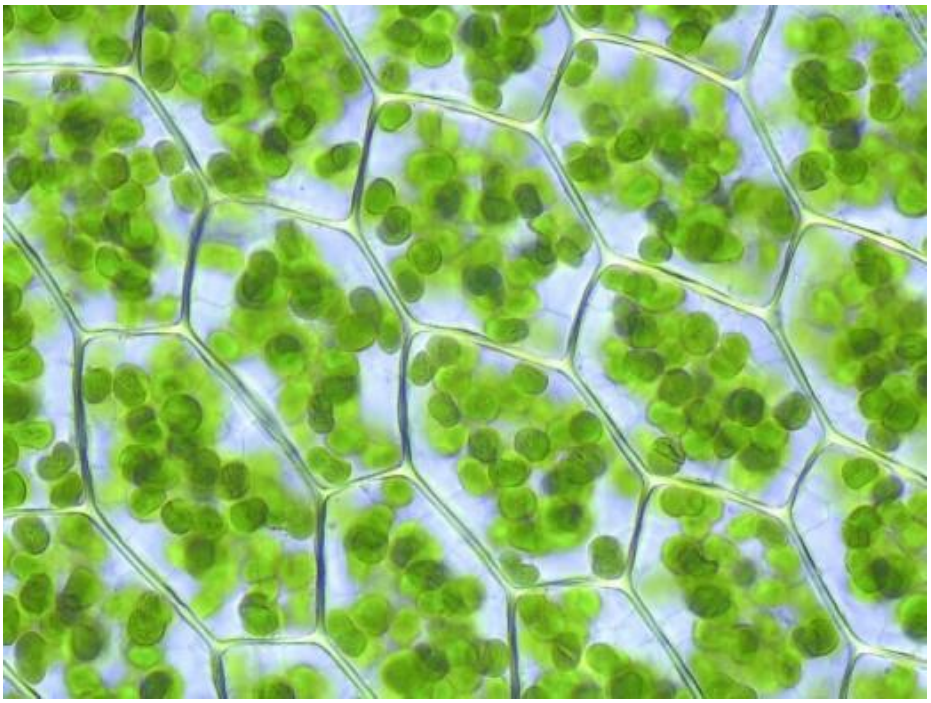
Light microscopic photographs of elaioplasts

2. Secretory Products- these are mainly the plant pigments, enzymes and nectar.

Pigments- Pigments secreted by plants are responsible for the various colours of leaves, flowers and fruits. Chlorophyll and anthocyanins are important plant pigments

Enzymes- these are organic catalysts (Catalytic proteins) in the protoplasm, colloidal in nature and capable of breaking down complex food materials into simpler ones. Also present in digestive glands of insect feeding plants.

Nectar- Nectar is sweet in taste and secreted by the floral parts of many plants nectaries.



Chlorophylls inside the plant cells

3. Excretory Products - Excretory Products are also called metabolic byproducts. Plants mostly store this metabolic byproducts in their different tissues systems either colloid or crystalloid form. Time to time excrete through leaves, stem, bark, fruits and seeds.

Classified into two – *Nitrogenous waste products* like Alkaloids

– *Non-nitrogenous waste products* like Tannin, Gums, Resins, Essential oils,

Mucilage, Latex, Mineral crystals

(i) Alkaloids are nitrogenous compounds, made up of carbon, hydrogen, oxygen and nitrogen. They are found in storage organs of plants such as seeds, bark and leaves. They are insoluble in water but soluble in alcohol. They have sour taste and some are poisonous. However, a large number of alkaloids, such as quinine, reserpine, nicotine, caffeine, thein, strychnine, morphine, atropine, are used as medicines.

(ii) Glucosides- are degradation products of carbohydrates. Some, such as digitoxin used in heart diseases, are used as medicine.

(iii) Tannins- are sour in taste and related to glucosides. They occur {n vacuolar sap, cell wall, bark and leaves of some plants. They are found mostly in unripe fruits. They are used on a large scale for hardening of leather, a process called tanning of leather.

(iv) Latex- is a milky substance secreted by latex glands. Robber secreted by the rubber tree Hevea brasiliensis is an important example.

(v) Essential oils- are volatile oils produced by special glint's and cells. Aromain flowers, leaves and bark are due to essential oils.

(vi) Resins- produced by the oxidation of essential oils. These are found in some special glands or canals either alone or in combination with essential oils. These are insoluble in water but soluble in ether and alcohol. These are used in the manufacture of paints and varnishes.

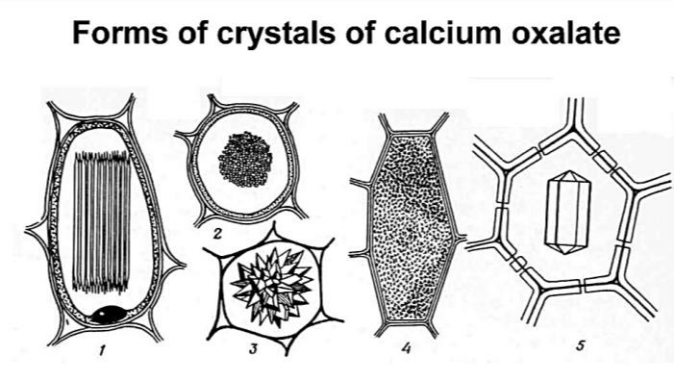
(vi) Gums- produced by the disintegration of cellulose cell wall. They are soluble in water. Used for sticking purposes, and also as medicine,

(vii) Organic Acids- are found in leaves and fruits. Tartaric acid is found in fruits of Tamarindus, oxalic acid in Oxalis and citric acid in Citrus fruits.

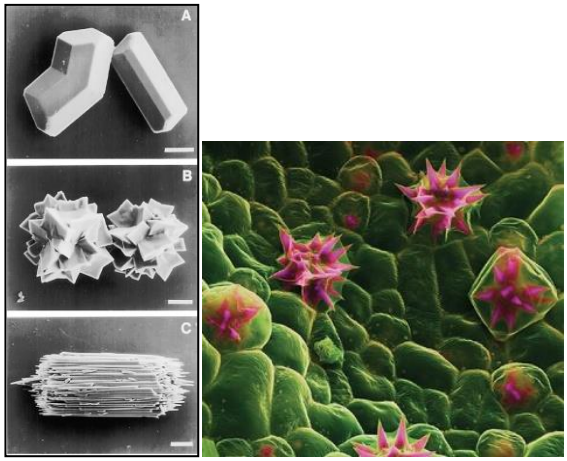
Mineral Crystals

Mineral crystals are formed by the reaction between acids produced by plants (oxalic acid, carbonic acid etc.) and the alkaline matters like calcium, magnesium and potash. Most important crystals in plants are Calcium oxalate, Calcium carbonate crystals, Silica crystals. They appear loosely in the cell or may be aggregated into groups and found hanging from cell walls.

Calcium oxalate crystals are found in different shapes within the cell – (i) **Prisms-Crystals** of calcium oxalate which are rectangular or pyramidal in shape found in leaves of lemon, Begonia; (ii) **Raphides** are thin elongated needle like crystals of calcium oxalate-found in raphide sacs, sometimes they are found in bundles, occurs in special mucilage coverings, present in rhizome of *Colocasia*. (iii) **Stellate crystals** found in special type of sclerenchyma of aquatic plants (Idioblasts); (iv) **Druses** – Sphaeroidal groups of calcium oxalate crystals found in *Nerium* leaf.



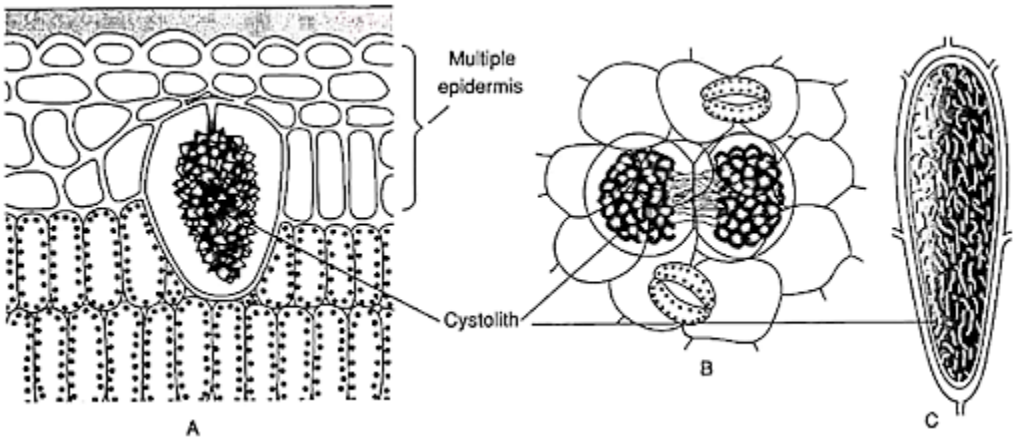
1,2 – raphides (1 – Lateral view, 2 – cross-section view); 3 – drusen; 4 – crystal sand; 5 – simple crystal



Electron microscopic photographs of Calcium oxalate crystals

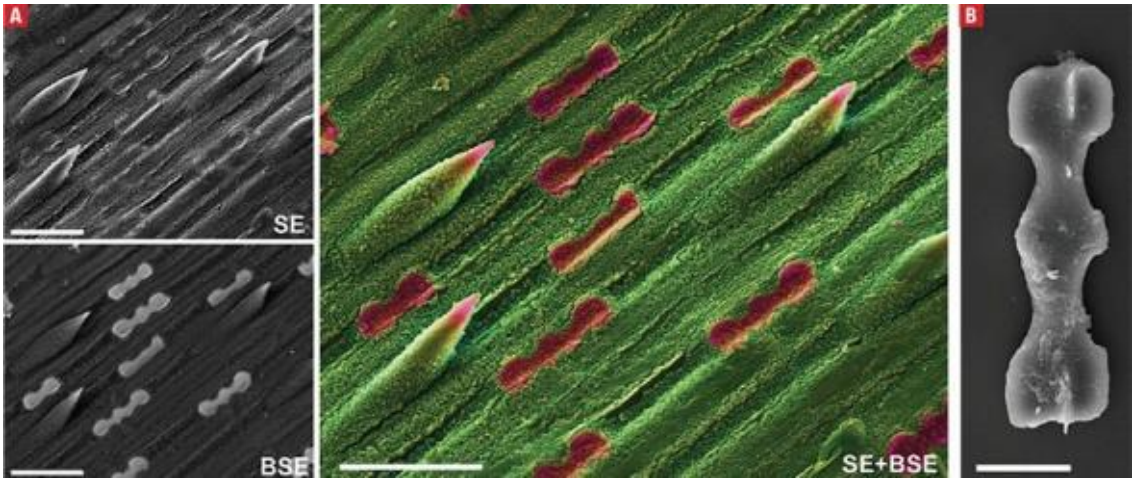
Calcium carbonate crystals – it form grape like clusters hanging from a stalk like projection into the cell cavity from the wall and crystals are deposited on this stalk called a **cystolith**. This is an extension of the cellulosic cell wall with calcium carbonate deposited in the form of granules appears as a bunch of grapes found in *Ficus benghalensis* leaf.

A pair of cystolithis seen together in Momordica–called **Double cystolith.**



Calcium carbonate crystals: A. Cystolith in *Ficus* sp., **B.** Double cystolith in Momordica, **C.** Elongated cystolith in the leaf of Acanthaceae

Crystals of Silica- Silica is a constituent of the cell wall of many plants and they are embedded in the cell wall or form an encrustation on the cell wall. Silica deposition makes the leaves and stems rough. Mainly found in grasses, wheat, sugarcane, rice etc.



Electron microscopy reveals the Crystals of Silica on grass leaf **(source: Ensikat & Weigend, 2019)**