16

FIBRES, SURGICAL DRESSINGS AND SUTURES

Natural and artificial fibres are used in surgical dressings. The natural fibres are obtained from vegetable sources (e.g., Cotton, Flax, Hemp, Jute, etc.) or from animal sources (e.g. Wool and Silk). These fibres are made up of long-chain molecules which may be a carbohydrate or a protein molecule. Some fibres, e.g., Nylon and Terylene, are synthetic fibres prepared from long-chain molecules of polymers. Regenerated carbohydrate materials and chemically modified fibres are Viscose, Acetate Rayons, Alginate yarn and Oxidized Cellulose. Asbestos and glass are obtained from mineral sources.

Fibres can be distinguished by chemical test and by studying their microscopic structures. Vegetable and regenerated carbohydrate materials are composed of cellulose units and respond to the following tests :

Tests of Vegetable and Regenerated Carbohydrate Fibres :

1. With Molisch reagent they produce violet colour.
2. On heating with aqueous picric acid solution they are not stained permanently.
3. With chlor-zinc iodine or a mixture of iodine and sulphuric acid they yield blue colour.
4. On ignition as such or boiling with sodalime they do not produce foul smell.
5. Vegetable fibres are soluble in copper oxide ammonia solution (cuoxam) forming a blue colour.

6. On boiling with Millon's reagent they do not produce red colour.

Tests of Animal Fibres : Animal fibres and regenerated protein fibres are proteinous compounds containing peptide linkage. They show the following tests :

1. On ignition they produce disagreeable odour.
2. They are dissolved in 5% aqueous potassium hydroxide solution.
3. They respond positively with Millon's test.
4. They are stained permanently with picric acid.

Synthetic and mineral fibres give negative tests of vegetable and animal fibres. Glass fibres melt on heating and form beads. There is no effect of heat on asbestos fibres.

ABSORBENT COTTON

Synonyms : Absorbent Wool; Purified Cotton; Kapas (Hindi).

Biological Source : Absorbent cotton consists of epidermal hairs of the seeds of *Gossypium herbaceum* Linn. and other species of *Gossypium* like *G. hirsutum*, Linn., *G. arboreum* Linn. and *G. barbadense* Linn. which are freed from adhering impurities, deprived of fatty matters, bleached and sterilized.

Family : Malvaceae.

Habitat : Cotton is cultivated in Egypt, India, South America, U.S.A., South Africa and Pakistan.

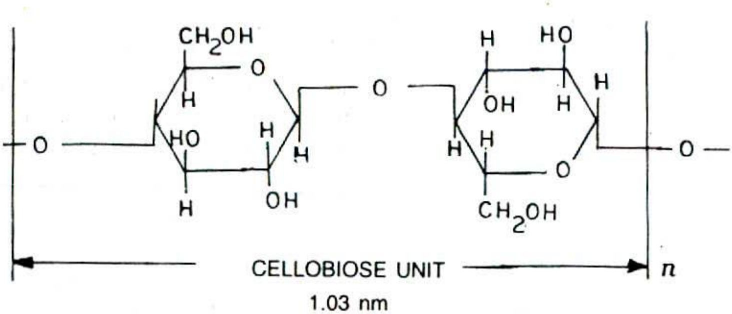
Preparation : The plants are shrubs or small trees which produce 3 to 5 celled capsules possessing numerous seeds. The capsules open on ripening along longitudinal sutures and a mass of white hair attached to the brownish seeds is visible. The cotton fibres are collected, dried and ginned to remove the hair from the seeds. The gin may be a roller or pneumatic type which is designed to pull the hair through a narrow space. For preparing Absorbent Cotton, the cotton is first carded to remove impurities such as immature and broken seeds, fragments of leaves and short hairs called as 'linters'. The linters are used to prepare the lower grades of cotton wool and rayons. It is subjected to cotton-combing machine which separates all the shorter fibres and a thread is spun consisting of long paralleled, uniform fibres. The short fibres of comber waste are used to prepare the best grades of cotton wool.

The comber waste is loosened and heated with dilute sodium hydroxide solution and soda ash solution at 1-3 atmospheric pressure for 10-15 hours. Most of the fatty cuticle is removed and trichome wall becomes absorbent in this process. It is washed with water, decolourized with sodium hypochlorite solution and treated with dilute hydrochloric acid. The dried fibres are in matted conditions and opened up by machines. It is converted into a continuous flat sheet, packed and sterilized.

Characters : Absorbent Cotton occurs as white, soft, fine hairy filament. Microscopically the filament consists of unicellular hair appearing like empty-twisted five-hoses, 2.5-5 cm in length, 9-24 μm in diameter. The number of twists varies from 75 per cm in Indian variety to 150 per cm in the Sea Island variety. The Cotton hair is cylindrical when young and becomes flattened and twisted on maturing. The Cotton is almost odourless and tasteless.

Chemical Nature : Absorbent Cotton consists of cellulose which is composed of glucose units linked by 1,4 β-linear glucoside bonds.

Uses : Absorbent Cotton is used for surgical dressings. It serves for mechanical support to absorb blood, mucus, pus, etc. It protects the wound from bacteria. Cotton is also used in textile industry; for manufacturing explosives, cellulose acetate, other cellulose derivatives like carbomethyl cellulose, cellulose acetate phthalate, ethyl cellulose, hydroxypropyl methyl cellulose, methyl cellulose, oxidized cellulose and pyroxilin.



JUTE

Synonym : Gunny.

Biological Source : Jute consists of the strands of phloem fibres obtained from the stem bark of *Corchorus capsularis*, Linn., *C. olitoritus* Linn. and other species of *Corchorus*.

Family : Tiliaceae.

Habitat : It is cultivated throughout the hotter parts of India in Bengal, Assam, Bihar and Orissa as well as in most tropical countries.

Jute is a rainy season crop. The maximum temperature during the crop season rarely exceeds 38°C. The seeds are sown from March to May. The crop is cultivated on alluvial soil. Jute seed is sown broadcast early from mid-February to mid-March. Germination takes place within 2 or 3 days. Jute plants respond quickly to early weeding, thinning and mulching. The plant harvests between June and September.

Preparation : Jute is an annual plant 3-4 m in height. The straight stems are cut in July during flowering stage. The leaves are removed and the stems are submerged into water tank in bundles for retting. The bundles are covered with straw to protect them from direct sunlight which would make the fibres specky. After 3 weeks the bark from the wood and the strands of phloem fibres from the surrounding softer tissues are removed. The ends of stems are beaten with a mallet to separate the wood from the fibres. The fibres so obtained are cleaned by jerking them backwards and forwards on the surface of the water. They are hanged in the sun to dry and bleach for few days. The fibres are graded on the basis of length, colour and glossiness.

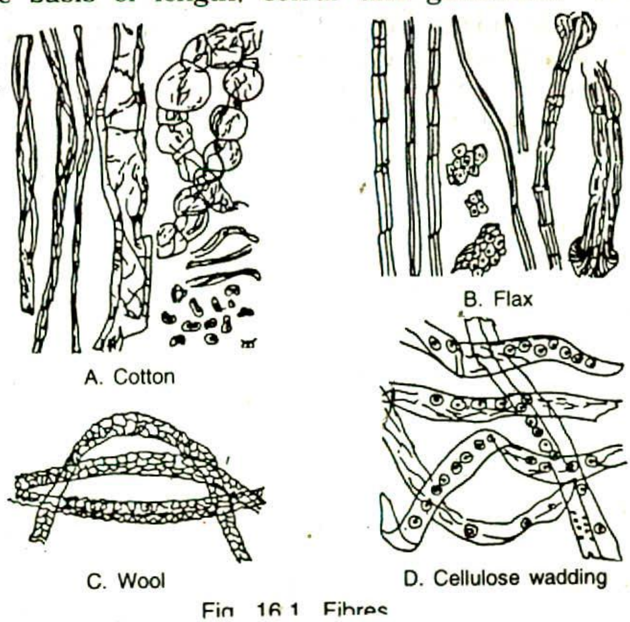


Fig. 16.1 Fibres

Characters : Jute is a yellowish-brown in colour, 1-3 m long and 30-140 µm in diameter. The individual fibres are 0.8-5 mm long and 10-25 µm in diameter. The apex is bluntly pointed and rounded wall is without markings and lumen is varying in size. They give deep red colour with phloroglucinol, yellow with iodine and sulphuric acid and with chlor-zinc-iodine.

Chemical Composition : Jute contains liganocellulose. The middle lamella is extensively lignified and is destroyed by oxidizing agent (a mixture of nitric acid and potassium chlorate).

Uses : Jute is used to prepare medicated tows, as a filtering and straining medium and to make gunny bags, yarns and ropes.

HEMP

Biological Source : Hemp is prepared from the pericyclic fibres of the stem of *Cannabis sativa* (Fam. Cannabinaceae). Plant is grown for fibres in Russia, Italy, France and America. The fibres are prepared by retting process as in case of jute. The individual fibre are about 22 µm in diameter and 35-40 mm in length. The fibre ends are bluntly rounded, some ends are bifurcated like fork due to injuries to the stem. The lumen of the hemp fibre is large, uniform and flattened. The wall is thick with fine cross lines, some are intersecting. The fibres give slightly red colour with phloroglucinol, inner wall blue and middle lamella yellow with iodine and sulphuric acid and purple to yellow colour with chlor-zinc iodine. Hemp is used to manufacture rope, twine and sail-cloth.

FLAX

Biological Source : Flax is the pericyclic fibres of the stem of *Linum usitatissium* Linn. (Fam. Linaceae). Flax is prepared by the process of retting similar to jute. Flax fibres are non-lignified with sharply pointed ends, average length is 25-30 mm, diameter varies from 12-25 µm. Some fibres are up to 120 mm long and lumen is narrow. The fibres have good lustre and more tensile strength than cotton. The commercial fibres contain fine transverse injuries received during beating. The fibres of old plants are coarse and harsh in texture. Flax fibres give colourless or slight pink colour with phloroglucinol, blue or violet with iodine and sulphuric acid and purple to yellow with chlor-zine iodine. Flax consists of pectocellulose. It is used as a filtering medium.

WOOL

Synonyms : Animal wool; Sheep's wool.

Biological Source : Wool is obtained from the protective covering or fleece of the sheep, *Ovis arries* Linn.

Family : Bovidae, Order - Ungulata.

Geographical Source : Wool producing countries are Australia, Russia, Argentina, India and America.

Preparation : Wool obtained from the animal is spreaded on a frame covered with wire netting to separate it into wool of different sizes and qualities. Simultaneously it is beaten over the netting to remove dust and dirt. The burrs and straw pieces are picked up. The wool is washed in tanks containing warm, soft, soapy water to remove wool greese. The wool is squeezed between rollers, dried and the fibres are mechanically loosened. Then it is carded and spun into yarns.

'Wool grease' from the washing process may be removed by meachanical means or by using organic solvents. Purified 'wool grease' is known as wool fat or anhydrous lanolin. It is employed in cosmetics and ointments.

Characters : Wool consists of elastic, lustrous and smooth hair. The hair are loosely fitted and slippery to touch. The outer most surface, cuticle, consists of imbricated, flattened, translucent epithelial scales. Wool is insoluble in warm hydrochloric acid and in cold concentrated sulphuric acid. Single wool fibre can resist breakage when subjected to weights of 15-30 g and when stretched as much as 25-30% of their lengths. Wool fibre has good to excellent affinity for dyestuffs. It may retain about 17% of moisture of its weight.

Wool fibre is deteriorated by ageing, larval attack such as by cloth moths and carpet beetles, exposure to sunlight and charing at 300°C. It does not continue to burn when removed from a flame. It has good resistance to dry-cleaning solvents, strong alkalies and high temperature.

Chemical Nautre : Raw wool consists of wool fibres (31%), 'wool sweat' or 'suint' composed of potassium salts of fatty acids (32%), dirt and dust (25%) and wool grease (lanolin).

Wool fibres are composed of the protein keratin, which is more easily damaged in unfavourable conditions than the cellulose fibres. Keratin is rich in the amino acid cystine. A cystine bridge, joining adjacent polypeptide chains, can be represented as :

$$\begin{array}{l} S - CH_2\ CH\ (NH_2).\ COOH \\ | \\ S - CH_2 - CH\ (NH_2).\ COOH \end{array}$$

Cystine

Stability of the protein is due to frequent primary valence cross-links (disulphide bonds) and secondary valence cross-links (hydrogen bonds) between neighbouring polypeptide chains. The unstable form of keratin is known as β-keratin, the stable form is called as α-keratin.

Uses : Wool is used to prepare crepe bandages and dressings and as a medium for filtration and staining.

SILK

Biological Source : Silk is obtained in the fibre-form from the cocoons of *Bombyx mori* Linn. commonly known as silk worm or mulberry silk worm, and other species of *Bombyx* and of *Antheraea* such as *A. mylitta, A. assama, A. pernyi* and *A. yama-mai.*

Odour : Lepidoptera.

Geographical Source : Silk is produced in China, Japan, India, Asia Minor, Italy, France and some other countries.

Preparation : Cultivation of domesticated silk is called sericulture in which the care of the domesticated silk worm from the egg stage through completion of the cocoon, and also production of mulberry trees for worm food are involved. Before the silk worm passes from the larval or caterpillar to pupal (chrysalis) stage, it secretes an oval cocoon around itself. The cocoon is about 2.5 cm in length and consists of a filament up to 1200 m long. The thread is composed of two silk fibres joined together by a layer of silk glue known as sericin. If pupal or chrysalis are allowed to mature stage, the insect will escape damaging the cocoon. Therefore, the cacoon are collected at the chrysalis stage and heated at 60-80° for few hours or exposed to steam for a short period to kill the pupae. The cocoons are graded and kept in hot water to soften the silk glue and loosen the fibres. The ends of the fibres from 2-15 cocoons are woven into a single thread by twisting and reeling.

The double fibre in the coccon is called as a *bave* and its constituent fibres are known as *brine*. Silk containing sericin is called as raw silk. It is cleaned out by treatment with hot soap solution to remove sericin. This process is known as stripping or degumming. The degumming process leaves silk lustrous and semitransparent with a smooth surface. The silk is sometimes treated with a finishing substance, such as metallic salt, to increase its weight, density and improve draping quality.

Characters : Silk is a continuous filament, 600-1200 m long. Silk fibres are soft, smooth and possess remarkable tensile strength. A silk filament can be streched about 20% beyond its original length before breaking but does not immediately resume its original length when stretched more than 2%. Silk is soluble in ammonical copper oxide solution, ammonical nickel oxide solution, concentrated alkalies, and in concentrated hydrochloric acid. It is insoluble in water, alcohol, ether and dilute alkalies.

Chemical Nature : Silk is consisted of the protein fibroin which on hydrolysis yields mainly glycine and alanine.

Uses : Silk is used for making ligatures and sieves.

REGENERATED FIBRES

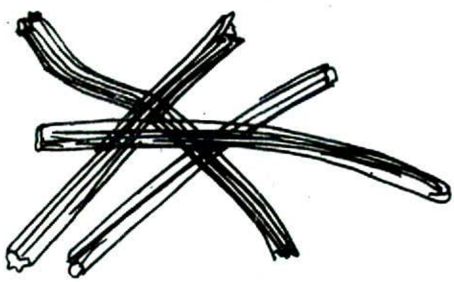
Regenerated fibres are prepared from naturally occurring polysaccharides. These compounds are modified to yield a suitable fibre form. Viscose, cellulose acetate, oxidized cellulose, nitrocellulose, etc. are the regenerated fibres.

VISCOSE

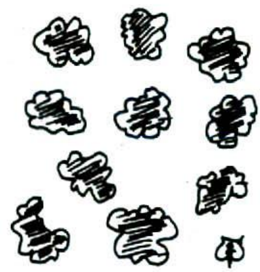
Synonyms : Rayon; Regenerated cellulose.

Viscose is a viscous orange-red aqueous solution of sodium cellulose xanthogenate obtained by dissolving wood pulp cellulose in sodium hydroxide solution and treating with carbon disulphide.

Preparation : Cellulose, obtained from Coniferous wood or cotton linters, is delignified to produce white pulp containing cellulose (80-90%) and hemicellulose. Hemicellulose is removed by treating the product with sodium hydroxide. The remaining alkali-cellulose (sodium cellulosate) is dissolved in a mixture of carbon disulphide and sodium hydroxide solution to afford a viscous solution of sodium cellulose xanthate. This solution is allowed to ripen, filtered and the filtrate is forced through a spinneret equipped with fine nozzles. It is immersed in a bath containing dilute sulphuric acid and sodium sulphate. The cellulose is regenerated as continuous filaments in the bath. The yarns are combined, twisted to strengthen, treated with sodium sulphide to remove free sulphur, bleached, washed, dried and a 10% moisture content is adjusted. Surgical dressings are prepared from the Viscose yarns.



A. Threads

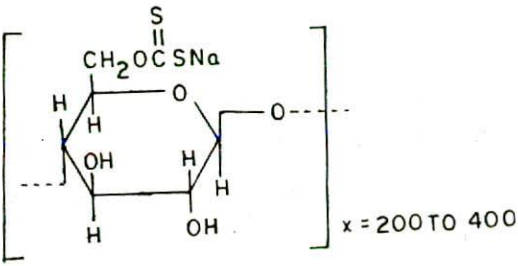


B. T.S. of Viscose fibres

Fig. 16.2. Viscose rayon

Characters : Viscose is a white, highly lustrous, pure form of cellulose. The molecules contain 450 glucose residue units as compared to 9000 glucose units in wood cellulose. Tensile strength is from two-third to one-and a half times that of Cotton. Viscose fibres are solid, transparent, 15-20 μm in diameter, slightly twisted, and contain grooves. Fibre-ends are abrupt and peculiar. The fibres give general tests of vegetable fibres. They can be delustred by addition of white pigment titanium oxide to the solution before preparation of the yarns. The *delustred viscose rayon* or *matt viscose* is used to manufacture surgical dressings. The filaments are identical to Cotton filaments, but they are matted white. The amount of pigment is controlled by assaying ash value.

When viscose solution is allowed to pass through long narrow slits into a regenerating bath, sheets of Viscose are formed. These sheets are washed, bleached, treated with a glycerin solution and dried to produce cellophane. Cellophane is heat-sealable packing material and is also used as a dialysing membrane, as a protective dressing and as a substituent of oiled silk.



Viscose Unit

Uses : Viscose rayon is used to manufacture fabrics, surgical dressings, absorbent wool, enzyme and cellophane.

METHYLCELLULOSE

Synonyms : Cellulose methyl ether; Methocel, Cellothyl; Syncelose; Bagolax; Cethyplose; Cethytin; Cologel; Cellumeth; Hydrolose; Nicel; Tearisol; Tylose.

Methylcellulose is prepared from wood pulp or chemical cotton by treatment with alkali and methylation of the alkali cellulose with methyl chloride under pressure, to convert hydroxyl groups into methyl ether groups. The molecules containing two of the three hydroxyl methylated groups of the glucose residue units of the cellulose chain are considered of high quality.

Methylcellulose occurs as white, fibrous powder, odourless, tasteless; swells in water and forms a clear to opalescent, viscous, colloidal solution in cold water. It is insoluble in hot water, alcohol and ether. An aqueous solution is best prepared by dispersing the granules in hot water with stirring and chilling to +5°C. The solution is then stable at room temperature. Presence of inorganic salts increases the viscosity. The solubility is dependent upon the degree of substitution. Commercial methylcellulose has a methoxyl content of 29%. Clear film may be casted from the aqueous solution.

Uses : In pharmacy Methylcellulose is used to increase the viscosity and to stabilize lotions, suspensions, pastes, ophthalmic preparations and some ointments. In medicine it is used as a hydrophilic colloid, laxative in chronic constipation and to curb appetite in obese persons as it gives a feeling of fullness. It is also used as a substitute for water-soluble gums; to render paper grease proof, in adhesives, as thickening agent in cosmetics, as protective colloid in emulsions, as binder and stabilizer in foods and as a bulk producer in the formulation of dietetic foods.

CELLULOSE ACETATE

Synonyms : Acetate rayon; Partially acetylated cellulose.

Several acetates of cellulose are known, which differ from one another only in the degree of acetylation. In triacetates, not less than 92% of the hydroxyl groups are acetylated. In characterizing the degree of acetylation, per cent acetyl value and per cent combined acetic acid are used.

All cellulose acetates are obtained by treating cellulose with acetic anhydride at various temperatures for different length of time to produce amorphous white solid material in granular, flake or powder form from which fibres may be produced by extrusion. Acetate rayon is prepared by treating cotton linters or wood cellulose with acetic acid and acetic anhydride in the presence of sulphuric acid as a catalyst to yield acetone-insoluble fully acetylated cellulose (primary acetate). Primary acetylated group is hydrolyzed by addition of water and an acetone-soluble secondary acetate is produced. The acetone solution is forced through a spinneret into a warm air chamber. On evaporation of the solvent filament of Cellulose acetate rayon is obtained.

Characters : Cellulose acetate resembles with Viscose rayon in its appearance. Commercial products do not have sharp melting points. Solubility is affected by the acetyl value; the triacetate is insoluble in water, alcohol, ether, but soluble in glacial acetic acid. The penta acetate is insoluble in water, but soluble in alcohol. The filaments are highly lustrous, grooved and slightly twisted.

Uses : Cellulose acetate rayon is used to manufacture rubber and celluloid substitutes, nonflammable photographic and cinema films, airplane dopes, varnishes and lacquers, filaments, phonograph records; water-proofing fabrics and rendering balloons gas-tight; sizing and finishing fabrics, coating skins, insulating electric wires; and tow for cigarette smoke filters. Acetate rayon is much less absorbent than viscose rayon. It is, therefore, unsuitable for manufacturing surgical dressings.

OXIDIZED CELLULOSE

Synonyms : Absorable cellulose; Cellulosic **acid**; Polyanhydroglucuronic acid; Oxycel; Hemo-Pak.

It is a cellulose of varied carboxyl content retaining the fibrous structure. It is prepared by oxidizing cotton wool or gauze with nitrogen dioxide until the number of carboxylic groups formed by the oxidation of the primary alcohol groups of the glucose moieties of the cellulose molecules reaches 16-22 per cent. After reaction the cellulose molecule contains glucuronic acid residue units and some glucose residue units.

Characters : Oxidized cellulose is identical with the normal cotton in appearance. It has dull colour, a harsher texture, charred odour and a sour taste. It tends to disintegrate on handling and does not turn into pasty on chewing. The degree of oxidation is sufficiently high to make the product soluble in dilute alkaline solutions. It is insoluble in water or acidic solutions.

Uses : It is used as local absorable haemostatic in surgery and in chromatography. But it delays bone repair and can not be sterilized by heat.

ALGINATE FIBRES

Alginate fibres are composed of calcium alginate. An aqueous solution of sodium alginate is pumped through a spinneret which is immersed in a bath containing acidic calcium chloride solution. In the bath sodium cations are substituted with calcium cations and the insoluble calcium alginate is precipitated as continuous filaments. The filaments are collected, washed and dried for surgical purposes, the filaments are cut up to give stable form of length 1 to 8 inches for preparing calcium alginate wool or a fabric. Trace amounts of substances are added to the calcium alginate to inhibit mould and bacterial growth.

Alginate fibres are fairly lustrous and pale cream coloured. The fibres may be processed into absorable haemostatic dressings. They give general tests for vegetable fibres. They are soluble in ammonical copper nitrate and 5% sodium citrate solution.

Uses : Alginate fibres are used as absorable haemostatic dressings; in neurosurgery, endaural and dental surgery; internally to arrest bleeding and form protective dressing for burns or sites from which skin grafts have been taken. Alginate fibres are compatible with antibiotics like penicillin. Calcium alginate wool is used as a swab for pathological work or bacterial study.

SYNTHETIC FIBRES

Synthetic fibres are produced by polycondensation of organic molecules which are more stronger than the natural fibres. Nylon, terylene, orlon and polyethylene are the polymers used as pharmaceutical aid.

NYLON

Synonyms : Caprolan; Enkalon; Grilon; Kabron; Mirlon; Perlon; Phrilon; Amilon.

Nylon is a manufactured fibre in which fibre forming substances are long-chain synthetic polyamide having recurring polyamide groups ($-CONH_2-$) as an integral part of the polymer chain. Nylon is usually prepared by condensing adipic acid with hexamethylene diamine. The molted polymer is pumped through a spinneret to produce filaments.

The filaments are smooth, solid cylinders, softens at 210° and melts at 223°; moisture regain is about 4%. Swelling is low. They are immune to microbiological attack; resistant to most organic chemicals, but dissolves in phenol, cresol and strong acids. They may be highly lustrous to dull white or coloured. On ignition the fibres melt and form a hard bead. They are soluble in 5 M hydrochloric acid, 90% formic acid, 90% phenol and insoluble in acetone. Chemically, nylon is represented as :

$$H - [NH\ (CH_2)_5\ CO\ ]_n\ OH;\ n = \text{approx } 200.$$

Uses : Nylon is used to prepare filter cloth, sieves, non-absorbable sutures, nylon syringes, film, textile fibres, monofilament, tire cord, fishing lines, tow ropes, etc.

TERYLENE (DACRON)

Terylene is a polyester fibre produced by condensating ethylene glycol with terephthalic acid. Its chemical formula may be represented as $H[OCH_2\ CH_2\ OOC\ C_6\ H_4\ CO]_n\ OH$. Terylene fibres are prepared by an identical process to that for nylon. On heating the fibres with phosphoric acid (90%) for 1 minute, it retain its form. This test is negative in case of nylon. Terylene is used in the same way as nylon.

ORLON

Synonyms : Polyacrylonitrile; Fiber A.

Orlon is obtained by polymerizing acrylonitrile. It is represented as $[CH_2\ CN\ (CN)\ ]_n$. It is a white fibre; sticks at 235°; ironing temperatures above 160° may cause yellowing; sp. gr. is 1.17. Its flammability is similar to that of rayon and cotton. Generally it has very good resistance to mineral acids; excellent resistance to common solvents, oils, greases, neutral salts, sunlight but it is degraded by strong alkalies. It resists attack by molds, mildew and insects. The 100% polyacrylonitrile fibres are rarely used commercially due to difficulty in dyeing.

Orlon fibre is suitable for furnishing (awnings, tents, furniture), anode bags in electro-plating, knitwear, rugs, dressings, etc.

POLYETHYLENE

Synonyms : Polythene; Ethene homopolymer; Agilene; Alathon; Alkathene; Courlene; Lupolen; Platilon.

Polyethylene is prepared by polymerization of liquid ethylene at high temperature and under pressure. The polymer is a plastic solid of milky transparency, tough and flexible at room temperature, m.p. 85-110°.

It is a good electrical insulator. It burns but hardly supports combustion. It is stable to water, non-oxidizing acids and alkalies, alcohols, ethers, ketones and esters at ordinary temperature. It is attacked by oxidizing acids such as nitric acid, perchloric acid, free halogens, benzene, petroleum ether, gasoline and lubricating oils, aromatic and chlorinated hydrocarbons. It has flexibility over a wide range of temperature.

The polymer $[CH_2\ -\ CH_2]_n$ is transformed into filaments by melt spinning and heat sealable packing film by the similar process as adopted in nylon.

Uses : Polyethylene is used as laboratory tubing, in making protheses, electrical insulation; packing materials, kitchenwire; tank and pipe linings; paper coatings and textile. As fibres are resistant to acid, alkali and most solvents, they are used in filtering fabrics. An outstanding property of polyethylene, both as resin and filament, is its low specific gravity (0.92). A low softening point (110°) limits it application in wearing apparel uses.

SURGICAL DRESSINGS

A material used to protect a wound and to heal is called a surgical dressing. They serve various function for the injured site. They remove wound exudates from the site, prevent infection, give physical protection to the healing wound and mechanical support to the supporting tissues. A good quality of dressing should be durable, easy to handle, sterilized, formed from loose threads and fibres and it should not adhere to the granulating surface.

Surgical dressings are classified as :

1. Primary wound dressings
2. Absorbents
3. Bandages,
4. Adhesive tapes and
5. Protectives.

1. **Primary Wound Dressings :** Primary wound dressings are applied over the wound surface to absorb pus, mucus, blood, etc. They minimize maceration. Some dressings adhere to the wound surface and cause pain on removing them. Now nonadherent dressings are available such as petrolatum-impregnated gauge, viscose gauze impregnated with a bland, hydrophilic oil-in-water emulsion or an absorbent pad faced with a soft plastic film having openings, etc.
2. **Absorbents :** Absorbent cotton is widely used to absorb wound secretions. Other absorbent materials are rayon wool, cotton wool, gauze pads, laparotomy sponges, sanitary napkins, disposable cleaners, eye pads, nursing pads, cotton tip applications, etc. They are used in the shape of balls or pads.
3. **Bandages :** A bandage is a material which holds dressing at the required site, applies pressure or supports an injured part or checks haemorrhage. The

bandages may be elastic or non-elastic in nature. Common gauze roller bandage and muslin bandage rolls are employed most frequently. Elastic bandages may be woven to form elastic bandage, crepe bandage and conforming bandage.

4. **Adhesive Tapes** : Surgical adhesive tapes may be a rubber-based adhesive or an acrylate adhesive. Rubber adhesive tapes are cheap, superior and provide strength of backing. In case of operation or post-operation acrylate, adhesive tapes are used to reduce skin trauma.
5. **Protectives** : Protectives are employed to cover wet dressings, poultices and for retention of heat. They prevent the escape of moisture from the dressing. Some protectives are plastic sheeting, rubber sheeting, waxed or oil-coated papers and plastic-coated papers.

SUTURES AND LIGATURES

A surgical suture is a thread or sting used for sewing or stiching together tissues, muscles and tendons with the help of a needle. It these threads or fibres are used to tie a blood vessel to stop bleeding without the use of a needles, then they are called ligatures. Sutures may be absorable which are digested in animal tissues, e.g. catgut, kangaroo tendon and synthetic polyesters. If the sutures are not absorbed in the body, they are called nonabsorbable sutures, e.g. Silk, Cotton, Nylon, Synthetic Polyester fibres and Stainless Steel wire. A good quality of suture should be well-sterilized, non-irritant; having well-mechanical strength, fine gauze and with minimum time of absorption.

Absorable sutures

Surgical Catgut : Catgut is a sterilized fibre or strand prepared from collagen of connective tissues obtained from healthy animals like sheep and cattle.

Preparation : The submucosal layer of small intestine of a freshly killed animal is used for the preparation of catgut. About 7.5 meter long intestine is cleaned and split longitudinally into ribbons. The inner most mucosa and two outer layers of submucosa, muscularis and serosal layers, are removed with the help of a machine leaving behind the submucosa. Up to six such ribbons are stretched, spun and dried to form a uniform strand. These fibres are polished to get smooth strings, gauzed for their diameter, cut into suitable lengths and sterilized by placing the catgut in glass tubes filled with anhydrous high-boiling liquids like toluene or xylene and then heating in an autoclave. Sterilization may be done by irradiating the suture by electron particles or by gamma rays from cobalt-60.

Kangaroo tendons, used in hernia and bone repairs, are prepared from the tails of kangaroo by the identical method adopted for the preparation of catgut. Chromicized surgical catguts are prepared by soaking the ribbons in solutions of chromium salts for tanning the tissues. These fibres are not affected by proteolytic enzymes in the body and they are not absorbed rapidly in the body.

Synthetic Polyesters : The polymers obtained by condensation of cyclic derivatives of glycolic acid (glycolide) with cyclic derivatives of lactic acid (lacticide) are used to prepare synthetic absorbable sutures. These sutures have high tensile strength and degradated by hydrolysis and absorbed in the tissue.

Non-absorbable sutures

Non-absorbable sutures are not affected by the body fluid and remained unchange for a long period. They are removed after healing of the wounds. Silk, cotton, nylon and metallic sutures are classified as non-absorbable sutures.

Silk Sutures : Silk sutures are prepared by spinning or twisting silk fibres into a single strand of varying diameters. The sutures are smooth and strong and braided by combining several twisted yarns into a compact mass. The strands are sterilized and boiled with water to soften them.

Cotton Sutures : Cotton sutures have uniform size and recommended in critical parts where strength of the sutures is required for long time.

Nylon Sutures : The microfilaments of nylon are braided into strands of required diameter. These sutures are strong, water resistant and used in skin and plastic surgery.

Linen Suture: A linen suture is cheap, very strong under moist condition but not uniform in diameter.

Metallic Sutures : Metallic wires of silver or stainless steel are used as surgical aid. These wires are available as monofilaments, twists and braids.

QUESTIONS

1. Give preparation and microscopical characters of Silk and Wool. What chemical tests will differentiate these fibres from other fibres ?
2. What are absorbable haemostatic dressings ? Give details of any one material used in the manufacture of these dressings.
3. Define dressing, bandage, sutures and ligatures. What are functions and properties of surgical dressings ? How will you differentiate absorbent and non-absorbent cotton fibres ?
4. Give an account of preparation of Absorbent Cotton. How does Cotton fibre differ from Wool in microscopic characters. What chemical tests will you perform to characterize the two fibres ?
5. Enumerate the various fibres used for surgical dressings. Give the microscopical characters and microchemical tests to distinguish the following : (a) Wool from nonabsorbent cotton (b) Absorbent cotton from nonabsorbent cotton (c) Cotton from silk.
6. Give the method of collection and preparation of silk. How are cotton, rayon and alginate fibres differentiated from one another by chemical tests ?
7. Give the source, preparation, microscopy, test of identification and constituents of animal wool.

17

PLANT ANATOMY

Cell is a fundamental unit of a living organism. The cell contains a cell wall and consists of the protoplasmic components and nonprotoplasmic materials.

A group of cells with the identical form and function is knwon a *tissue* in which the cell membranes are connected with a pectin layer called middle lamella. The cytoplasmic threads, called *plasmodesmata*, are consisted of cell wall, cell membrane, protoplasm and middle lamella. They interconnect the protoplasm of different cells and assist to conduct food and communicate stimuli. Plant tissues are divided into three main groups :

1. Dermal tissues,
2. Fundamental or group tissues, and
3. Vascular tissues.

1. Dermal Tissues

These tissues consist of outer protective coverings such as epidermis, periderm, trichomes, stomata, etc.

(i) **Epidermis :** Epidermis is the outermost protective single layer of young plant body. The epidermal cells are narrowly placed with no intercellular spaces. They show wide variation in shape, size and arrangement. A cuticle layer, containing cutin, is usually present on the outer surface. The cuticle layer is not present in root epidermal tissues.

Suberin, found in cork cells, and cutin consist of mixtures of polymerized fatty acids such as suberic acid, COOH $[CH_2]_6$ COOH. These compounds give yellow to brown colour with chlor-zinc iodine; red colour with Soudan glycerin and yellow colour with potash solution.

The structures of the epidermis and stomata are helpful in the identification of leaves. Straight-walled epidermal cells are present in Coca and Senna leaves, wavy-walled epidermal cells in Stramonium, Hyoscyamus and Belladonna; beaded walls in Lobelia and Digitalis species; a papillose epidermis in Coca Leaf.

(ii) **Stomata :** A stomata is made of a pair of similar cells, called guards cells, placed parallel to each other. It contains a pore in the centre through which gaseous exchange takes place. The epidermal cells surrounding the stomata are called subsidiary cells and they are different in shape. On the basis of arrangement with the subsidiary cells, the stomata are divided into four different classes :

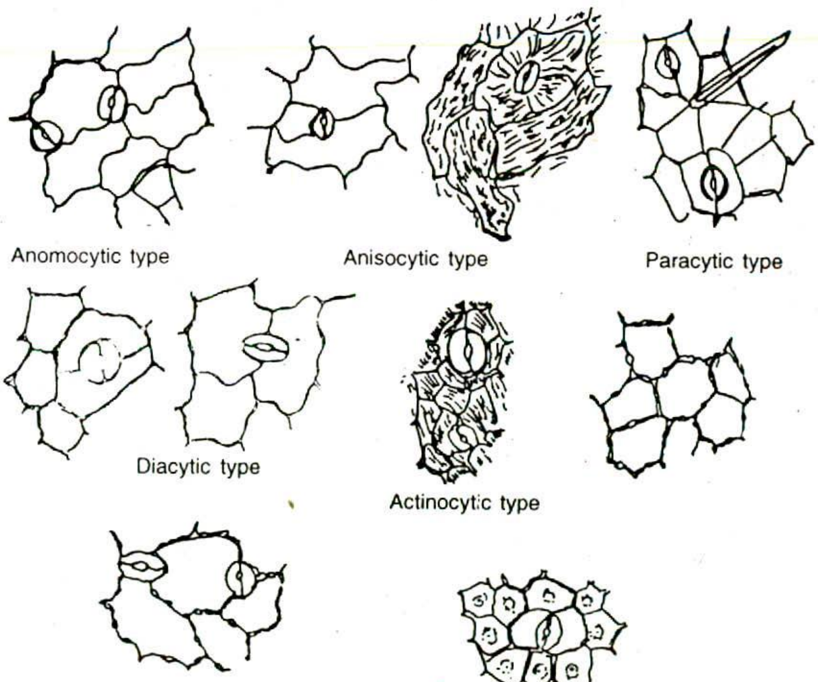


Fig. 17.1. Different kinds of stomata

(a) *Anomocytic or Ranunculaceous* type (Irregular type): The cells surrounding the stomal pore are irregularly arranged and cannot be distinguished from the other epidermal cells, e.g. Lobelia, Digitalis, Buchu.

(b) *Cruciferous or Anisocytic* (Unequal celled) : The stomal pore is surrounded by three or four subsidiary cells, one of which is markedly smaller than the others, e.g. Belladonna, Stramonium.

(c) *Rubiaceous or Paracytic* type (Paralled-celled) : Two subsidiary cells with their long axis are parallel to the pore, e.g. Senna, Coca.

(d) *Diacytic* or *Caryophyllaceous* type (Crossed celled) : The stoma is accompanied by two subsidiary cells, with their long axis at right angles to the pore of the stomata, e.g. Spearmint, Peppermint, Thyme, etc.

(e) *Actinocytic* (radiate-called) : This stoma is surrounded by a circle of radiating cells, e.g. Ursi.

(iii) **Epidermal Trichomes :** Trichomes are present on many leaves, herbaceous stems, flowers, fruits and seeds. A trichome may be differentiated into a base embeded in the epidermal cell and a tube like projecting body. Trichomes may be classified into two groups :

(a) *Covering trichomes :* They have protective function.

(b) *Glandular trichomes :* They secrete essential oils or oleo-resins. Both covering and glandular trichomes may be unicellular or multicellular, uniseriate or multiseriate and stalk or sessile.

(iv) **Endodermis (Periderm) :** The endodermis is a specialized layer of cells making the inner layer of the cortex. In mature plants the epidermis is replaced by endodermis due to the activity of the meristematic tissue called phellogen or cork cambium. The cells of the endodermis appear in transverse section four sided, oval or elliptical and often extended in the tangenital direction. The cells are longitudinally elongated.

In periderm lenticels are present which are pores identical in function. In lenticels, there are no guard cells and they remain always open.

2. Fundamental or Ground Tissues

Fundamental tissues include hypodermis, cortex, pith, mesophyll and midrib region.

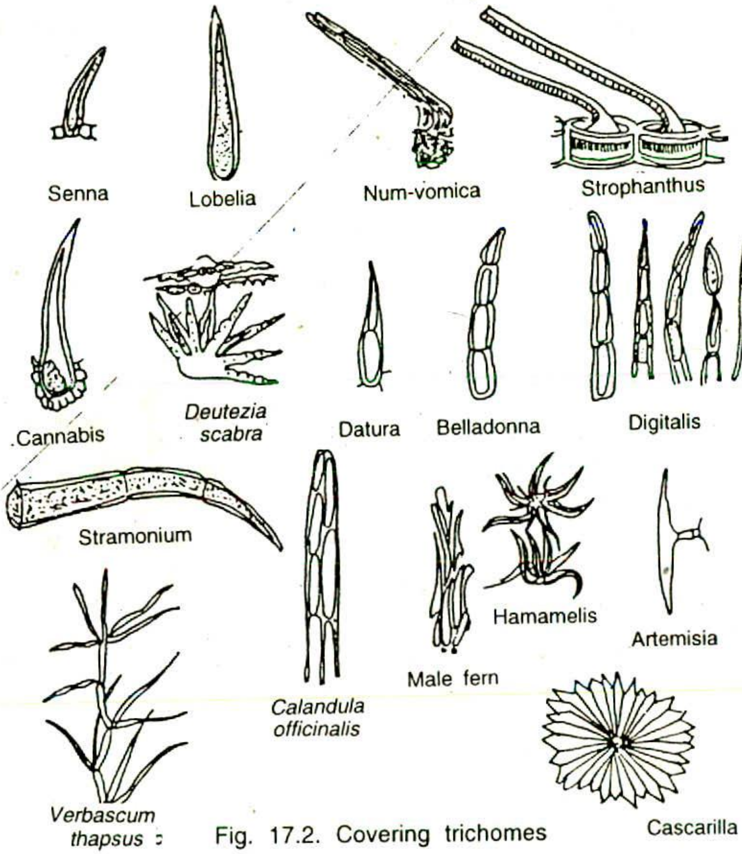


Fig. 17.2. Covering trichomes

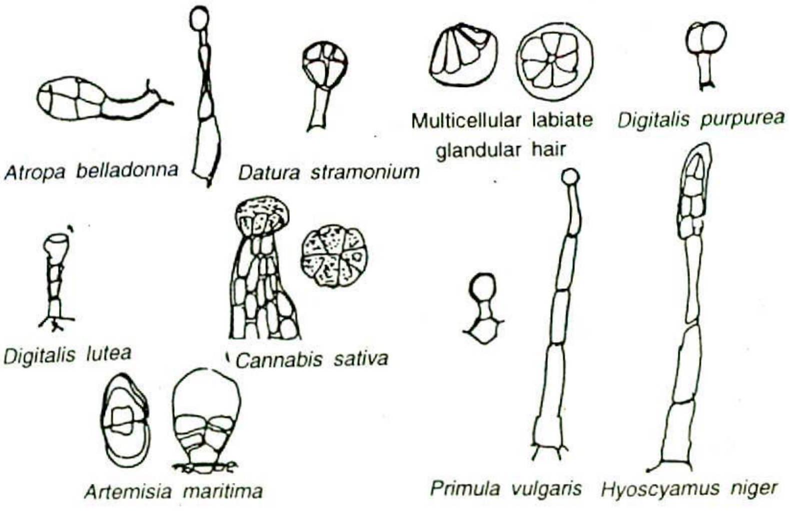


Fig. 17.3. Grandular hairs

(i) **Parenchyma** : Parenchyma contains living and thin walled cells with intercellular spaces. These cells vary in shape and are present in the cortex of root, cortex and pith of stem and mesophyll of leaves. Some parenchyma cells are pitted and contain reticulated thickening. Aerenchyma is parenchyma with large intercellular spaces. Chlorenchyma is parenchyma containing chloroplasts. The main functions of parenchyma are storage and photosynthesis.

(ii) **Collenchyma** : Collenchyma is a living tissue derived from parenchyma and has greater mechanical strength. The walls are thickened due to deposition of cellulose. These cells are usually present in cortical region of stem, petiole, bark and midrib of a leaf. The cells are usually 4 to 6 sided in transverse section, and axially elongated.

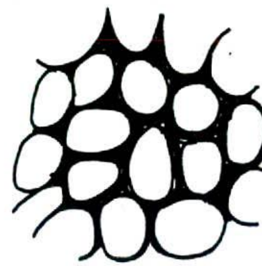


Fig. 17.4. Collenchymatous tissue

(iii) **Sclerenchyma** : Sclerenchyma cells are the dead and lignified tissues. The cell walls are heavily thickened with lignin. They occur in all parts of the plant body and give mechanical strength. These cells may occur as stone cells or fibres.

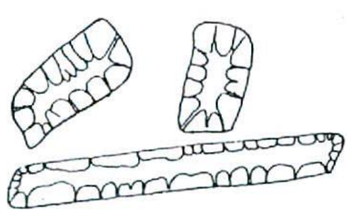


Fig. 17.5. Stone Cells

The stone cells or sclereids are isodiametrical or irregular in shape. Their walls are thick, lignified, often show well-marked stratification and traversed by pit-canals which are usually funnel-shaped or branched. The cell lumen is small and cell contents of diagnostic significance may be present. Stone cells are present in the hard outer coats of seeds and fruits and in the bark and pericyclic regions of woody stems. They occur singly or in groups.

Sclerenchymatous fibres are narrow, usually elongated with pointed ends. The tissue is composed of spindle-shaped or elongated cells with pointed ends and known as prosenchyma. The cell wall may be composed of pure cellulose and is usually lignified. Most mature fibres are unicellular and give mechanical support to the plant.

Isolated groups of pericyclic fibres occur in Lobelia and Cinnamon bark. Xylem fibres are derived from tracheids and have smaller pits, thicker walls and tapering ends. Phloem fibres may be lignified or unlignified.

3. Vascular Tissues

Vascular tissue system conducts food material and water. Phleom is a living tissue and conducts food material from leaves to the different parts of the plant. Xylem is a dead tissue and conducts water from roots to the leaves.

(i) **Phloem** : Phloem consists of sieve-tubes, companion cells, phloem parenchyma and secretory cells. It contains a vertical series of elongated cells and interconnected by perforations in their walls in areas known as sieve plates. Laticiferous tissues may also occur in the phloem.

(ii) **Xylem** : The structural elements of xylem are tracheids, vessels or tracheae, xylem fibres, xylem parenchyma and rays.

Tracheids are elongated tubes pointed at both ends. Their cell walls are lignified and pitted. Vessels or tracheae constitute of elongated tubes but without any oblique perforated walls. The vessels of the protoxylem show annular or spiral thickenings. The later-formed xylem contains sclariform and reticulate thickenings. The secondary wall thickening is composed of lignocellulose.

The living meshwork of a secondary xylem is composed of rays and xylem parenchyma. The xylem parenchyma cells are often axilly elongated, sometimes thin-walled but usually are thick and lignified. The formation of concentric zones of xylem parenchyma may give rise to 'false annular rings'.

According to the mode of presence of the xylem and phloem the vascular bundles may be collateral, bicollateral, concentric, and radial.

(a) **Collateral :** This is the most common type of vascular bundle found in stems and leaves. In this system the xylem and phloem remain side by side arranged on the same radius, phloem on the outer side and xylem on the inner side. Collateral bundles may be open when cambium is present in between phloem and xylem or closed when cambium is absent.

(b) **Bicollateral :** When another patch of phloem is present on the inner side of the external phloem, then the vascular bundle is called as bicollateral.

(c) **Concentric :** In this system one kind of vascular tissue surrounds the other.

(d) **Radial :** Here the xylem and phloem occur in separate patches on alternate radii on the axis. Radial vascular bundles are characteristic of roots.

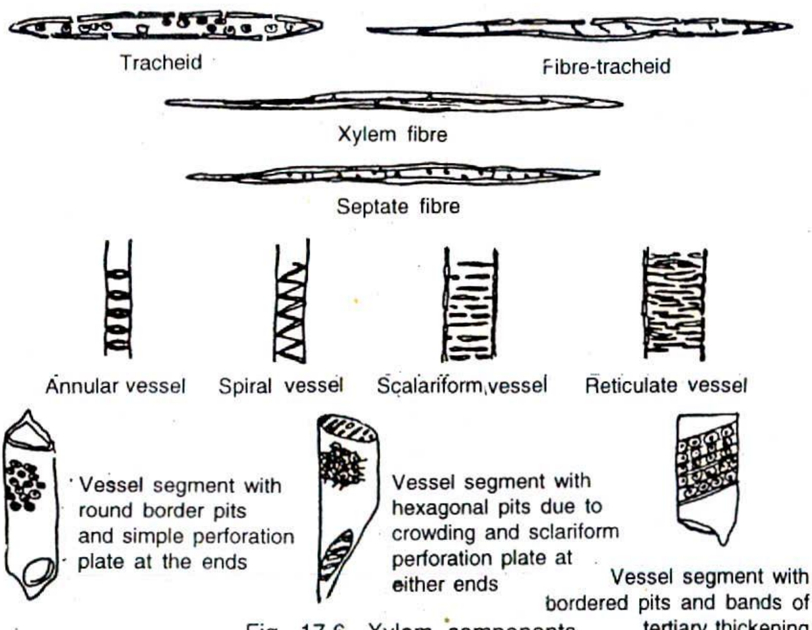


Fig. 17.6. Xylem components

In dicot stems the vascular bundles are arranged in the form of a ring and in monocot, the bundles are scattered.

Cambium : Cambium is a meristematic tissue present between the phloem and xylem in dicot stems. It is absent in young roots, but appears on maturing the plant between the radially placed phloem and xylem. Then it forms a zig-zag ring giving out secondary xylem on the inner side and secondary phloem on the outer side. The delicate primary structures are either crushed or poorly represented in developed plant parts.

Medullary rays are composed of parenchymatous cells, run diagonally and extend from pith (medulla) to the cortex through the secondary xylem and secondary phloem.

Secretory Tissues : Secretory cells, secretory cavities or sacs, secretory ducts or canals and latex tissue are the secretory tissues. Cells containing oils, resins, oleoresins and mucilage are present. The vittae of Umbelliferae are schizogenous oleoresin canals and they are found in the stem, roots and leaves. Latex (laticiferous) tissue consists of cells or tubes which contains a milky fluid.

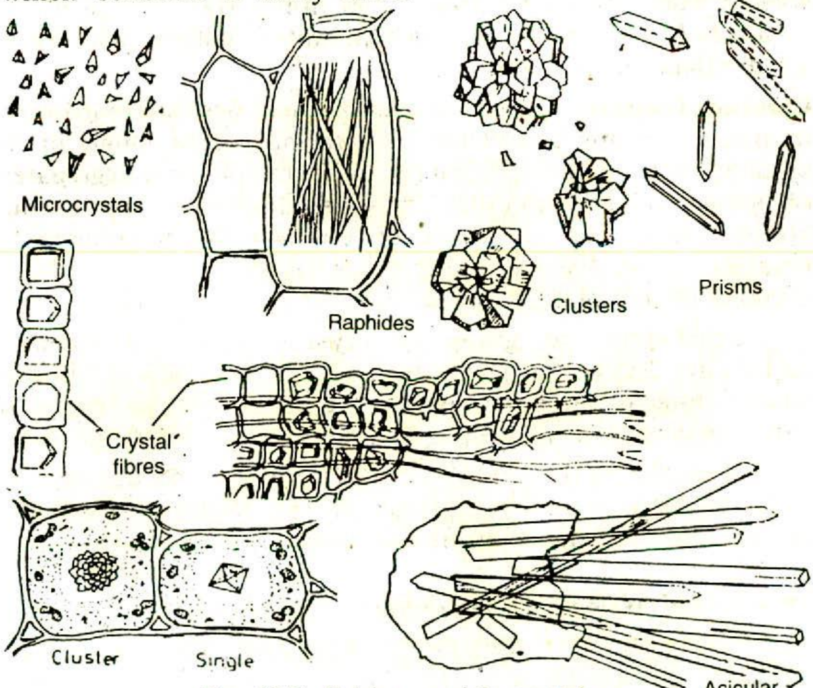


Fig. 17.7. Calcium oxalate crystals.

Three types of secretory cavities are known : *Schizogenous* cavity which is formed due to splitting of the epithelial cells; *Lysigenous* cavity - formed due to dissolution of cells and *Schizo-lysigenous* cavity - formed by both the operations.

Ergastic Cell Contents : These cell contents are identified by microscopical examination or by physical and chemical tests. They include carbohydrates, proteins, fixed oil, fats, alkaloids, volatile oils, resins, gums, calcium oxalate, silica, etc.

Starch : Starch occurs as granules in roots, rhizomes, fruits and seeds. Starch of various sources differs in shape and size.

Proteins : Protein is found in the form of aleurone grains surrounded by thin membrane. The ground mass of protein encloses one or more rounded bodies and an angular body known as the crystolloid.

Fixed Oils and Fats : They are usually present in seeds.

Gum, mucilage and pectins are polysaccharide complexes formed from sugar and uronic acid units. They are insoluble in alcohol but dissolve or swell in water. Volatile oils occur as droplets in the cell.

Calcium Oxalate : These crystals occur in five different forms in plants. Prisms of calcium oxalate may occur singly or in small groups. Sphaeraphides (Druses) are spherical aggregates of sharp pointed angular crystals. Raphides are needle shaped single or collection of bundles. Micro-sphenoidal crystals occur like an amorphous mass in a cell. These crystals shine brightly when seen in polarized light.

Crystoliths are group of crystals made of calcium carbonate. They are present as small bunches of grapes whose stalk are made of cellulose. Calcium oxalate dissolves with effervescence in acetic, hydrochloric or sulphuric acid.

Silica forms the skeletons of diatoms and occurs on cell walls as masses in the interior of cells. Silica is insoluble in all acids except hydrofluoric acid.

Senna Leaf *(Cassia angustifolia)*

Leaf presents an isobilateral structure containing the following tissues :

Epidermis : Epidermal cells are tabular with straight anticlinical walls and frequently containing mucilage. Upper epidermis is single-layered with a thick layer of cuticle on outerside. Covering trichomes, present on both sides, are unicellular, with thick warty walls, usually curved near the base and pointed in the direction of the limb; the base surrounded by radial epidermal cells. Two-celled paracylic stomata are present on both sides in equal numbers.

Mesophyll : Palisade layers, cluster crystals and spongy mesophyll are the part of mesophyll. Upper palisade layer is compact, single-layered, with elongated, narrow, columnar cells present over the midrib portion. The cells of lower palisade are smaller than that of upper palisade, loosely arranged with warty walls and present at lamina. The parenchymatous cells of spongy mesophyll are narrow, thin, loosely arranged and present between upper and lower palisade. Occasional cluster crystals of calcium oxalate are present in the mesophyll.

Midrib : The midrib is biconvex and its lower part contains collenchymatous cells. The cells of the upper palisade are smaller. Collateral vascular bundles are incompletely surrounded by sclerenchymatous fibres with a crystal sheath of calcium oxalate crystals and present on the central part of the midrib. Xylem is towards the ventral surface and phloem towards the dorsal surface.

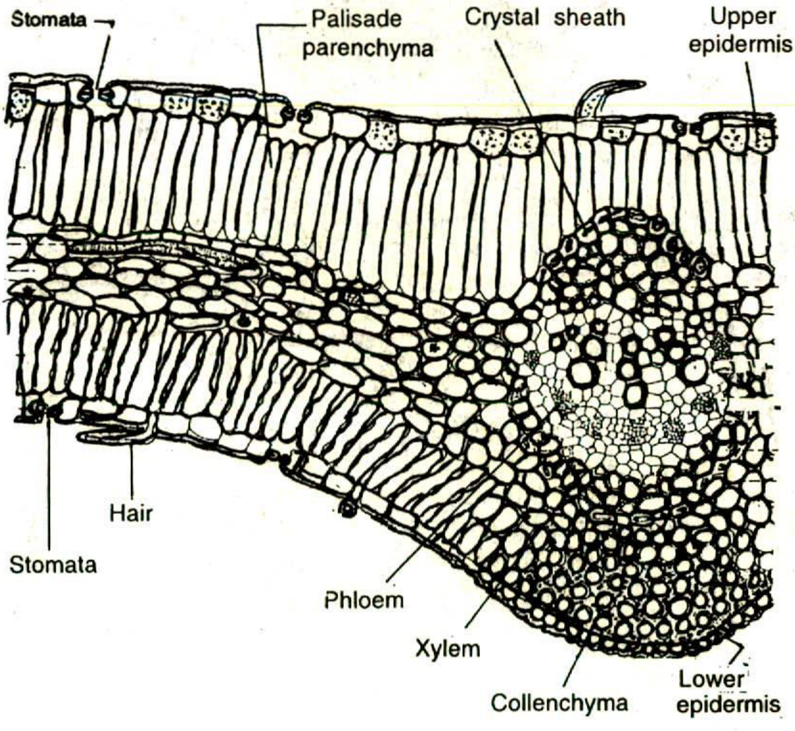


Fig. 17.8. Transverse section of Senna Leaflet

Datura Leaf *(Datura stramonium)*

A transverse section of Datura leaf shows a bifacial structure. The important tissues of epidermis, mesophyll and midrib region are :

Epidermis : The cells of upper epidermis are single layered and rectangular. The lower epidermal cells have wavy walls. Both surfaces are covered with smooth cuticle. Covering and glandular trichomes are present, being more numerous in young leaves. The covering trichomes are uniseriate, conical, composed of three to five cells with warty walls; blunt at the apex. The glandular trichomes are short and clavate, with two to seven cells in the head. Stomata are anisocytic and more frequent on the lower epidermis.

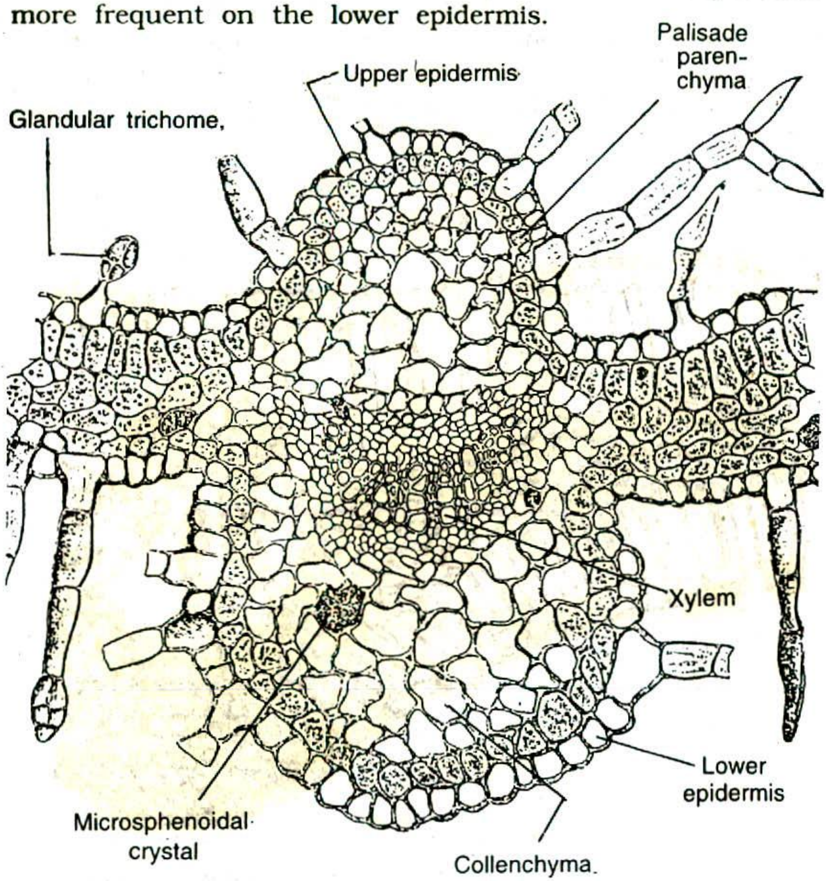


Fig. 17.9. Transverse section of Datura Leaf

Mesophyll : Mesophyll is dorsiventral with single palisade layer containing compact and radially elongated cells. Under palisade layer there is a crystal layer with each cell containing cluster crystals of calcium oxalate, long, or occasional prisms of microsphenoidal crystals. No crystals are present in cells adjoining the veins. Spongy parenchyma of mesophyll is multilayered and loosely arranged with intercellular spaces.

Midrib : The midrib shows a bicollateral structure. Typical subepidermal cells of collenchyma are present on both surfaces. The epidermal layers of lamina are continuous in the midrib region. Collenchymatous layer is followed by cortical parenchyma containing prisms of calcium oxalate and microsphenoidal crystals.

Cinchona Bark *(Cinchona succirubra)*

Transverse section of the bark shows periderm, cortex and secondary phloem.

Periderm : It is composed of multi-layered thin-walled cork cells, arranged in a regular radial rows and appearing polygonal. The contents of the cells are thin-walled and dark reddish in colour. The cork cells are impregnated with suberin. There are 3-4 layers of thin walled rectangular cells of phellogen without any cellular contents. There are 6-8 layers of thin rectangular cells without any cellular contents near the phellogen and arranged in radial rows.

Cortex : The cortex is composed of thin-walled, tangentially elongated, pitted and multi-layered cells. They contain starch granules, or amorphous reddish brown matter, with scattered idioblasts, possessing microprisms of calcium oxalate and large secretory cells, spaced at intervals near the inner part.

Phloem : It consists of narrow sieve tubes, sieve plates, phloem parenchyma which resembles that of the cortex and with large characteristic spindle shaped phloem fibres. The fibres occur with thick, conspicuously striated walls transversed by funnel-shaped pits, with isolated or in irregular radial rows.

Medullary rays are two to three cells wide, with thin-walled, somewhat radially elongated cells. The fibres are present with phloem parenchyma and in between medullary rays. Phloem fibres are numerous, fusiform, mostly isolated, rounded to oval, in different sizes, yellow in colour, thick-walled, heavily lignified with a small lumen and stratification. The distribution and size of the phloem fibres differ in various species. Sclereids are rare.

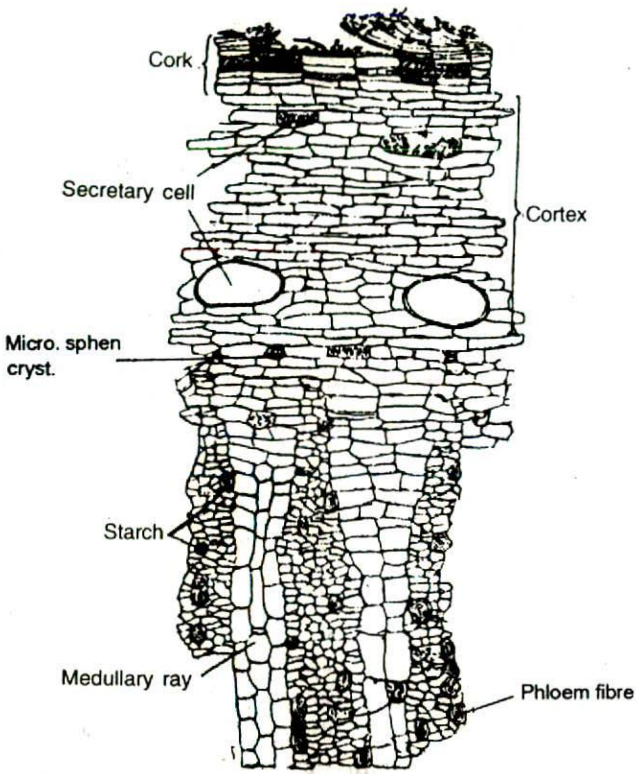


Fig. 17.10. Transverse Section of Cinchona bark

Fennel *(Foeniculum vulgare)*

Transverse section of Fennel mericarp shows commisural and dorsal surfaces. The commisural surface is flat containing two pronounced ridges and carpophore in the middle. The dorsal surface has five ridges. Mericarp is divided into pericarp, testa and bulky endosperm. The epicarp (exocarp) of the pericarp encircles the entire mericarp and consists of a layer of polygonal, tangentially elongated cells with smooth cuticle.

The mesocarp is made of parenchyma and bicollateral vascular bundles below the primary ridges. Vascular bundles are surrounded by reticulate and lignified parenchyma. **Yellowish brown** and elliptical **vittae** (schizogenous ducts), four on the dorsal surface and two on the commissural surface, are present in the mesocarp.

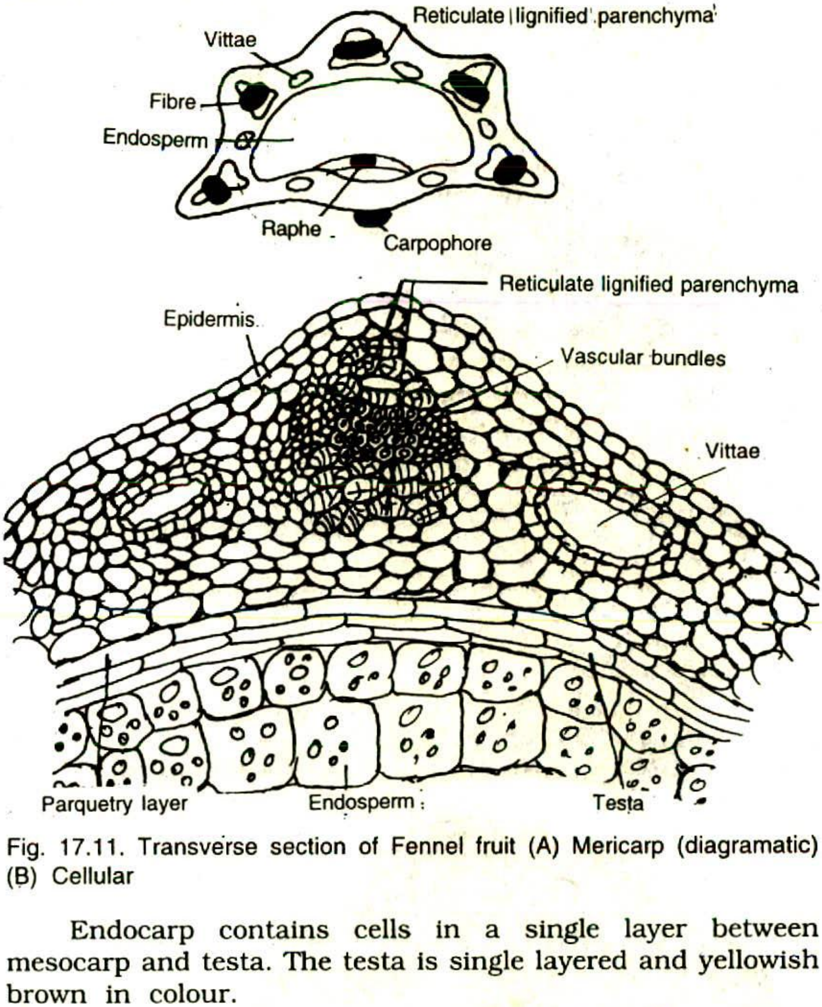


Fig. 17.11. Transverse section of Fennel fruit (A) Mericarp (diagramatic) (B) Cellular

Endocarp contains cells in a single layer between mesocarp and testa. The testa is single layered and yellowish brown in colour.

Endosperm consists of thick-walled, polygonal, colourless parenchyma. It contains aleurone grains and oil globules. A crescent shaped embryo is seen in sections through the apical region of mesocarp. Raphae is present in the middle of commissural surface in front of carpophore.

Clove Flower Bud *(Syzygium aromaticum)*

Transverse section of Clove hypanthium below the ovary shows epidermis, cortex and columella.

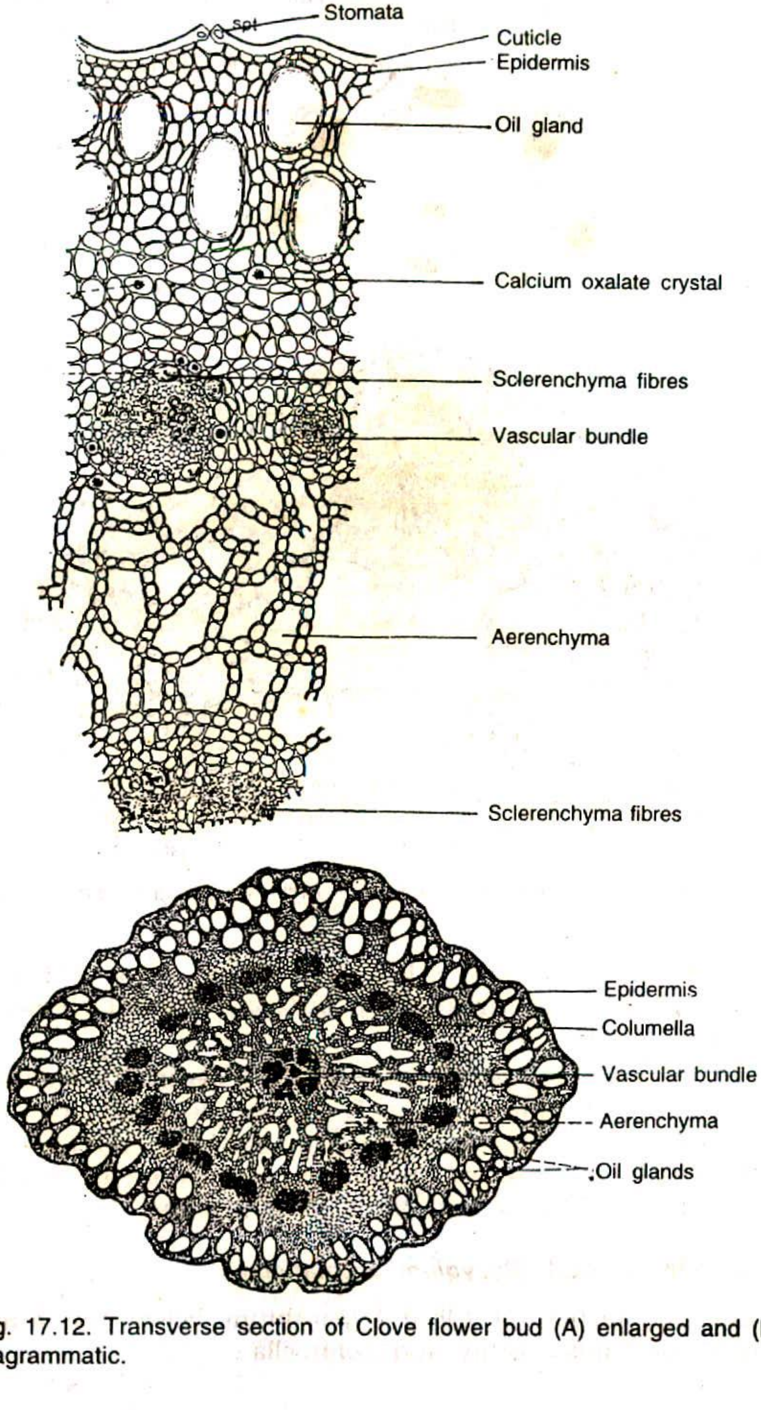


Fig. 17.12. Transverse section of Clove flower bud (A) enlarged and (B) diagrammatic.

Epidermis is heavily cuticularized with straight walls in which occur ranunculaceous stomata.

There are three different regions in the cortex. The peripheral region is composed of 2-3 layers of large, ellipsoidal, schizolysigenous oil glands arranged in two or three intermixed layers. The oil glands are ellipsoidal in shape, with the long axis radial and show an epithelium composed of two or three layers of flattened cells. Clusters of crystals of calcium oxalate occur in many of the parenchymatous cells. Within the oil gland layer there is a zone of cells with somewhat thickened walls embedding a ring of bicollateral vascular bundles. The ground tissue of this zone contains cluster crystals of calcium oxalate. The meristeles are enclosed in an incomplete ring of lignified fibres.

The middle region contains one or two rings of bicollateral vascular bundles with few pericyclic fibres. The xylem is composed of 3-5 lignified spiral vessels. Within the ring of vascular bundles is a zone of aerenchyma, composed of air spaces and columella. The ground tissue of the columella is parenchymatous and rich in calcium oxalate clusters. In the outer region of the columella is a ring of some 17 small vascular bundles. Numerous sphaeraphides are present scattered throughout the columella.

The hypanthium, in the region of the ovary, shows epidermis, oil gland layer and ring of bicollateral bundles. Within this is a zone of cells with strongly thickened cellulose wall. The dissepiment of the ovary is parenchymatous; the placentae are rich in cluster crystals and contains vascular bundles.

Ginger Rhizome *(Zingiber Officinale)*

A transverse section of unpeeled Ginger rhizome shows a zone of cork cells, cortex, endodermis and ground tissues.

Outer zone of cork tissue consists of irregularly arranged cells. The cork cambium is differentiated. Within the cork is a broad cortex, differentiated into an outer zone of flattened parenchyma and an inner zone of normal parenchyma. The cortical cells contain abundant starch grains. These are almost entirely simple, ovoid or sack-shaped and have a markedly eccentric hilum. Numerous oil cells, with suberized walls enclosing yellowish-brown oleoresin, are scattered in the cortex. The inner cortical zone usually contains about three rings of collateral, closed vascular bundles. The larger bundles are enclosed in a sheath of septate, non-lignified fibres. Each vascular bundle contains phloem, showing well-marked sieve-tubes and a xylem composed of 1-14 vessels with annular spiral or reticulate thickening. The inner part of the cortex is marked by a single-layered endodermis free from starch. The outermost layer of the stele is marked by a single layered pericycle. The vascular bundles of stele resemble those of the cortex, and are scattered as in monocotyledonous stems.

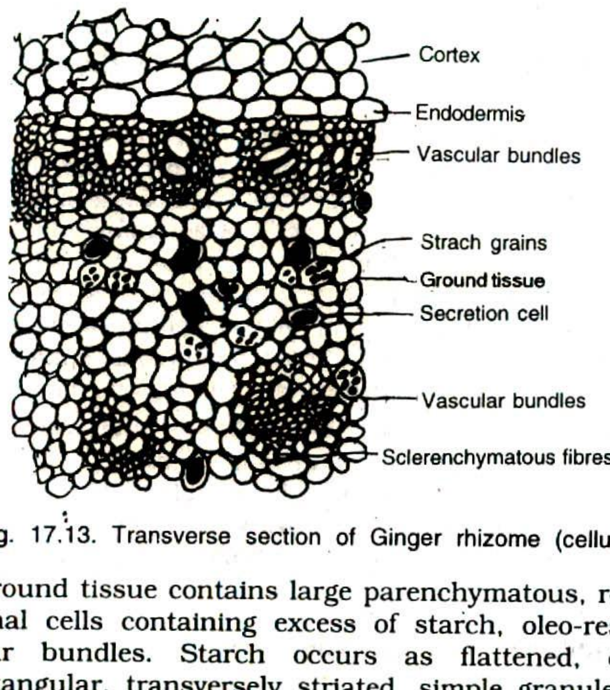


Fig. 17.13. Transverse section of Ginger rhizome (cellular)

Ground tissue contains large parenchymatous, rounded, polygonal cells containing excess of starch, oleo-resin and vascular bundles. Starch occurs as flattened, oval or subrectangular, transversely striated, simple granules, each with a hilum in a projection towards one end. Oleo-resin cells contains suberized cell walls and yellow contents. Pigment cells contain dark, reddish brown contents and occur either singly in ground tissue or in axial rows accompanying the vascular bundles. Sclereids and calcium oxalate crystals are absent.

Nux-Vomica Seed *(Strychnos nux-vomica)*

The transverse section shows hairy thin testa and a bulky endosperm.

The testa consists of collapsed parenchyma and a single epidermal layer of very typical lignified hair. Each hairy epidermal cell has a very large, thick-walled base with slit-like pits. The upper portions of each hair are set at almost a right angle to the bases and all radiate out towards the margin of the seed giving the testa a silky appearance. The upper part of the wall of the hair is composed of about ten longitudinal ridge-like thickenings united by a thin wall. The lumen is circular in the upper part but in the base has branches.

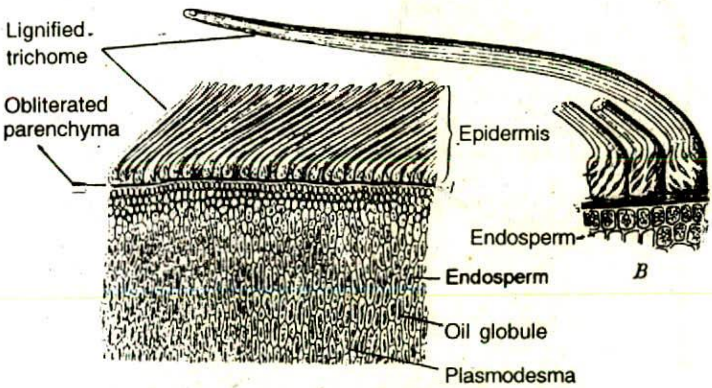


Fig. 17.14. Transverse section of Nux-vomica seed (cellular)

The endosperm consists of a large, thick-walled cellulosic parenchyma. The walls are non-lignified, composed mainly of hemicellulose and swell considerably in water; the lumen is polygonal. Outermost layers of the endosperm appear palisade like whereas polyhedral, unlignified, parenchymatous cells are present in the inner layer. Well-marked interconnected plasmodesma (protoplasmic threads) is observed by staining the section with dilute iodine. Aleurone grains and fixed oil droplets are also present in endosperm. Strychnine is most abundant in the inner layer of the endosperm and brucine in the outer layers. The epidermis of the endosperm is formed of smaller cells.

Ipecac Root *(Cephaelis ipecacuanha)*

A transverse section of the root shows a thin brown cork, wide secondary cortex (phelloderm) and vascular bundles.

The cork layer is composed of thin-walled polyhedral, tabular cells. The cells of phelloderm are parenchymatous and contain starch, usually in compound grains with from two to eight components or raphides of calcium oxalate. The individual starch granules are oval, rounded or roughly hemispherical.

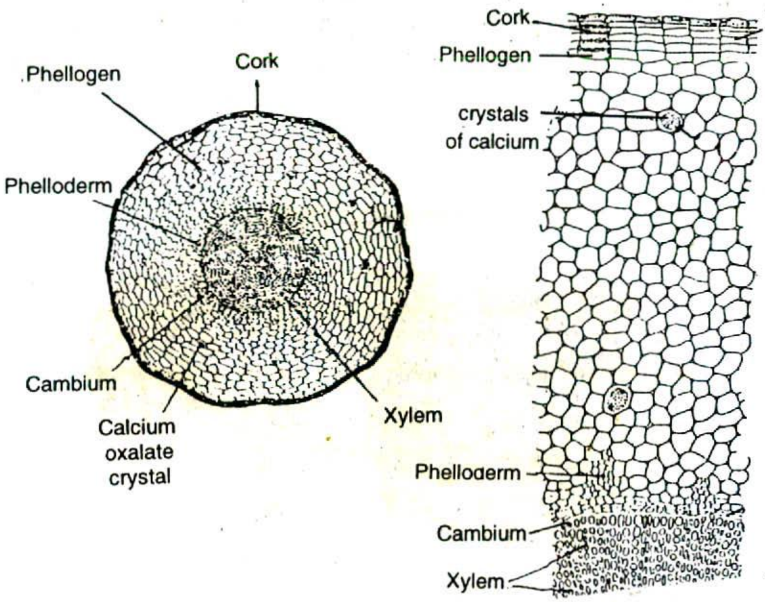


Fig. 17.15. Transverse section of Ipecacunha root.

The secondary xylem consists of narrow tracheidal-vessels and tracheids, both having bordered pits in their lateral walls, associated with xylem parenchyma. The segments of the tracheidal-vessels usually have the communicating opening on the side walls near the ends. The cells of the xylem parenchyma have simple pits. The vessel elements have simple and circular perforations. Cells of xylem parenchyma and medullary rays contain abundant starch consisting of simple granules. The medullary rays are one or two and their cells are wide.

The phloem occurs as small groups of sieve tissue embedded in parenchyma. The phloem is entirely parenchymatous, containing no sclerenchymatous cells or fibres.

Coriander Fruit *(Coriandrum sativum)*

A transverse section of a fully ripe fruit shows only two mature vittae in each mericarp, pericarp, mesocarp and endosperm.

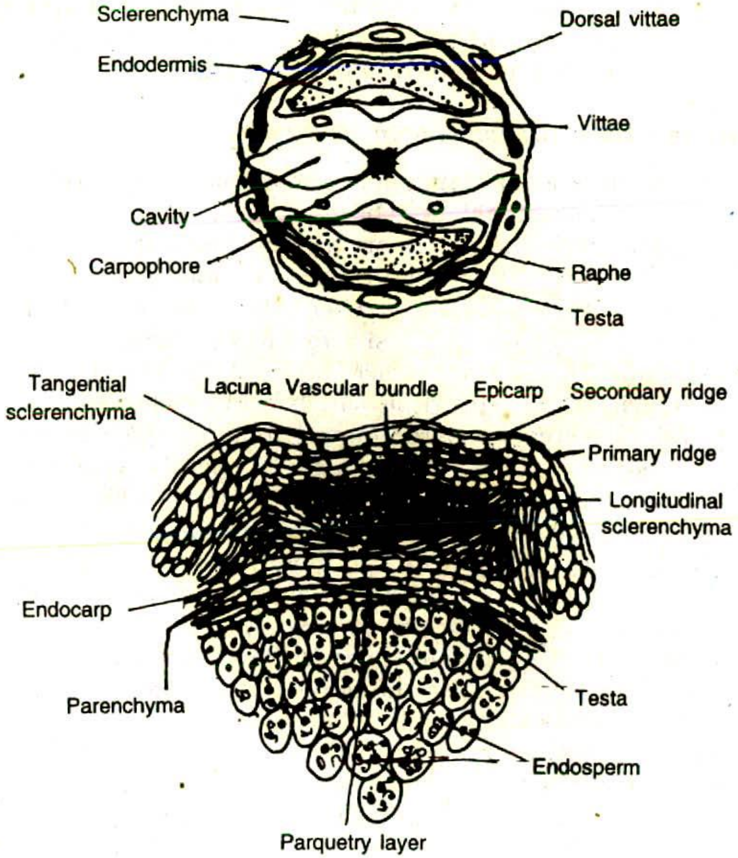


Fig. 17.16. Transverse section of Coriander fruit (A) Outline diagram (B) Cellular x 150

Vittae are present on the commissural surface. Mesocarp is differentiated into outer, middle and inner zones. Outer zone is parenchymatous, containing degenerated vittae as tangentially flattened cavities. Middle zone is sclarenchymatous, composed of sinuous rows of pitted, fusiform lignified cells often crossing one another at right angles and forming definite longitudinal strands in the primary ridges and tangentially directed in the secondary ridges. Inner mesocarp is partially composed of thin-walled hexagonal sclereids. The inner epidermis of mesocarp consists of cells showing parquetry arrangement and the hypodermis of large, slightly thickened, flattened hexagonal sclerenchyma. Endosperm is parenchymatous, made up of thickened cellulose walls, contains fixed oil and numerous aleurone grains with minute rosettes of calcium oxalate. The testa is composed of brown flattened cells.

Cinnamon Bark *(Cinnamomum zeylanicum)*

Transverse section of Cinnamon under microscope indicates that except occasional patches of cork and underlying parenchyma, cork and cortex are absent. The outermost layer consists of a continuous band, three or four cells wide, of pericyclic lignified sclerenchyma. On the outer margin there are small group of about six to fifteen *pericyclic fibres* occurring at intervals. The sclereids have thickened lignified walls, showing well-defined pit canals. The thickening on the outer walls is often less pronounced than on the radial and inner tangential walls. The lumen is clearly visible and contains a few starch grains. The pericyclic fibres have strongly thickened lignified walls showing stratification and pit canals. Primary phloem can not be differentiated. The secondary phloem is consisted of phloem parenchyma, containing oil and mucliage; phloem fibres and medullary rays. The *sieve-tubes* are arranged in tangenital bands which are completely collapsed in the outer layers. The sieve plates are on the transverse walls. The phloem parenchyma is composed of thin-walled cells, with yellowish-brown cells and contains starch grains. These cells are sub-rectangular in shape. Some cells contain scattered minute needles of calcium oxalate. Some of the phloem parenchyma cells contain tannins. The secretary cells, containing volatile oil or mucilage, are two or three times the diameter of the phloem fibres, and are axially elongated. The phloem fibres, which occur isolated or in tangential rows, are more abundant towards the inner part of the bark. The secondary phloem is divided up by the radial medullary rays, which are uni- or biseriate near the cambium but become broader towards the outside by tangenital growth the the cells. The rays are 7-14 cells in height. The medullary ray cells are radially elongated, thin walled with yellow-brown cell contents possessing numerous acicular crystals of calcium oxalate.

Fig. 17.17. Transverse section of Cinnamon bark.

QUESTIONS

1. Describe various plant tissues with suitable examples? How do these tissues assist in authentication of a drug ?
2. Discuss different types of stomata, secretary tissues and calcium oxalate crystals.
3. Draw cellular diagrames of any two of the following : (a) Clove, (b) Senna (c) Fennel.

18

PESTICIDES

Pest control is a major problem in cultivation of plants throughout the world. A pesticide is any toxic substance used to kill animals or plants that cause economic damage to crop or ornamental plants or are hazardous to the health of domestic animals or humans.

Rodents damage stored food products in homes and in warehouses. Weeds interfere with the normal growth of crop and garden plants. Fungi growth take place on vegetable and fruit plants. Various types of insects destroy the crop and food articles.

All pesticides interfere with normal metabolic processes in the pest organisms and often are classified according to the type of organism they are intended to control, *viz.* fungicides, herbicides, insecticides, rodenticides, molluscacides, nematocides and fumigants. Methods of these pesticides employ similar toxic substances. The means of application, chemical nature, types of products, precautions to be taken, symptions of accidental poisoning and immediate means of treatment are part of knowledge which must be known to the distributors and customers. The manufacturer must provide the efficacy of the product, its safety toward human beings, crops, livestock, wildlife and the general environment. The pesticide should not be deposited as residue on food which causes such a hazard.

Types of Pests

Rodents and arthropods are the most destructive animal pests. The plant pests include weeds and the fungi pathogenic to cultivated plants.

Rodents : Rodents are mammals like rat, mouse, rabbit and monkey, which have sharp gnawing incisor teeth. In some stores the crude drugs are often contaminated due to fecal pallets and hair from the fur of rats and mice. Rodents are responsible for transmitting diseases from which they are suffering. Biting of a rat causes rat-bite fever, an infectious disease caused by microorganisms. A large number of lice infected rodents transmit typhus fever, bubonic plague, and rat leprosy. Rats carry ticks and mites which carry tularemia, Rocky Mountain spotted fever, and undulant fever producing microorganisms.

Arthropods

Arthropods are the insects, spiders, ticks, mites, and lice. Some of these cause discomfort only, while others cause fatal diseases. Insects represent the class of the phylum Arthropoda and according to their mouth parts they are divided into two morphologic groups :

1. biting and chewing, and
2. piercing and sucking.

The insects of the first category are dependant on the leaves and stems of plants. They are present in excess number to strip a cultivated field. Grasshoppers and locusts destroy the crop during the developmental process and after maturity stage. Tomato horn worms and army worms cause destruction during larva or caterpiller stage.

Most of the insects possess a piercing-sucking modification of mouth parts with which they penetrate into the epidermal tissues of plant organs and suck the juice from the soft tissues. The examples are aphids (plant lice), San Jose scale, Chinch bugs, squash bugs, cabbage bugs and leafhoppers.

Cockroaches, termites, silverfish, cloth moths, carpet beetles, flies, bedbugs, fleas, and mosquitoes are house hold insects which have either chewing jaws or possess a piercing sucking mechanism. Mosquitoes and deerflies bite human beings and animals. The malarial mosquito exples some of its protozoan-laden saliva during penetration of the human epithelium. The microorganisms enter the blood stream when the long hollow tube, called probocis, contacts the capillaries to obtain the drop of blood. Malaria, yellow fever, sleeping sickness, dengue fever, and other infectious diseases are spread by this process. The destruction of mosquitoes, flies, ticks and related arthropods stop spreading of these disastrous diseases for ever.

Piercing-sucking mouth parts are present in lice, fleas, mites,ticks and spiders. Rocky Mountain spotted fever is spread by the wood tick, *Dermacentor andersoni* and the dog tick *D.variabilis*. The rat flea, *Xenopsylla cheopsis*, is responsible for the spread of endemic typhus fever, and the body mouse, *Pediculis corporis*, causes typhus. Mites like *Sarcoptes scabiei* produce scabies. The hairy spiders bite can kill birds and small mammals. The black widow spider, *Latrodectus mactans*, bite is painful. A bacterium transmitted to human beings by the bite of a deer tick, *Ixodes ricinus*, causes lyme disease in U.S.A. which is an affliction of summer.

Weeds

Any undesirable plant is known as weed. A weed may be a dandelion in a lawn, a thistle plant (Gokhru) in a vegetable garden, or mustard in a clove field. Undesirable plants in gardens interfere in the growth of cultivated plants by consuming most of the available water contents and minerals of the soil. Weeds grow and flourish in the conditions of much sunshine, ample moisture and well-fertilized soil which are provided for cultivation of some ornamental plants and vegetables. If weeds are allowed to grow, they will soon acquire possession of the garden and gradually destroy the more dilicate, cultivated plants. Similarly, the quality of the field crops, specially grains, become poor due to presence of weed seeds.

A considerable number of weeds are toxic in nature. Corn cockle, *Agostemma githago*, contains a cyanophore type of glycoside, and its seeds cause death when they are present in excessive quantities in wheat flour. A large number of plants give rise to allergic reactions in certain individuals. Once a person has been sensitized to a particular allergen, subsequent exposure to the materials produces an antigen-antibody reaction which results in the liberation of histamine or identical compounds causing allergic symptoms. Allergies are commonly asthma and dermatitis. Pollens of grasses like timothy (*Phleum pratense*), cocks foot (*Dactylis glomerata*) and perennial rye (*Lolium perenne*) as well as that of nettle (*Urtica dioica*), Plantain (*Plantogo* spp.) and ragweeds (*Ambrosia* spp.) are responsible for seasonal hay fever. A number of common moulds produce spores which cause rhinitis and asthma in sensitive individuals. *Rhus* spp.like *R. radicans* (poison ivy), *R. toxicodendron* (poison oak), *R. deversiloba* (Pacific poison oak) and *R. vernix* (poison elder) (fam. Anacardiaceae) contain contactant allergens which produce severe dermatitis associated with watery blisters. Sesquiterpene lactones from the species of Compositae, Lauraceae and Magnoliaceae and from the Liverwort *Frullania* (Fam. Jubulaceae) are a major class of compounds causing allergic contact dermatitis in human. The fruits and seeds of *Menispermum canadense* and *Datura stramonium* are poisonous when swallowed.

Some of the poisonous fungi when taken orally produce hallucinations. The examples are *Amanita, Psilocybe* and *Conocybe.* Certain cacti contain protoalkaloids, some of which have marked hallucinogenic properties.

Fungi Parasitic on Plants

Various type of fungi growing on plants produce many diseases such as wheat rust, white pine blister rust, Dutch elm disease, hollyhock rust, orange leaf rust of black berries and raspberries, asparagus rust and rose rust. Various fungicides and chemical agents are available for the control of fungus disease. Precaution is taken from the beginning of cultivation of a crop. The seeds should be freed of adhering fungus spores before being planted. It is treated with a suitable fungicide such as Thiram (tetramethylthiuram disulphide). Different type of windborne bacteria and fungi grow on tender shoots. They contaminate young seedlings and plants growing near these infected plants. In such cases, sprays or fungicidal dusts are applied to prevent germination of the parasitic species.

Different types of microorganisms produce a number of plant diseases. Viral diseases are caused by tobacco mosaic and the bean mosaic. Bacteria are responsible for the diseases like carrot rot, 'fire blight' of pear and apple and the wilt of cucumber, squash and melon. Physmycetes cause 'damping off' fungus, downy mildew of grapes and 'late blight' of potatoes. The diseases such as powdery mildew of lilac, American chestnut blight and Dutch elm disease are produced by Ascomycetes. The microorganisms Ascomycetes cause the corn smut, 'loose smut' of oats, wheat rust, apple rust and other rusts.

Methods of Control of Pests

The following methods are adopted for pest control.

Mechanical Methods : Mechanical methods include hand-picking, burning, trapping and pruning. Large caterpillers, e.g. a large, green tomato hornworm larva, can be located rapidly and removed by hand. Weeds are removed by hand-picking. The tent caterpillers gather on branches of trees and shrubs. By pruning or cutting out such branches is an effective measure. If the insect's tent is located near the trunk where cutting is difficult, then this part is burnt by a torch of burning oil-soaked rags at the end of a long pole. Burning helps in destruction of both animal and plant pests removed by hand-picking or pruning.

For determining the spread of certain flying insects in an infected area, they are trapped by a pleasantly flavoured attractant placed in funnel-shaped containers. Anise oil, Rose o or other attractants are mixed with sawdust and placed in glass containers over which a funnel-shaped entrance has been fitted. The insects fly or crawl through the opening into the jar. Japanese beetles, gypsy moth, codling moth, etc. are located by this method.

Special traps are used to catch larger field insects, rats and mice. Metal reinforcement corners on window frames and door sills are used to prevent the access of rodents to storage sheds and barns. Modern concrete warehouses are helpful to control rodents. Window screens, electrified screens, specially coloured lights and other devices are also employed for controlling insects.

Biological Methods : Some animals or insects feed upon smaller forms which destroy the plants. Some insects have a short life cycle which parasitize larger insects. For examples, rabbits are helpful in destroying certain type of weeds. Cats, owls, kites and hawks are enemies of mice and rats. Insects are eaten by birds.

Certain flies and wasps lay eggs on the body of large destructive insects like slow-moving larvae. The eggs of the parasitic insects hatch rapidly into small larvae which consume the body tissues of the larger species. Ultimately, the larger forms die and the parasitized organism is developed into cocoon stage. It is emerged as adult fly and begins the cycle once again.

Environmental Methods: The environmental conditions surrounding the pest are changed either by removing its food supply or by interfering the completion of its life cycle. Mosquito larvae in water are killed by spreading a layer of oil.

Agricultural Methods : A more select crop plant is developed that will resist attack by pests like fungus and bacterial attack. Plants can absorb sufficient organic phosphorus compounds through the roots and foliage to cause the death of insects eating the leaves. Crop rotation is another useful agricultural method. If the chief source of food of a particular insect is withheld for one or more seasons, insects are controlled dramatically. The development of varieties of winter wheat, grown when insect pests are inactive, is important. Grub stage of some insects is unearth by deep ploughing rather than shallow furrowing.

Chemical Methods : Chemicals are designated to be effective as rodenticide (against rats, mice, moles, etc), insecitides (against various insects and arthropods), herbicides (against weeds and undesirable plants) and fungicides (against all types of fungi).

Particular chemical agents are used as poison baits, spray solutions, suspensions for spraying, aerosols, fumigants, residual poisons, stomach poisons, and repellents. They may be inorganic, or organic compounds obtained from natural sources, or synthetic organic complexes.

Pest Control by Chemicals

The choice of chemicals is dependent on the type of pest. If the pest is a rat or mouse, the chemical used will differ according to the locating conditions of the pest. An insect pest may be a chewing or sucking type, a running or flying type, an indoor or outdoor type. Similarly, chemicals are selected properly to control weeds and parasitic fungi, herbicide or fungicide.

Rodenticides

Poisonous chemicals are put into poison baits to control rats and mice. The chemicals must be sufficiently toxic to kill in reasonably small amounts. A chemical known as Norbormide, is the most effective rodenticide. Norbormide consistently kills the laboratory rats but has no effect upon other test animals. The other most effective synthetic rodenticide is Warfarin, 3-(α-acetonylbenzyl)-4-hydroxy-coumarin. It does not kill all rodents. Other chemicals are sodium fluoroacetate also known as 1080, 2-pivalyl-1, 3-indandione or Pival, α-naphthyl-thiourea or ANTU, thallium sulphate, zinc phosphide, arsenic trioxide and barium carbonate. Precautions must be taken that animal pets and small childern should not swallow any of these poisonous chemicals.

Two natural plant products are used as rodenticides which are Red Squill and strychnine. Red Squill and White Squill are both varieties of *Drimia maritima* (Fam. Liliaceae). The Red Squill has reddish-brown outer scales while deep purple inner ones are present in white variety. In addtion to other cardio-active glycosides, the bulb of the Red Squill also contains the glucosides scilliroside and scillirubroside. Unlike other mammals, rodents do not regurgitate the Squill bulb, and death follows convulsions and respiratory failure.

Salts of the alkaloid strychnine are used to control rodents. Such products are effective for small rodents, they are not commonly employed as rat poison. The toxicity of strychnine to other animals and its painful poisonous action do not make it a poison of choice.

Some fumigants have been used either to kill rodents or to drive them from their nesting place. These include calcium cyanide, methyl bromide, and carbon monoxide.

Insecticides

Insecticides are classified according to the life cycle of insects which they affect; e.g., *Ovicides*, against the egg stage; *Larvicides*, against the larvae, caterpillares, and maggots; *Muscicides*, aganist the house fly (*Mosca domestica*); *Pediculicides*, against the body louse (*Pediculus corporis*); and *Miticides* or *Scabicides*, against the scabies mite (*Sarcoptes scabiei*). Insecticides may be stomach poisons or contact poisons. They may be obtained from a natural source or synthesized by chemical reactions.

Systemic Poisons

A systemic poison is ingested by the insect and distributed from the alimentary canal throughout its tissues.

Stomach poisoning chemicals are used to control chewing insects. The death of the insect is caused upon ingestion by interfering with respiratory system, depression of the nervous system, by over stimulation and consequent paralysis of the neuromotor system or by some other mechanism. The poison is sprayed in the form of dust, solution and suspension over the area with the help of power-sprayers or by airoplanes. The chewing insects consume the plants, the poison is taken into the stomach and is absorbed through the gastrointestinal tract. They remain effective till they are not washed away by rain or by sprinkling device or they are not readily oxidized to nontoxic forms.

Lead arsenate in acid or basic form, calcium arsenate, Paris green, and arsenic trioxide are some important poisons. Calcium arsenate is used on cotton, tomatoes, and potatoes. Use of calcium arsenate damages the leaves of many other plants. Paris green is a complex salt of copper and arsenic. In addition to these, a number of phosphorus containing compounds have been synthesized as insecticides. For example, Schradan, (Octamethylpyrophosphoamide), Demeton, Methyl Demeton, Thimet and Di-Syston are the synthetic insecticides. They are readily absorbed through both the roots and the foliage of plants. They remain within the plants tissues and protect the plants. against insects for a long time. These compounds are toxic to mammals and, therefore, are used to treat nonedible crops.

For household pests there are a number of stomach poisons for chewing insects. Cockroaches are killed by sodium fluoride and sodium fluorosilicate. The powdered chemical adhering to the antennae, leg bristles and other body hairs do not enter into the body until the insects clean themselves. During the cleaning process the poison is swallowed and then absorbed. If the powder is carried into the nesting places, other insects may be affected. Sodium arsenite or sodium arsenate in the form of sweetened baits or sodium fluoride as a dust are used to control the ants in the house.

Contact Poisons

Contact poisons come into direct contact with the pests which are applied as dusts, sprays or aerosols. Insects gathering to the underside of leaves will not be effected if the poison is spread only at the upper side. Insect like flies and mosquitoes will be effected only when they come into contact with the spray or the atmosphere in the particular area is heavily saturated with the aerosol. Sometimes the insects develop resistance to the contact poison and then they are controlled with difficulty. Organic contact insecticides may be of natural origin or synthetic type. The important natural plant insecticides are white hellebore, sabadilla, rotenoids, rotenone, cinerins, pyrethrins, phyrethrum flowers, nicotine and its salts and powdered tobacco leaves.

The examples of synthetic insecticides are DDT, methoxychlor, TDE, benzene hexachloride and its isomer, lindane, chlordane, aldrin, dieldrin, heptachlor, toxaphene, the organic phosphorus insecticides such as parathion, malathion, and fluorophosphates and the organic nitrogen compounds.

Natural Contact Insecticides

Leaf Tobacco : It consists of the cured and dried leaves of the Virginia tobacco plant, *Nicotiana tabacum* (Fam. Solanaceae). The genus *Nicotiana* is comprised of about 100 species. *Nicotiana tabacum* is a tall annual herb indigenous to tropical America and widely cultivated. The stem is simple, bearing large, pubescent, ovate, entire, decurrent leaves, the veins of which are prominent and more or less hairy.

Nicotine (0.6-9%) is the characteristic alkaloid of the genus and is prepared commercially from waste material of the tobacco industry. A lesser amount of nornicotine and an aromatic compound, nicotianin or tobacco comphor are also present in the herb. The charactersitic flavour is due to the nicotianin which is formed during the curing of the leaves. The roots of *N. tabacum* contain about eight pyridine alkaloids, including nicotine, nornicotine, anabasine and anatabine.

Nicotine is a pyridine-type alkaloid which is pale yellow, oily liquid, very hygroscopic; turns brown on exposure to air or light; acrid burning taste; develops odour of pyridine; volatile with steam. It forms salts with almost any acid and double salt with many metals and acids. It is miscible with water below 60°C, very soluble in alcohol, chloroform, ether, petroleum ether, etc. It is poisonous, being a local irritant and paralyzent.

Nicotine is used as insecticide and fumigant. As a contact poison, it is most effective as soap, i.e., as the laurate, oleate, or naphthenate. As a stomach poison a combination with bentonite has come into use. Nicotine sulphate in a 40% solution (Black leaf 40) is quite toxic to aphids; if the solution is alkalised, the toxicity is increased. Soap solution decomposes the sulphate to the free alkaloid which is considerably more poisonous to the insects.

Nicotine is highly toxic. The symptoms include extreme nausea, vomiting, evacuation of bowel and bladder, mental confusion, twitching and convulsions. The base is readily absorbed through mucous membranes and intact skin, but the salts are not.

Pyrethrum Flowers (Synonyms-Pyrethrum Flower Heads, or Insect Flowers, Dalmation insect powder; Persion insect powder). These are the dried flower heads of *Chrysanthemum cinerariaefolium* or of *C. marschallii* (Fam. Compositae). Pyrethrum contains about 0.5% of total pyrethrins (Pyrethrin I and Pyrethrin II).

Pyrethrum flowers are collected from 2- to 6- years old plants by hand. They are dried and stored. The plant is widely grown in Kenya, Ecuador, Japan, Yugoslavia, east central Africa, Brazil and India.

The insecticidal activity of Pyrethrum arises from four esters, the pyrethrins I and II and the cinerins I and II. They are complex esters of chrysanthemum carboxylic acid and the monomethyl ester of chrysanthemum dicarboxylic acid with pyrethrolones and cinerolones. The pyrethroids (or rethroids) are synthetic compounds of a similar structure of the pyrethrins themselves. The most important pyrethroids are allethrin, furethrin and cyclethrin.

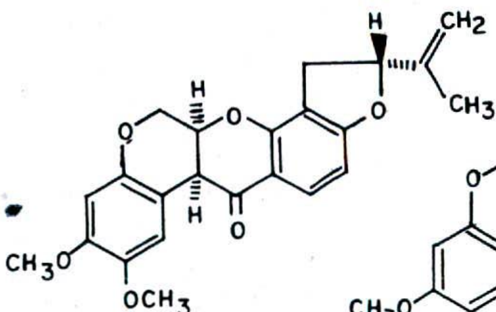
The Pyrethrum flowers are a contact poison for insects. They are largely used in the form of powder, but sprays in which the active principles are dissolved in kerosene or other organic solvent. It can cause severe allergic dermatitis and systemic allergic reactions. Large amounts may cause nausea, vomiting, tinnitus, headaches and other CNS disturbances.

Derris and Lonchocarpus : The roots of many species of *Derris* and *Lonchocarpus* (Fam. Leguminosae) show insecticidal properties. Derris consists of the dried rhizome and roots of *Derris elliptica, D. malaccensis* and possibly other species. Lonchocarpus are the dried roots of *Lanchocarpus utilis, L. urucu* and some other species.

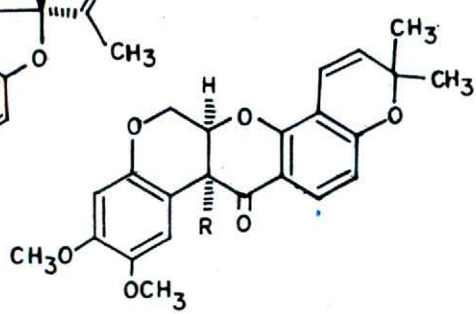
Derris is native of Malaya and cultivated there and in Burma, Thailand, Malaysia, Indonesia and the Philippine Islands. The genus Lonchocarpus is grown mainly in Mexico, Central and South America, England, Africa and Australia.

These roots contain rotenone (3-10%), deguelin, toxicarol, or tephrosin. Rotenone is a colourless crystalline substance which is insoluble in water but soluble in many organic solvents. All these compounds show insecticidal properties. It is an insecticide which is widely used to control both chewing and sucking insects.

Derris and Lonchocarpus roots have been used as fish poisons. For dusting purposes the powdered root is finally ground and diluted with a suitable carrier (talc, clay) to a concentration of 1 per cent. For spray purposes the powdered roots may be mixed with water or preferably with organic solvents such as ethylene dichloride, trichloroethylene or chlorbenzene. Rotenone extracts with oil and emulsifying agents and extracts dissolved in paraffin oil are excellent house-hold and cattle sprays. Rotenone decomposes upon exposure. Inhalation or ingestion of large doses may cause numbers of oral mucous membrane, nausea, vomiting, muscle tremors and tachypnea.



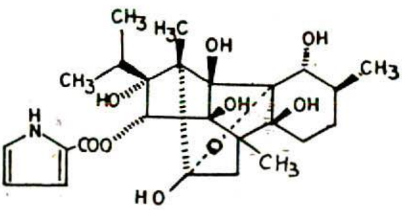
Rotenone



Deguelin (R=H)
Tephrosin (R=OH)

Cevadilla Seed (or Sabadilla) : It consists of the seeds of *Schoenocaulon officinale* (Fam. Liliaceae), a plant found from Mexico to Venezuela. The seeds are dark brown to black, sharply pointed and about 6 mm long. The seeds contain veratrine alkaloids (2-4%) which is a mixture of cevadine, veratridine, sabadilline, sabadine and cevadinine. The powdered seeds and preparations of 'Veratrine' are used as a dust or spray to control thrips and various true bugs which attack vegetables.

Ryania : The roots and stems of *Ryania speciosa* (Fam. Flacourtiaceae) contain 0.16-0.2% of alkaloids having insecticidal properties. Ryanodine, the principal alkaloid, is a complex ester involving 1-pyrrole-carboxylic acid. The plant is used in the control of various lepidopterous larvae which attack fruits and particulary European corn borer, codling moth and sugar cane borer. It may be used as a dust made from a 40% extract. Due to its low toxicity, Ryania has no residue hazard.



Ryanodine

Synthetic Contact Insecticides

The synthetic organic insecticides are classified into four groups:

1. organic sulphur,
2. chlorinated hydrocarbons,
3. non-halogenated organic compounds, and
4. organophosphorus derivatives.

Among the sulphur compounds are the carbamates, thiuram derivatives, mercaptans, thiazines, and organic thiocyanates (rhodanates). Sulphur is the traditional and ancient remedy for scabies. Tetraethylthiuram monosulphide, an organic sulphur compound, is as effective as sulphur.

Among halogenated organic compounds, naphthalene (moth flakes or moth balls) and para-dichlorobenzene (Dichloricide) are used as moth repellents.

A large number of chlorinated hydrocarbons have been employed as *contact poison*. These substances exert their lethal action after they have passed through the insect cuticle. Dicophane (D.D.T) is the best known of all chlorinated compounds. It is also known as chlorophenothane. Dicophane is also used for the eradiction of head lice. Important insecticides related to DDT are methoxychlor or TDE. These compounds may be degraded by living systems into less toxic metabolites. They remain unreacted for many years in soil and marine sediments and, therefore, present a continual threat to animal communities.

Gamma Benzene Hexachloride, the γ-isomer of hexachlorocyclohexane, shows insecticidal properties. It has a strong, disagreeable odour and used as sprays for crop plants, animals and garden plants. It is also used to destroy head lice and to treat scabies. Aldrin, a chlorinated hydrocarbon insecticide, has been used to control grasshoppers. It is stable in alkaline condition. Its epoxy derivative, Dieldrin, shows identical action and retains a longer residual effect. Endrin is a stereo-isomer of Dieldrin and exhibits excellent insect-killing effect. Chlordane insecticide is used to control insects in lawns, gardens, and homes.

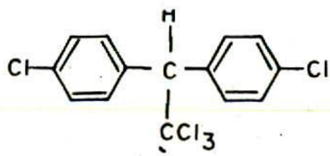
Pentachlorophenol, C_6Cl_5OH, protects lumber against termites and wood-rotting fungi when used as a 5% mixture in an organic suspension. Methyl bromide is an excellent fumigant for treating store products and green vegetables. In the form of solution methyl bromide is used as a soil sterilizant for the control of nematodes and certain insects. The simpler chlorinated hydrocarbons such as chloroform, paradichlorobenzene, carbon tetrachloride and trichloroethylene also have insecticidal activity and used as fumigants. The compounds like hydrocyanic acid gas, and carbon disulphide are also employed in destroying insects. The chlorinated hydrocarbons are toxic to man and animals and they should be kept well away from foodstuffs and animal feed.

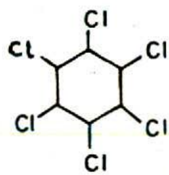
Certain substituents on the benzene ring (C_2H_5-,CH_3O-, F-, Cl-, and Br-) increase the potency of these insecticides either by increasing the lipid solubility of the compounds or by improving the fit on the receptor surface. Other substituents (C_4H_9-, C_6H_8-, NH_2-, NO_2-, -OH and COOH) reduce the potency. All the active compounds are very soluble in lipids and their molecular weights lie within the range 270 to 450.

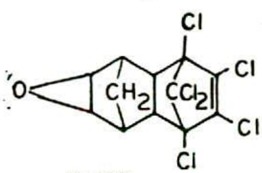
Gamma benzene hexachloride (Quellada) is used to destroy head lice and to treat scabies. Dicophane is also employed for the eradication of head lice.

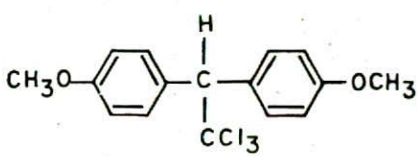
Members of organophosphorus derivatives include the insecticides like tetraethylpyrophosphate (TEPP), parathion, chlorthion, diazinon, trichlorphon (dipterex) and octamethylpyrophosphate (OMPA). These compounds are used both as contact poisons and as systemic poisons. A systemic poison is one that is ingested by the insect and distributed from the alimentary tract throughout its tissues. These poisons are applied to plants liable to attack by insects.

The organophosphorous insecticides form stable compounds with a number of esterases including cholinesterase. These insecticides are toxic to man and animals. They are being successfully employed in regions in which insects have developed resistance to the chlorinated hydrocarbons. Malathion (Carbofos; Prioderm) is extensively used as a dusting powder in cases of infestation with body lice.


Chlorophenothane (DDT)


Gamma Benzene Hexachlorobenzene


Dieldrin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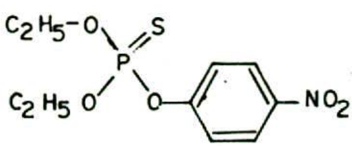
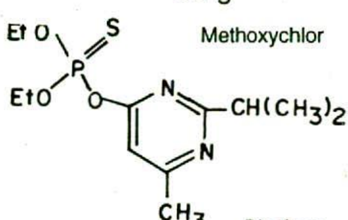

Parathion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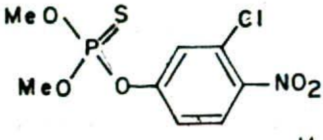
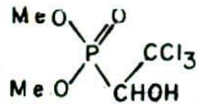
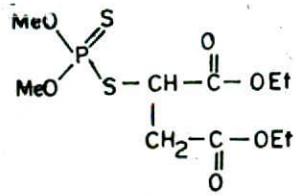


Chlorthion



Dipterex (Trichlorphon)



Malathion

Repellents

The natural product Citronella oil has been used as a mean of preventing insect attack. The synthetic products include dimethyl phthalate, Ethohexadiol (Rutgers 612) and Butopyronoxyl. These compounds are mixed in Dimethyl phthalate in ratio of Dimethyl phthalate (6 parts), Ethohexadiol (2 parts) and Butopyronoxyl (2 parts), a synonym for this solution is 622 mixture. Diethyltoluamide is another effective insect repellent.

Herbicides

Any agent, usually chemical, used for killing or inhibiting the growth of unwanted plants, are known as herbicides. They are classified as selective and nonselective depending upon thier destructive properties. Selective herbicides eliminate undesirable species and produce some deleterious effect on the desired plants. Non selective herbicides destroy all types of plant life.

Earlier sea salts, by-products of chemical industries, and various oils were used as weed-killers. Carbon disulphide, borax and arsenic trioxide are also used as weed killers. The herbicides are also divided as foliage applied and soil herbicides. Contact herbicides (e.g. sulphuric acid, diquat, paraquat) kill only the plant organs. Translocated herbicides (e.g. amitrole, picloram, 2, 4-D) are effective against roots or other organs to which they are transported from above ground. With respect to planting times, herbicides are also classified as pre-plant, pre-emergence, or post-emergence weed killers. Pre-plant herbicides may be applied to the soil or to weeds before crop planting.

Weeds and other vegetable grow along railroad sides, highways, around buildings, vacant lands, and playing grounds. They are killed by nonselective chemicals. Calcium cyanamide, potassium and sodium cyanides, ammonium thiocyanate, ammonium sulphamate, sodium chlorate, sodium chloride, arsenic trioxide, sodium arsenate, and sulphuric acid are effective weed-killers.

2,4-Dichlorophenoxyacetic acid (2,4-D) was the first organic herbicide. The compound applied to leaf surface without absorption, penetrates the cuticle and then enters into the vascular system of the plant. The toxic effects of the compound are dependent on its translocation to all parts of the plant.

2,4,5-Trichlorophenoxyacetic acid (2,4,5-T) is a related product which is more effective than 2,4-D. Phenoxyethyl sulphates, 2, 5-D and 3, 4-D have herbicidal properties identical to 2,4-D. Carbomates, urea derivatives, chlorinated acids, phenols, and dinitro .compounds are used as soil sterilizers, floral retarding agents, defoliants and selective herbicides.

The effective synthetic herbicides are 2, 2-dichloropropionic acid (Dalapon), 4-amino-3, 5, 6-trichloropicolinic acid (Tordon) and 3-amino-1, 2, 4-triazole (Aminotriazole). Dalapon is effective against grass-killer, whereas Tordon controls many woody species. Broadleaf weeds and perennial grasses are controlled by aminotriazole.

Plant Growth Regulators

The natural plant growth-promoting substance, gibberellic acid, is obtained from the fungus *Gibberella fugikurai* (Sawada). Six gibberellins, A_1, A_2, A_3, A_4, A_7 and A_9, have been isolated from filtrates of the fungus.

Chemically, gibberellins are the tetracyclic diterpenes. They are more highly functionalized than other groups of terpenoids. These compounds are produced in minute quantities within plants where they act as hormones of various developmental processes. Gibberellin-like compounds occur in higher plants. They are responsible for the development, maturation, budding, flower formation, fruit ripening and various other growth processes. Substances like 2,4-D and 2,4,5-T also possess auxin-like activity, but they are more effective as herbicides.

Fungicides or Antimycotic

Fungicides are any toxic substances which are used to kill or inhibit the growth of fungi, molds, mildews and yeasts that either cause economic damage or endanger the health of domestic animals or humans. Mostly fungicides are applied as sprays or dust. Seed fungicides are applied as a protective covering before germination. Systemic fungicides, or chemotherapeutants are applied to plants, where they become distributed throughout the tissue and act to eradicate existing disease or to protect against possible disease.

Protective fungicides are applied before the disease appears. They are used as sprays or dust to protect leaves and fruits and as seed disinfectants to eliminate the germination of spores simultaneously with seeds. Protectant agents are also used as wood preservatives to prevent dry rot and other fungus attacks on lumber. Eradicant fungicides are applied after the presence of fungi is observed. They kill by direct contact or else prevent the formation of spores. Thus, further spread of the fungus is inhibited.

A chemical combination of copper sulphate, lime and water is known as *Bordeaux mixture*. It is a protective fungicide. Sulphur is also used to control fungus disease. Lime-sulphur mixture is fungicide having both protective and eradicant properties. Its activity is due to calcium polysulphide which are very toxic to the fungus. Sulphur is mixed with nicotine, pyrethrum extracts, and rotenone to get better result. The other useful fungicides are the thiocarbamates, especially the dimethylthiocarbamates and the ethylene bisthiocarbamates; mercury compounds, quaternary ammonium compounds, nitro and heterocyclic nitrogen compounds, antibiotics, chlorophenols and other phenols and formaldehyde.

Fumigant

Fumigant is any volatile, poisonous substance that is used to kill insects, nematodes and other animals or plants that damage stored foods or seeds, human dwellings, clothing and nursery stock. Soil fumigants are sprayed or spread over an area to be cultivated and are worked over an area to be cultivated and into the soil to control disease-causing fungi, nematodes and weeds.

Some chemically simpler chlorinated hydrocarbons such as chloroform, p-dichlorobenzene, carbon tetrachloride and trichloroethylene also have insecticidal activity and they are used as fumigants. They are applied in gaseous form or as an aerosol in enclosed spaces such as rooms, cupboards, boxes, etc. These chlorinated hydrocarbons are highly dangerous to man and they must be used with care.

QUESTIONS

1. What are pesticides ? Classify different type of pests.
2. What are weeds ? Describe fungi parasitic on plants.
3. Discuss pesticides and methods adopted for pest control.
4. Write biological methods for pest control. Discuss different types of rodenticides and insecticides.
5. What are contact poisons ? Describe natural contact insecticides for pest control.
6. Write informative notes on the following :
    (a) Herbicides
    (b) Fungicides
    (c) Fumigant
    (d) Weeds
    (e) Rodenticides
    (f) Insecticides

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VARIABILITY IN DRUG ACTIVITY

During the development of plants, there is a considerable variation in size, shape, colour and other characters within a given population. There is also a difference in the content of the active constituents in the fresh drug. The content of the active constituents and the ratio between different constituents are not static, but vary continually in the living organisms according to the interaction of factors inside and outside of the organisms. Due to complexity of life processes and as change in one factor affects the influence of another factor, it is generally difficult to ascertain the exact effect of a given factor.

As a rule, there is a greater variation in content of medicinally active components, which are secondary metabolites, than in the contents of normal metabolites and storage products. For example, fat content of bitter almond varies from 40 to 63 per cent, but the amount of amyglalin differs from 0 to 8.5 per cent. The variation of therapeutic components in some drugs are as : atropin in Belladonna leaf (0.3-1.7%), alkaloids in Cinchona (4-14%), glycosides in Digitalis leaf (5.5-21 units), alkaloids in Ergot (0-0.2%), glycyrrhizin in Licorice (3-12%), morphine in Opium (3-12%) and menthol ester in Peppermint oil (2-11%).

The quality of crude drugs is dependent on the amount of active compounds present in it. Variation in the morphology or in concentration of active constituents may be due to several factors which may be due to genetic factors; by differences in the environmental conditions or due to methods used in the collection, preparation and storage of the crude drugs.

EFFECTS OF ENDOGENOUS OR GENETIC FACTORS

Members of a given species are rarely genetically homogenous. When the genetic difference is great, which resides in the genes, the morphology and biochemical diversity for each species are different. They can bring about differences in the amount or the type of chemical constituents produced. Whenever such biochemical variation occurs, each particular type is known as a *physiological variety*. Thus, there is not difference between bitter and sweet almond trees, but th seeds of the former contain a bitter glycoside (amygda'. *Duboisia myoporoides* of Northern Australia produces mainly scopolamine, while this plant grown in Southern Australia yields chiefly hyoscyamine. *Eucalyptus dives* of Australia yields an essential oil that varies greatly in odour and chemical contents from tree to tree. On the basis of the chemical composition of the oil, four physiological varieties of the tree have been distinguished.

The seeds of *Strophanthus sarmentosus* are biochemically polymorphic. The variety from the Belgian Congo produces sarverogenin; variety from French Sudan yields sarmentogenin; and from French Guiana gives very small amount of either compound. Morphological differences are insignificant. Similar variation is observed in varieties of Comphor trees; in red and white Squills; in Rauwolfia, etc. Some types of *Rheum palmatum* are rich in rhein, other are poor in this compound. There is a little variation in the content of chrysophanol. Among the three forms of diphtheritic organisms known as *gravis*, *media* and *mitis*, the last causes much less serious infections than the others.

Selection : There is a variation in the intensity of expression of given characteristics in any given population of plants. The plants may be genetically heterogenous to some extent. Genetic differences exist normally from one plant to the other. If a plant having most desirable characteristics is chosen & interbred, a derived second population may have a tendency toward improvement with respect to that particular quality. Continued selection and breeding of the most desirable plants will improve greatly in the particular quality chosen. If the plants are of a 'pure breed' and all variation is due to environmental factors, selection and breeding will have no effect.

Selective breeding of medicinal plants has resulted in plants with increased constancy of quality, increased growth, resistance to disease, winter-hardiness, and other desirable characteristics. It is a tedious and time-consuming task. Selection work on *Cinchona ledgeriana* with about 5% alkaloids has furnished types which yield bark with up to 15% alkaloids. Selection programmes with *Mentha arvensis* have developed drought-resistant and rust-resistant types yielding high amount of menthol. The rotene content of *Derris* (insecticide) has been raised from 3% to 13% in some clones by selective breeding. The average yields of essential oil in several plants have been increased by selective breeding. Selection work is important in the fermentation industries where high-yielding strains suitable for certain economical media are developed. In nature, some strains of a given microbe are active in producing antibiotics, e.g. the strain of *Bacillus subtilis* from the throat of Mary Tracy is used industrially. Careful selection of active strains is important to produce toxins, vaccines, and other pharmaceuticals.

Mutation : Exposure to ionizing radiation (X-ray, gamma rays, radioactive isotopes) or nonionizing radiation (ultraviolet) or some mutagenic chemical agents, sometimes changes the nature of a gene artificially. This change, a mutation, generally may cause the gene to lose its function entirely or in part; or it may cause the gene to do a different job. Mutation may also arise spontaneously in nature. Nothing is known about such changes. The mutant gene is passed from parent to progency in its changed form. Genes control the morphological characters of an individual and its biochemical nature. Genes determine the presence of enzymes which catalyze the formation of vital biochemical metabolites. The original strain of *Penicillium chrysogenum* used in the production of penicillin yielded about 100 units of penicillin per ml of culture medium. By single-spore isolation, strains were obtained which yielded up to 250 units per ml of medium. X-ray treatment of this strain gave mutants which could produce 500 units per ml, and utraviolet mutants of the latter gave strain which produced about 1,000 units per ml. Similar improvements have been obtained with other antibiotic-producing organisms.

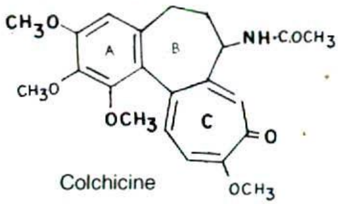
Mutation and selection develop resistance to chemotherapeutic agents by pathogenic microbes. When a microbe is cultured in a medium containing an antibiotic to which it is sensitive, majority of the organisms will be eliminated by the antibiotic, but a few organisms will survive which are mutants resistant to the antibiotic. The resistant organisms are free to multiply and grow, giving rise to a new population which is resistant.

Mutation is a random process occurring at all times. In an industry, the strain of organisms used should be entirely pure and uniform since a change in the strain of organism used in a fermentation process may cause great economic loss and danger to human lives. Therefore, the stock cultures are maintained under very stringent conditions, and constant checks to ensure their uniformity.

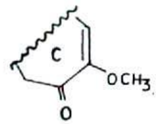
Genetic changes in a plant involves multiplication of entire chromosome set to give 3n, 4n, 6n, etc. body cells (polyploidy), addition of one or a few chromosomes (extrachromosomal type), gross structural changes, and submicroscopic changes or point mutations which include alteration in the DNA chromosomal material. Such mutations constantly occur in nature at a slow rate. Many mutations are of recessive type and do not become apparent until, the F_2 generation of a self-pollinated plant.

Polyploidy : Each living cell contains in its nucleus two sets of chromosomes. Since the chromosomes in the nucleus are present in duplicate, the normal cell is referred to as a diploid. If the chromosomes reduplicate within the nucleus, four sets of chromosomes are formed without subsequent division of the cell. In this way a condition arises wherein the nucleus contains more than its normal complement of chromosomes. This condition is called as "polyploidy". Through various mechanisms, a condition arises in which the cell contains three sets of chromosomes (triploidy); four sets (tetraploidy), etc. Polyploidy may develop in a plant through natural means, or by treating the cells, especially the seed, with heat or with colchicine or other specific compound. Various changes take place in the chemical composition of the individual due to the increase in the chromosome component of the nucleus. The most prominent changes brought about are in the size of the plant and its organs along with some physiological changes.

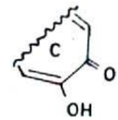
In the presence of colchicine, chromosomes in a cell undergoing mitosis divide without the formation of a mitotic spindle figure. Therefore, sister cells are not formed. A 72 hour treatment of the growing root tips of onion with colchicine solution produces 256 chromosomes. The "C-mitotic" activity of colchicine may arise from its interaction with the disulphide bonds of the spindle protein and by inhibition of the conversion of globular proteins to fibrous proteins. On discontinuation of treatment, the spindle figure again forms in the normal way. Colchicine is 100 time more active than its isomer isocolchicine while colchiceine is almost inactive.



Colchicine



Isocolchicine



Colchiceine

Plant materials are treated with colchicine in various ways. Seeds are soaked in an aqueous solution of colchicine (0.2-2.0%) for 1-4 days before planting. Seedlings are imported on to filter paper soaked in the solution for protection of the growing points. In an other method, the soil around the roots of young seedlings can be moistered with the colchicine solution. Young buds and shoots are also treated by immersion lanolin pastes and agar gels are used in tissue culture technique.

Newly formed polyploids are stabilized themselves in a number of generations. Such type of treatment does not give a uniform plant concerning chromosome number. Typical effects of polyploidy are larger flowers, pollen grains and stomata. With Lobelia, tetraploid plants are smaller than diploid ones. With tetraploid caraway plants, the total volatile oil content was increased by 100 per cent. In opium, the concentration of morphire per unit area increases up to 100 per cent.

In some species polyploidy does not affect the relative proportion of a compound. Solanaceous herbs produce excess amounts of tropane alkaloids in the 4n state and reduced quantities as heploids. The proportion of carvone in oil of caraway obtained from 4 n plants is also unchanged. *Digitalis lanata* in 4 n state contains a relatively high proportion of lanatosides A and B compared with the 2n form. There is also a difference in the sequiterpene lactones of *Ambrosia dumora* in the diploid and polyploid states.

Some medicinal plants have shown an increase in the content of active constituents on induction of polyploidy.

Colchicine-induced tetraploidy of *Datura stramonium* produced two-times more alkaloid than the normal diploids. Double content of an alkaloid is produced in tetraploids of *Atropa belladonna* in comparison to the diploid controls. An increase in alkaloid content has been observed in polyploids of *Lobelia* and *Nicotiana species*. Tetraploids of a *Cinchona* species contained 1.12% of alkaloid, more than twice the amount contained in the diploid plants.

Hybridization : The mating of inherently different individuals to produce hybrid progeny is called hybridization. Some desirable morphological or biochemical characteristics may be developed into the progeny by this process. Genes are introduced by hybridization for resistance to decrease, increased stature, excess production of starch and vitamins, different colour of the flowers, etc. Hybrids of *Cinchona* yield more amount of quinine. A hybrid developed by crossing *C. succirubra* with *C. ledgeriana* yields a bark which contains 11.2% of alkaloid. The parent species produced 3.4% and 5.1% of the alkaloid, respectively.

Each planting must be made with new hybrid seed produced by crossing in original parental species. The seeds will produce progeny which are not uniform, some reverting to the parental types, and others being of intermediate types. When plants of peppermint are allowed to mate at random, the resulting seeds give rise to plants producing oils of varying composition. A gradual change occurred in the flavour of the oil from spearmint hybrid yielding oils of different composition. For maintaining genetic purity of peppermint and spearmint hybrids, the plants must be propagated by planting stolons.

EFFECTS OF EXOGENOUS OR ECOLOGICAL FACTORS

The influence of ecological factors on the activity of drugs is very important. The drug industries pay better prices for drugs of high quality. Many species of medicinal plants grow wild in different parts of the world. The plants are scattered and it becomes difficult to collect and process them. Therefore, there is large demand for certain products and so the necessity to cultivate them on a large scale has become ever more. The following problems should be tackled to obtain an economic yield of good quality.

Climate and Light : Climate, e.g. temperature, rainfall, length of day and altitude, plays an important role in the growth of plants. Different crops require different climatic pattern. In cloudy weather the amount of carbohydrates in leaves is decreased, since photosynthesis is light-dependent. As carbohydrates serve as the initial starting material for biosynthesis, their abundance affect the amount of secondary metabolites. Changes in temperature may also influence plant growth by affecting the rate of chemical reactions. Enzymatic reactions slow down at lower temperatures. Some intermediate may accumulate in the cell and some of them will not produced faster to meet the required demand. It gives rise autointoxication or side reaction products. The contents of alkaloids in Stramonium leaves lower in rainy and cloudy weather.. Dry sunny weather and higher temperatures increase the content of essential oil of Lavender, Valerian and Wormwood. Belladonna leaves grown in sunny location contain 3-4 times more alkaloids than plant grown in shade. Similar variations have been observed in case of Opium, Lobelia, Cinchona and Peppermint. The average optimum temperature for nicotine production in *Nicotiana rustica* is 20°C. The fatty acids produced at low temperatures contain a higher content of double bonds than those formed at higher temperatures. The maximum alkaloidal content of Kurchi bark was observed when the atmospheric temperature was around 25°C.

Sudden natural calamities like flood, drought, frost, snow, hail, and wind are unusual features in hilly areas. Preventive measures have to be taken to guard the crops against these natural calamities. Limited crops may be cultivated in these conditions.

Rainfall shows effects on humidity and water-holding properties of the soil. Production of volatile oils varies under different conditions of rainfall. Continuous rain loses water-soluble substances from leaves and roots by leaching and affects the production of some alkaloids in Solanaceous plants, glycoside and volatile oil-producing plants.

Latitude and Altitude : The effect of latitude is important in fat producing plants. Tropical plants (Palm oil, Cocao butter) contain mainly saturated fatty acids, while the subtropical plants give a larger amount of unsaturated acids. The Olive, Almond and Sesame oils are predominant in oleic acid. The plants of temperate zones (Cottonseed, Sunflower) also contain more unsaturated acids. Plants growing at different latitudes produce oils of different saturation.

The coconut palm grows in a maritine climate and the sugar cane is a lowland plant. Elevation is required for tea (100-2000 m), cocoa (100-200 m) coffee (800-1800 m), rhubarb, tragacanth and cinchona. *Cinchona succirubra* grows well at low levels but alkaloids are not produced. The bitter constituents of *Gentiana lutea* are increased with altitude. The alkaloids of *Aconitum napellus* and *Lobellia inflata* and the oil content of Thyme and Peppermint decrease with altitude. Pyrethrum gives the best yields of flower-heads and pyrethrins at high altitudes on Equator (East Africa).

Allelopathy : Living organisms constantly exert an influence, called allelopathy, upon each other. Where different plants are growing side by side, there may be growth promotion or growth suppression. It effects upon leaf development, leaf shedding or maturation of the fruits. Some organisms exists only when living together. They live in *symbiosis*. Allelopathic effect among plants is transmitted by exhalation from leaves or secretions from roots. The flora of the soil changes with the amount of fertilizer, nature of the organic substance, humidity, etc.

Nutrition : Proper nutrition is essential for all living organisms. Suitable media for the microbes is used for the production of drugs. The consistency of Lard depends upon the nature of the hogs food. The content of alkaloids of Ergot shows differences up to 30% according to the variety of the rye host plant. The availability of light of proper intensity and duration is an important factor in plant nutrition. Other factors, such as temperature, humidity, inorganic salts, etc. also affect the efficacy of photosynthesis. Thus, the nutritional status of a plant may have some effect on the formation of secondary constituents such as alkaloids or glycosides.

Sunny weather prior to harvesting of peppermint gives more oil than rainy and overcast weather. Isolated camphor trees give a higher yield of camphor than trees grown in dense stands. The plant of *Fagopyrum esculentum* grown in shade produces less rutine than the plants grown in light. Belladonna leaves contain the most alkaloids in the middle of the summer when there is a maximum of light and growth. The content of glycosides in Digitalis leaves is higher in the afternoon than during the night, due to availability of more sugar.

The density of the plant population is an important factor affecting the availability of light, inorganic nutrient and water. Some species (e.g. Papaver) grow and develop well under the new climatic condition. Sometimes, the ability to elaborate specific substances is lost when the plant is transferred to another climate. The *Astragalus* species, a source of Tragacanth, ceases to produce gum when transferred to northern regions of Mediterranean areas. In some cases, strains of a plant are selected which give rise new plants. *Digitalis purpurea*, Thyme and Peppermint produce less active constituents when grown in lowlands. Aconitum furnishes a drug less active when grown in the mountains than that grown in the lowland. Thus, there is no definite rule to predict the activity of a given species when it is transferred to a new climate.

Minerals, Water and Oxygen : Inorganic ions are essential for growth and biochemical functioning of all living organisms. They serve many functions such as catalysts, cell constituents and proper balance of elements. Their solubility depends upon the pH of the soil. Therefore, one has to study the soil conditions, e.g. the kind of soil, depth, capacity of moisture, its pH, status of macro- and micronutrients.

Different drug plants require specific growth conditions for development and to yield a maximum crop. During transfer of a wild drug plant to cultivation hebitate, it is necessary to provide them with a soil essentially similar to that of their natural habitat. Stramonium gives good yields only on rich soil. Chamomile develops only on an acid soil. The quantity of fertilizer does not affect the content of active principles in plants, if the inorganic elements are present in sufficient amount to prevent deficiency symptoms from developing. An increase of phosphorus or nitrogen increases the production of essential oil in Anise and Coriander and of capsaicin in Capsicum.

Availability of water in the soil affects the activity of some drugs. Valerian produces less essential oil on swampy ground than on dry land. Mucilage content of Althea root is lower in drugs from damp soil. Mucilage acts as a water-absorbing agent, preventing the plant from drying out. Swamy land may cause decreased oxygen tension around roots, affecting in the pH of the soil and the uptake of minerals.

Stage of Development : Aged and young plant organs yield drugs of different activity. The anthelmintic principle, santonin of Levant wormseed, decreases when flower heads increases during growth. In Pyrethrum flowers, the flower buds are more valuable than the expanded flowers, because they contain more active compounds, pyrethrins: The contents of ascorbic acid in rose hips *(Rosa rugosa)* is at its maximum (12%) in the last days of September. The contents of essential oil in American wormseed is highest during pollination. Medicinal Rhubarb contains more anthraquinone in spring and during flowering than during winter. Young leaves of anthraquinone plants contain much more anthraquinone than do fully developed leaves. The Camphor tree accumulates more and more camphor from year to year which is maximum at the age of 40 years. Aconite tuber contains three times more alkaloid in winter time as during summer.

Parasites : Like animals, plants have infectious diseases. Microbes and viruses attack them, creating distrubances of the metabolic processes of the host. Crops are reduced by plant infections. Henbane contains less alkaloid when attacked by rust. Peppermint cultures are affected by *Verticillium.* Valerian, Fennel, Belladonna, Stramonium, etc. are also attacked by mildews and rusts.

Virus infestation of plant changes the leaves and may hinder the development of other organs. Strains of various plants have been developed which are resistant to the more common infectious diseases. *Streptomyces* species, used in the production of antibiotics, are quite susceptible to attack by certain bacteriophages.

Preserving and Processing Procedures : Earlier the drugs were used mostly in fresh form. When the drugs were obtained from far away places, preservation of these products became a necessity. Several drugs lose their effectiveness on drying. *Cochlearia officinalis* on drying destroys its vitamin C content. Spasmolytic properties of Thyme are lost in a dried sample.

Enzyme Activity : Enzymatic processes continue during drying, but gradually the cell loses its control and power to coordinate these processes. Several drugs containing glycosides lose activity during drying due to the action of glycosidases. Normally, enzyme and substrate occur jointly in the cell. In the living cell they are spatially separated.

In some plants, enzyme and substrate are found in different cells, e.g. the glycoside of mustard seed. When the cells are crushed, the enzyme and substrate are united to react each other.

Fresh white Squill bulb contains the cardioactive glycosides scillaren A and B. During preservation of this drug, a large proportion of the glycosides is destroyed.

$$\text{Scillaren A} \xrightarrow[+H_2O]{\text{Scillarenase}} \text{Proscillaridin A + Glucose}$$

Proscillaridin A and its anhydride, scillaridin, have weaker cardiac activity than scillaren A. The fresh bark of Cascara sagrada gives no reaction of anthraquinone, but after lying in the air for sometime, it forms red colour with alkali (Borntraeger reaction). Sometimes desirable transformation takes place during drying. For example, vanillin is produced by hydrolysis of a glucoside in a fermentation process in Vanila bean. Cacao beans change in colour and flavour on fermentation process. Caffeine-tannin complex of tea is converted by enzymes into free caffeine and oxidized tannin, phlobaphenes. If the enzymes are destroyed in these materials prior to drying, no changes occur.

Enzymes also cause deterioration in activity of crude drugs. In Opium, a peroxidase is present which can cause a loss of up to 50% of the morphine of aqueous solutions, which can be prevented by heating morphine to 70° to destroy the enzyme. The enzyme present in the fresh latex of the Opium poppy reduces the content of morphine up to 13 per cent.

Browning : Fresh barks of Cinchona, Cascara sagrada and Cinnamon and fresh Cola nuts are white to yellow inside, but darken to brown on drying. Many leaves and fruits become brown on drying and storage. Browning changes the taste, odour and activity. Browning is due to both enzymatic and nonenzymatic reasons and becomes faster in the presence of oxygen and at elevated temperatures. Polyphenol oxidase enzymes cause oxidation of polyphenols (tannins and flavonoids) to relative quinones, which polymerize readily to yield dark-coloured compounds. The reaction is accelerated after damage to the tissue or after physiological injury, such as freezing, thawing or slow drying. This type of browning is inhibited by addition of ascorbic acid which reduces the formation of quinone. The oxidation is highest in powdered drugs as the diffusion of oxygen into the inner portions of the tissues is slow.

Browning also occurs due to interaction of free sugar or dehydroascorbic acid with free amino acids to form dark compounds. Addition of sulphur dioxide prevents browning by eliminating carbonyl groups.

$$R\text{-}CHO + SO_2 + H_2O \longrightarrow R\text{-}CH(OH)SO_3H$$

Browning of dried leaves is due to transformation of chlorophyll into phaeochlorophyll in the presence of acidic cell sap. Bright green colour is retained in slight acidic conditions.

Oxidation, Evaporation, and Polymerization : Unpleasant odour of Henbane leaves and Coriander fruits disappears on drying due to evaporation or transformation of flavouring substances. Volatile oils evaporate at high temperatures, therefore, drying in sunshine causes greater loss of volatile oil constituents than drying in the shade. Lavender, Peppermint, Sage and Thyme loss about 10% of their oil on drying in the shade, but up to 24% if dried in the sun. Heat created during powdering and artificial heat used in the drying of crude drugs destroy thermolabile constituents.

The oil constituents are first dissolved in water and diffuse through the cell wall in solution. Oxygenated compounds of essential oils, e.g. alcohols, aldehydes and carboxylic acids, are highly soluble in water and evaporated to a greater extent than the hydrocarbons. The drugs which carry oil glands on the surface lose oil faster than thicker organs. Peppermint with oil glands on the leaf surface, loses about 40% of its oil in dried leaves.

Effect of Storage : Chemical changes in drugs occur most readily during storage and the process is known as aging. In the presence of lipases, fats in seeds are hydrolyzed to glycerol and fatty acids. In living cells, the consumption of glycerol and fatty acids is continued to prevent the accumulation of any of them, but in dead cells, fatty acids are deposited. Peroxides formed during this process may destroy therapeutic constituents. Storage of Ergot causes rancidity and becomes inferior in quality. Therefore, powdered Ergot must be stored only in the defatted form.

Enzymatic Process : The enzymes of the fresh drugs are not destroyed completely during drying. However, when the water content of the tissues is reduced below 5%, enzymatic reactions are reduced. Hygroscopic materials absorb humidity from the atmosphere varying water content between 5 and 15 per cent. Therefore, crude drugs, such as Digitalis and Senna leaves, should be stored in closed containers over dehydrating agents such as lime or calcium chloride. This type of storage is costly and difficult.

Oxidative Processes : Drugs darken during storage due to oxidation reactions. Diffusion of oxygen into large pieces of a drug requires a longer time than diffusion into the interior of small particles. Therefore, drugs containing phenolic compounds lose activity more rapidly when stored in powder forms. Many essential oils on exposure to air develop typical odour and become viscous. Addition of oxygen to double bonds gradually forms peroxides, aldehydes, ketones, alcohols and acids. In bitter almond, benzaldehyde is partly converted to benzoic acid on storing the oil in air. Peroxides form many secondary products in the oil in the presence of oxygen. Anethole of Anise oil upon storage gives rise to ketone, aldehyde and acid. Therefore, the oils should be kept in completely filled bottles to eliminate the effect of oxygen. The bitter compound of Gentian root, gentiopicrin, is oxidized in air to gentiamarin and H_2O_2, and the aglycones of these two glycosides are further oxidized to a larger number of products.

Post-mortem oxidation is used for the improvement of some drugs. The fresh bark of Cascara sagrada contains the active constituents in the reduced form, anthranols, which have an irritating effect upon the mucous membranes and causes griping and nausea. During drying, a part of these compounds is oxidized to anthraquinones. Therefore, the drugs should be stored at least one year before used to destroy the griping property. The oxidation proceeds faster at elevated temperatures. Therefore, the drugs should also be heated for one hour at 100°. The colour of chrysarobin is changed from yellow to brown on storage in air and, hence, its antiseptic property is reduced.

Rancidification : Spoilage of fats during storage in called rancidification. New compounds are formed which may change the consistency and therapeutic value of the fat. As inflamed areas of the skin are more sensitive to irritation, rancidified fats are undesirable for use in medicine.

The main types of rancidity are acid rancidity, carbonyl compound rancidity and peroxide rancidity. The fat splitting enzymes, lipases, produce free acids in the presence of water causing acid rancidity. Natural fats contain small amounts of water in disperse form. Therefore, natural fats should be stored under anhydrous conditions. The activity of lipases is inhibited by lowering the pH. The lipases are thermolabile, i.e., they are destroyed by heat. Many fats are exposed to steam for some time.

Oxidative rancidity is very important in the deterioration of fats. Microbes are developed when the fats contain water or proteins, e.g. lard and butter. By the action of microbes upon fat, methyl ketones having a strong and disagreeable odour are formed :

$$R\text{-}CH_2\text{-}CH_2\text{-}COOH \xrightarrow{-2H} R\text{-}CH = CH\text{-}COOH \xrightarrow{+H_2O}$$

$$R\text{-}CHOH\text{-}CH_2\text{-}COOH \xrightarrow{-2H} R\text{-}CO\text{-}CH_2COOH \xrightarrow{-CO_2} R\text{-}CO\text{-}CH_3$$

Unsaturated fats absorb oxygen in the presence of light, increasing the weight, becoming more viscous and finally a solid material. The iodine value of the fat is decreased. At elevated temperatures, oxygen adds unsaturated acid to form peroxides which on rearrangement splits the molecule between the carbons forming aldehydes of disagreeable odour. The reaction is autocatalytic and started by UV light. Many substances, e.g. Fe, Cu, Co, Mn, hemin, and others accelerate the rate of oxidation. Such substances are called oxidants. Other substances retard the rate of oxidation and known as antioxidants. Carotenes, gallic and ascorbic acids, pomiferin, tocopherol (vitamin E) and nordihydroguaiaretic acid are used as antioxidants.

Racemization : In natural products, most physiologically active compounds occur in l-form. Racenization in *dl*-form has only half the activity. The racemic forms of atropine and ergot alkaloids lose half of their alkaloidal activity.

Light : Many substances are affected by light. Santonin of Levant wormseed turns yellow in the light. The carotenoids of Saffron is decolourized in the light. Essential oils turn gradually dark and viscous in the light. Vitamins A, B_2 and C are sensitive to light. The alkaloid content of Coca leaf, Stramonium leaf and of Veratrum root decreases faster when the drugs are dried in light.

Plant Growth Regulators

Plant growth regulators affect the morphological and physiological processes of plants in low concentrations. These are organic compounds which modify the plant growth. Some growth regulators occur naturally, e.g. plant hormones (auxins, gibberellins, zeatin); some of them are synthetic compounds, e.g. kinetin, adenine, 6-benzyl adenine, benzimidazole, N, N'-diphenyl urea and ethylene.

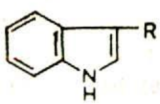
Five well known plant hormones are the auxins, gibberellins, cytokinins, abscisic acid and its derivatives and ethylene. They are specific in their action and show effects in very low concentration. They take part in cell division, organogenesis, senescence and dormancy. Their treatment influences the size of the plant, effects earlier growth and root development, improves the level of proteins and amino acids, and enhances the production of secondary metabolites.

Auxins : Auxins promote elongation of coleoptile tissues. Indoleacetic acid (IAA) is the principal natural auxin which occurs in actively growing tissues. Other similar natural compounds are indoleacetaldehyde, indoleacetonitrile and indolepyruvic acid. All these compounds are derived from tryptophan in plants. The synthetic auxins include indole-3-butyric acid, α-naphthyl acetic acid (NAA), naphthyl acetamide, 2,4-dichlorophenoxyacetic acid (2, 4-D), 5-carboxymethyl-N, N-dimethyl dithiocarbanate, etc.

Auxins elongate cells to increase the length of a stem; inhibit root growth and adventitious root production; and produce fruits in the absence of pollination. In low concentrations auxins accelerate the rooting of woody and herbaceous cuttings and in high concentrations they act as selective herbicides or weed-killers. They influence the physical and chemical properties in leaf abscission and inhibition of lateral buds.

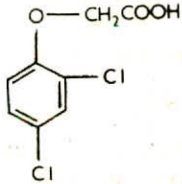
In plants IAA oxidase controls the oxidative degradation of IAA. Orthodiphenols, e.g. caffeic and chlorogenic acids, inhibit the action of the enzyme and stimulate the growth.

Monophenols, e.g. p-coumaric acid, promote the action of IAA oxidase and inhibit the growth. α-Naphthyl acetic acid (NAA) is used for rooting of cuttings. IAA has been used for rooting of cuttings of *Cinchona, Carica, Coffea, Pinus* and other species. Auxins in specific concentration destroy some species of plants leaving other unaffected. 2, 4-Dichlorophenoxyacetic acid is toxic to dicotyledenous plants like dandelion and plantain. Treatment of seedlings and young plants of *Mentha piperita* with derivatives of NAA increases yield up to 40% of oil which contains 4.5 - 9% more menthol than the control. 2, 4-D produces abnormal and bizarre form of *D. stramonium;* an increase trichome production; and smooth fruits as distinct from those with spines.

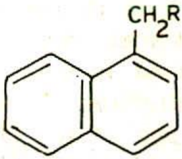


Indole-3-acetic acid ($R = CH_2COOH$)

Indole-3-butyric acid ($R=CH_2CH_2CH_2COOH$)



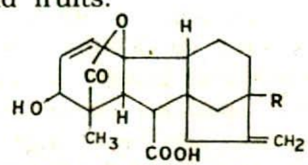
2, 4-Dichloro-phenoxyacetic acid



α-Naphthyl acetic acid ($R = COOH$)

α-Naphthylacetamide ($R = CONH_2$)

Gibberellins : Gibberellins (GA) are the tetracyclic endrogenous plant hormones and were originally discovered as the phytotoxic metabolites of a rice pathogen, *Gibberella fugikuroi.* Many of their functional groups are attached on parent ring system. More than 40 gibberellins have been detected in plants and fungi. They are present in all plant organs. Commercially, they are used for promotion of vegetative and fruit growth, flower initiation, induction of parthenocarpy and breaking dormancy. Gibberellin A was found to be a mixture of about 6 components, e.g. GA_1, GA_2 GA_3 (Gibberellic acid), GA_4, GA_7 and GA_9. Gibberellins are synthesized in leaves and they usually accumulate in immature seeds and fruits.



Gibberellic acid (GA_3) : R = OH

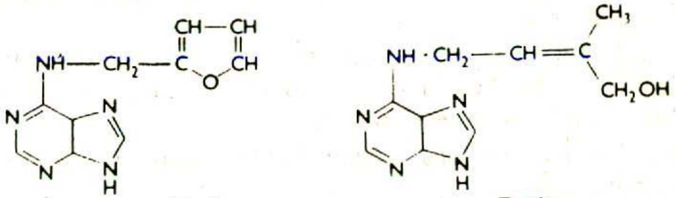
GA_7 : R = H

Gibberellins promote rapid expansion of plant cells, stimulate seed germination, breaking dormancy, induction of flowers, elongation of stem, increase in size of leaves and induction of parthenocarpic fruit leading to seedless fruit sets. The effects of gibberellins and auxins in cell division are almost similar. Gibberellins occur in plants in deactivated forms.

Application of GA shows various types of modifications in medicinal plants. Its spray on flowers of *Humulus lupulus* advances the maturity of the hops by 10 days. GA treatment on *Mentha piperita* has shown typical elongation of the internodes, changes in leaf shapes, loss of ribs on the stem, variation in chlorophyll content, fewer glandular hairs and decrease in the volatile oil yield up to 52.4 per cent. GA treatment on *Chenopodium ambrosioides* showed 33% increase in volatile oil. GA increases the volatile oil content of *Anethum graveolens* up to 50% and of *A. sowa* up to 30 per cent. The hormone increases yield of Digitalis glycosides per shoot. In *Hyoscyamus niger* the hormone elongates the stem having narrow leaves, shows more rapid onset of flowering and decreases of overall yield of alkaloids. Similar reduction of alkaloid contents of *Datura* species, Tobbaco, *Duboisia* species, *Catharanthus roseus*, *Rauwolfia serpentina* and *Thea sinensis* has been observed. Application of GA decreases sennosides in *Cassia angustifolia* and glycoside rutin in buckwheat plant.

Gluconeogenic enzymes effects the action of gibberellic acid. The hormone induces the synthesis of α-amylase and other hydrolytic enzymes and involves in mobilizing seed storage reserves during germination.

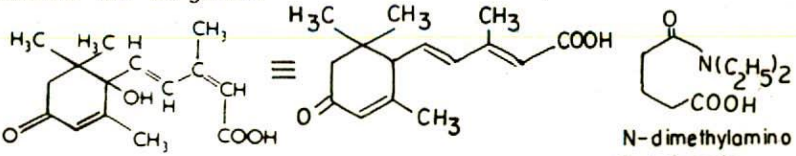
Cytokinins : Cytokinins have a specific effect on cell division. They regulate the pattern and frequency of organ production and have an inhibitory effect on senescence. These hormones are either natural (zeatin) or synthetic (kinetin) compounds. Zeatin is a 6-substituted adenine derivative. Cytokinin promotes cell division in the formation of adventitious buds and shoots; inhibits senescence; influences the expansion of cells in leaf discs and cotyledons; delays breakdown of chlorophyll; and degradates protein in ageing leaves. Kinetin treatment of *Datura meteloides* showed shorter and bushier plants, decreased growth and no change in alkaloid content. Cytokinin activity on *Duboisia* hybrids increased 18% in leaf yield and 16% increase in hyoscine. With *Cassia angustifolia*, there was a slight increase in sennoside content. Kinetins take part in nucleic acid metabolism and protein synthesis. In plants, some RNA shows cytokinin-type activity. They act on some enzymes which form amino acids.



Kinetin

Zeatin

Growth Inhibitors : Natural growth inhibitors affect bud opening, seed germination and development of dormancy. Abscisic acid, a natural growth inhibitor, has been isolated from the fungus, *Cenospora rosicola*. The synthetic growth inhibitor, N-dimethylamino-succinamic acid, reduced the height of *Datura* species and there was up to 90% increase in the alkaloidal content. Phosphon produced the same effects on *D. ferox*.



Abscisic acid (ABA)

N-dimethylamino Succinamic

Ethylene : Ethylene, $CH_2 = CH_2$, is a colourless, flammable gas which induces growth responses in plants. It occurs in ripening fruits, flowers, and other plant organs. Commercially, it is used for induction of fruit abscission, breaking dormancy and stimulation of latex flow from 36 to 136% in rubber plants. At low concentrations it increases the sennoside concentration in *Cassia angustifolia*. It stimulates the production of phytuberin and phytuberol.

QUESTIONS

1. Enumerate the genetic factors that influence the quality of crude drugs. Give an account of chemical races.
2. What do you understand by ontogenetic variations of secondary plant metabolites ? Give suitable examples where such variations are of pharmaceutical significance.

3. Describe the genetic or exogenous factors which affect the plant constituents. Give suitable examples under each class.
4. Discuss genetic methods of improving drug yielding plants. Explain the terms selection, polyploidy and chemical races.
5. Enumerate factors responsible for variability of phytoconstituents in medicinal plants and how do they affect plant-drug evaluation.
6. Discuss the factors which bring about variability of constituents.