Non living inclusions in plant cell: - Reserve food materials -carbohydrate (starch), protein (Aleurone grain) and lipids (fats and oil);

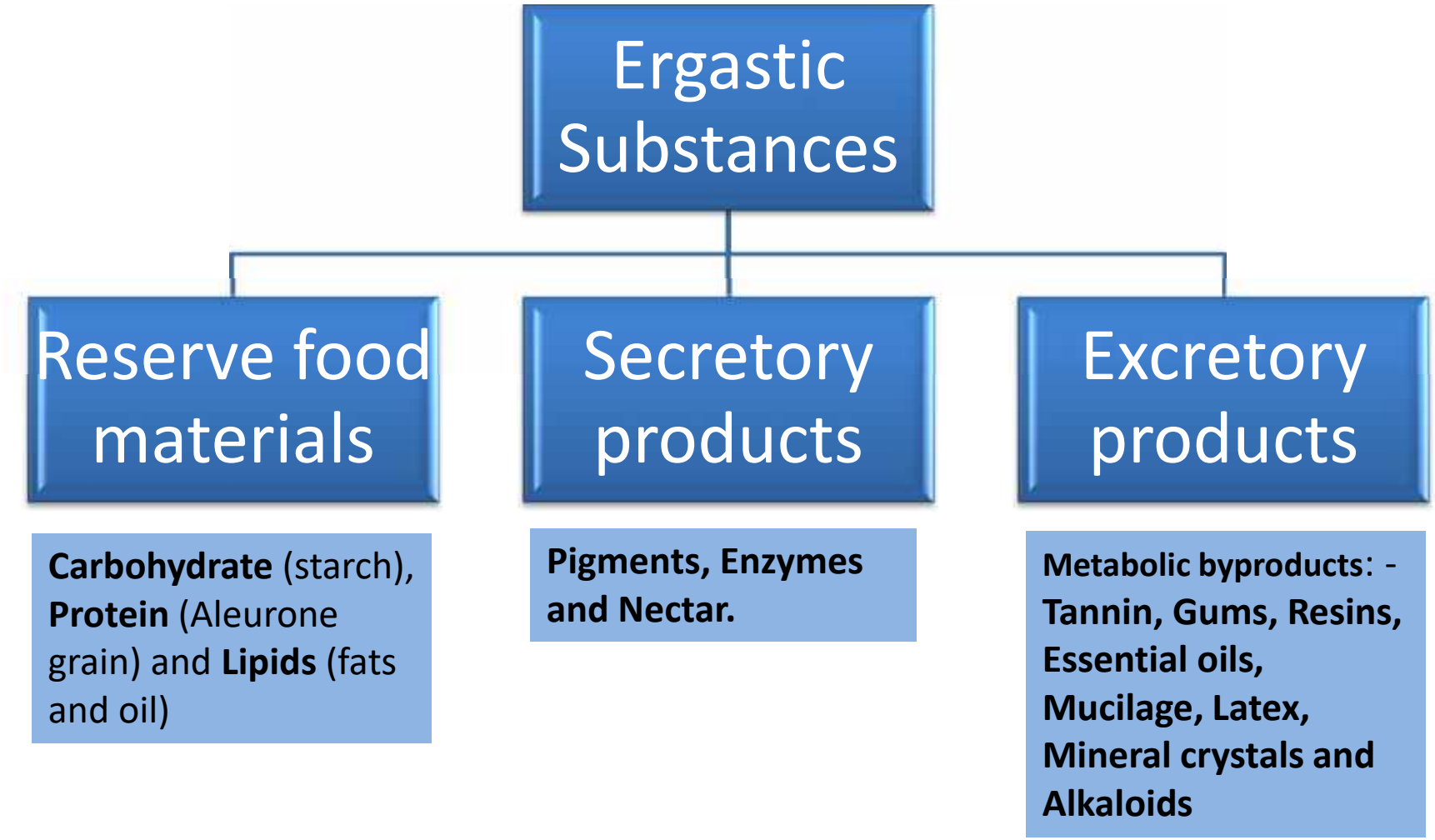
Secretory products- pigments, enzymes and nectar.

Metabolic byproducts: - tannin, gums, resins, essential oils, mucilage, latex, mineral crystals and alkaloids

NON-LIVING INCLUSIONS OF THE CELL

- Cell contents are divided into two:
  - **Living inclusions-** all the cell organelles like nucleus, ER, chloroplasts, mitochondria etc.
  - **Non-living inclusions-** the organic or inorganic substances that are metabolic by-products of the cell- also called non-protoplasmic inclusions or **ERGASTIC SUBSTANCES**

Classification of Ergastic Substances



Reserve Food Materials

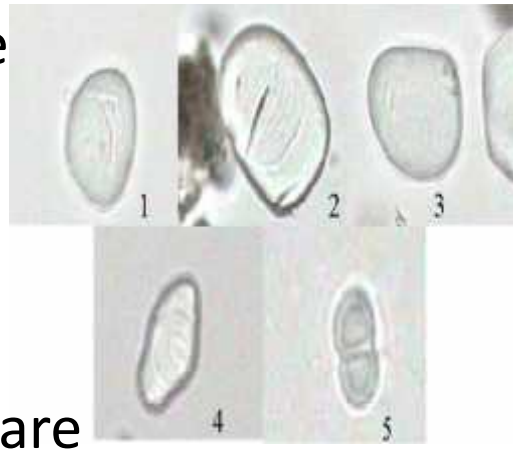
- These are substances manufactured by the plants from CO_2 and water and stored in the plant cells as food materials
- They breakdown to release energy and are used for various metabolic reactions of the cell
- When produced in excess they are stored in the form of reserve food materials
- These reserve food materials may be:
  - Starch
  - Proteins
  - Lipids (Oils and Fat)

Starch

- 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
    - Unbranched water soluble
  - Beta amylose (amylopectin)
    - Branched and water insoluble

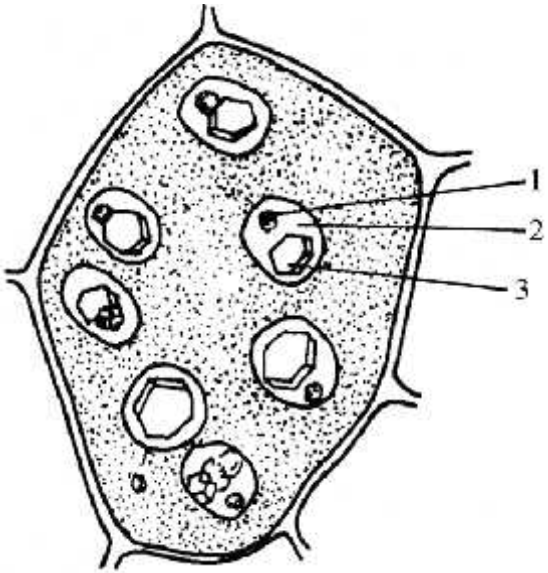
Starch

- Starch occurs in the form of variously shaped grains
- Stains bluish black with iodine
- 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**
- 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
- Satrch is deposited in the leucoplast (amyloplasts)in cells



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
- Crystalloid is proteinaceous and globoid is a double phosphate of calcium and magnesium



Proteins in plants

Fibrous proteins

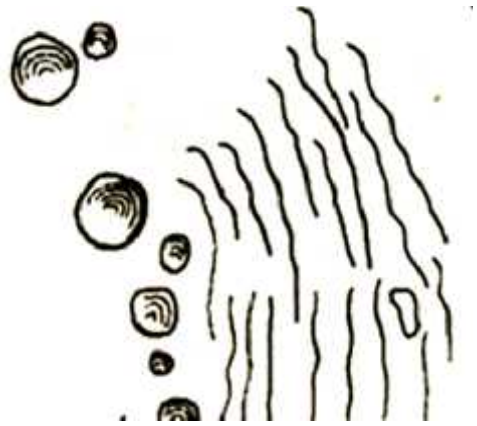
- Insoluble in water
- Serve as structural parts of cells

Globular proteins

- Soluble in water
- Two types:
  - Simple- Made up of amino acids only
  - Conjugated- Made up of amino acids and a non-protein substance Eg., Lipoprotein- lipid + protein

Lipids (Fats and Oils)

- Compounds containing carbon, hydrogen and very less amount of oxygen
- They are glycerides of fatty acids
- Insoluble in water, soluble in organic solvents
- Occurs as minute globules in the protoplasm or in organelles called elaioplasts or sphaerosomes
- Found in fruits and oily seeds like ground-nut, coconut, castor seed, sunflower, olive fruits etc.
- Solid at ordinary temperature- Fats
- Liquids at ordinary temperature- Oils



Secretory Products

- Ergastic substances without any food value
- Secreted by the protoplasm and helps reactions in cells
- Sometimes secreted in special sacs or glands
- Three types:
  - Pigments
  - Enzymes
  - Nectar

Pigments

- Pigments secreted by plants are responsible for the various colours of leaves, flowers and fruits
- Chlorophyll and anthocyanins are important plant pigments
- Chlorophyll is secreted by the chloroplasts- Responsible for photosynthesis
- It is a combination of chlorophyll a, chlorophyll b (responsible for green colour), xanthophyll and carotene (responsible for red, orange and yellow colours)
- Anthocyanin is a water soluble pigment in the cell sap of vacuoles – responsible for blue, violet and pink colours
- Phycobilins are pigments present in algae for photosynthesis

Enzymes

- Organic catalysts (Catalytic proteins) in the protoplasm
- Colloidal in nature and capable of breaking down complex food materials into simpler ones
- Enzymes play a major role in all physiological processes like photosynthesis, respiration, protein synthesis etc.
- Also present in digestive glands of insect feeding plants

Nectar

- Sweet in taste and secreted by the floral parts of many plants- Nectaries
- Nectar contains sucrose, glucose and fructose
- Nectaries vary greatly in morphology and anatomy.
  - **Extrafloral nectaries** are usually represented by glandular hairs or glandular epidermis.
  - **Floral nectaries** usually form multicellular outgrowths on the flower parts.
- Floral nectaries may be located in many floral parts such as stamens or at the base or on top of the ovary
- Floral nectar attracts insect pollinators of entomophilous plants while extrafloral nectar may attract ants which defend the plant from herbivorous insects.

Excretory Products

- **Also called Metabolic byproducts**: Useless to plants and hence excreted through leaves, stem, bark, fruits and seeds
- Classified into two:
  - Nitrogenous waste products
    - **Alkaloids**
  - Non-nitrogenous waste products
    - **Tannin**
    - **Gums**
    - **Resins**
    - **Essential oils**
    - **Mucilage**
    - **Latex**
    - **Mineral crystals**

Alkaloids

- They are complex compounds of amino acids(amines)
- Many of these alkaloids have medicinal properties which are used to cure diseases in humans
- Nicotine- Tobacco
- Caffeine- Coffee
- Strychnine- Strychnos

Tannin

- Bitter substances in the cell sap, cell walls and barks of woody plants
- Present in young fruits and quantity decreases with ripening
- Some tannins are used to produce ink
- Some of these are medicinal
- They protect plants from the attack of insects and parasites

Gums

- Gums consist of Ca, Mg & K-salts of polyuronides
- Gums have the common property of swelling in water to form either gels or viscous, sticky solutions
- Exuded from stems and twigs of many plants
- Eg., Acacia- Gum arabic
- Uses
  - Stabilizer in emulsion
  - It has demulcent (softening) properties and so it is used in cough, diarrhoea and throat medicinal preparations.
  - Suspending agent, adhesive and binder in tablet granulation.

Resins

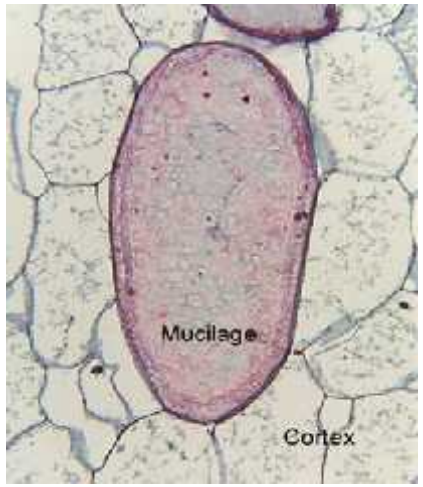
- “Resin” applies to product which is more or less solid, with a complex chemical nature. When heated, they will often soften & melt.
- Produced mainly by coniferous trees
- Resins are insoluble in water and in petroleum spirit. Will dissolve more or less completely in alcohol, chloroform & ether.
- Eg., Turpentine

Essential Oils

- Volatile oils found in special cells or glands
- Responsible for the fragrant odours of flowers, fruits, bark and wood
- Found in the petals of rose, jasmine and some flowers
- Lavender oil from Lavendula, Cinnamon oil from Cinnamomum zeylanicum (Karuva), Peppermint oil from Peppermint
- Used in the preparation of various perfumes and soaps

Mucilage

- Mucilages are generally normal products of metabolism formed within the cell (intracellular formation).
- It is a polymer of galactan which swells and forms a slimy solution with water
- It is secreted by mucilage cavities or ducts
- Some trichomes (hair like outgrowths) also secrete mucilage



Mucilage

Function of Mucilage:

- Storage material
- Water storage reservoir
- Protection for germinating seeds

Mucilage is often found in

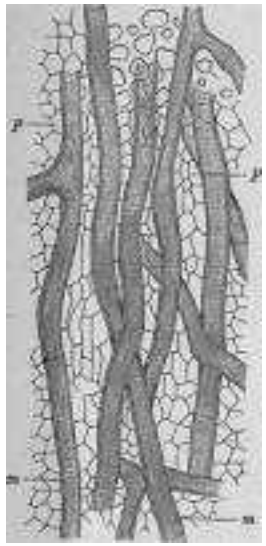
- Epidermal leaf cells (Senna)
- Seed coats (linseeds, psyllium)
- Roots (marshmallow)
- Barks (Slippery elm)

Latex

- Latex is a milky fluid that is commonly composed of both organic (alkaloids, rubber particles) and inorganic substances in an aqueous phase.
- Occurs in specialized cells or ducts called laticifers
- Often milky or colourless
- Contains nutritive substances like starch, proteins, sugar etc. and also waste products like resins, gums, tannin and alkaloid
- Rubber- Hevea braziliensis
- Latex in Carica papaya contains enzyme papain
- Latex is abundant in plants belonging to Euphorbiaceae

Laticifers

- Latex is a white secretion which contains carbohydrates, organic acids, alkaloids etc.
- Cells or tissues responsible for secreting latex called laticifers
- Two types of laticifers:
  - Non-articulated- Latex cells originate from single cells which are capable of growing for a long time and forms tube like structures
  - Articulated- Latex vessels formed by articulations of a number of elongated cells placed end to end.



Mineral Crystals

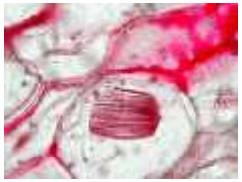
- Mineral crystals are formed by the reaction between acids produced by plants (oxalic acid, carbonic acid etc.) and the alkaline matters like calcium, magnesium and potash
- Most important crystals in plants
  - Calcium oxalate
  - Calcium carbonate crystals
  - Silica crystals
- They lie loose in the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

Calcium Oxalate Crystals

- Most common types of crystals
- They are of different forms
  - Prisms
  - Raphides
  - Druses or Sphaeroraphides

- Prisms- Crystals of calcium oxalate which are rectangular or pyramidal in shape
  - Found in leaves of lemon, Begonia

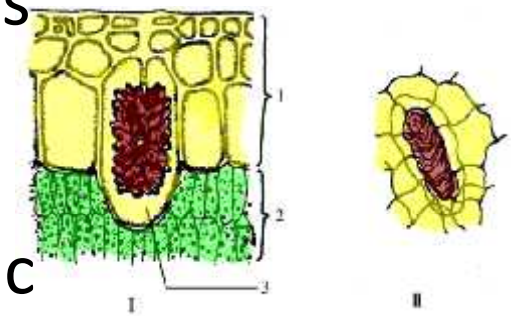
- Raphides
  - Thin elongated needle like crystals of calcium oxalate- found in raphide sacs
  - Sometimes they are found in bundles
  - Occurs in special mucilage coverings
  - Present in rhizome of Colocasia
  - The raphides at times induce irritation- a means of protection from animals
  - These crystals are destroyed on boiling
  - Stellate crystals found in sclerenchyma of aquatic plants- Idioblasts



- Druses
  - Sphaeroidal groups of calcium oxalate crystals

Calcium carbonate crystals

- Calcium carbonate crystals form grape like clusters hanging from a stalk like projection into the cell cavity from the wall and crystals are deposited on this stalk
- This is called a cystolith
- The cystolith is an extension of the cellulosic cell wall with calcium carbonate deposited in the form of granules
- Found in Ficus benghalensis
- A pair of cystolith is seen together in Momordica – called Double cystolith



Crystals of Silica

- Silica is a constituent of the cell wall of many plants
- They are embedded in the cell wall or forms an encrustation on the cell wall
- The silica deposition makes the leaves and stems rough
- Found in grasses, wheat, sugarcane, rice etc.

Classification of Ergastic Substances