Pharmacognosy

Lecture Three

Objectives

This lecture will discuss the following topics.

- A Taxonomic Approach to The Study of Medicinal Plants and Animal-Derived Drugs.
- Production of Crude drugs: Cultivation, Collection, Drying and storage
- Deterioration of Crud drug
- Practice Questions

References

1. W.C Evans, "Treise and Evans: Pharmacognosy" 16 Edition, 2009.
2. Biren N Shah, A.K Seth "Textbook of Pharmacognosy and Phytochemistry" First Edition 2010, ELSEVIER.

1. A Taxonomic Approach to The Study of Medicinal Plants and Animal Derived Drugs

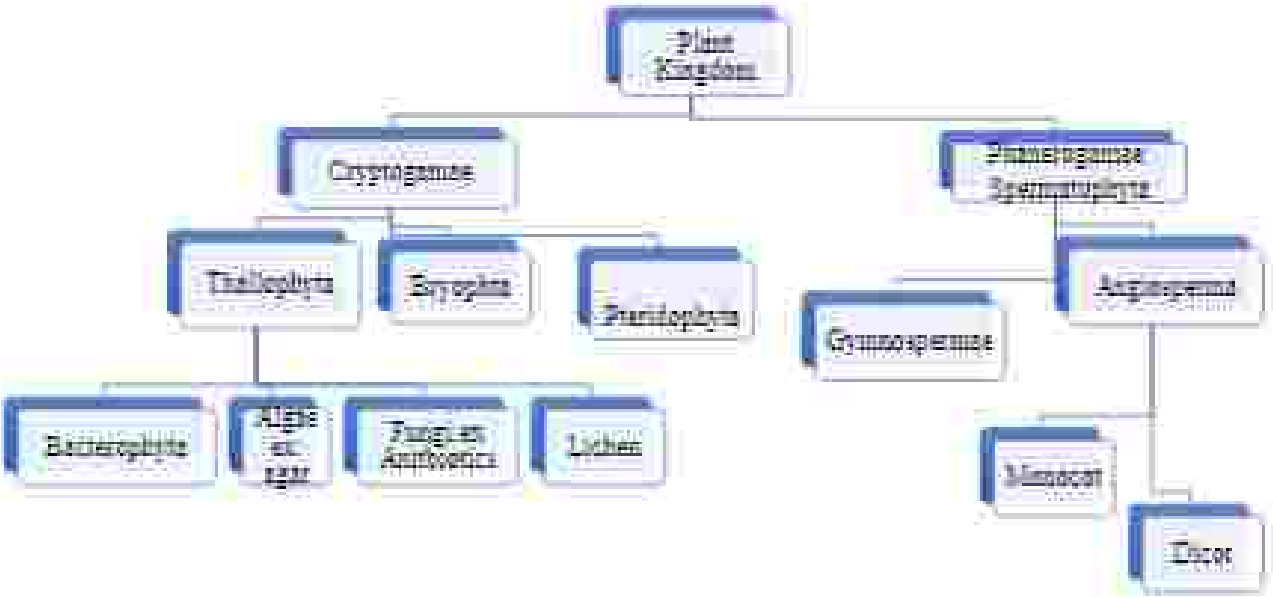
The plant and animal kingdoms are divided into several phyla for classification purposes. In addition to the phyla, the classification includes groupings of gradually diminishing size, namely divisions, classes, orders, suborders, and families. According to the system used, these groupings may or may not indicate phylogenetic relationships.

In this lecture, the principal plant families of pharmaceutical interest are arranged according to Engler's botanical scheme (Figure 1).

An examination of the list of drugs derived from natural sources, as included in any pharmacopeia, indicates that the majority are derived from the **Spermatophyta**—the dominant seedbearing plants of the land. Within the Spermatophyta, the number of species and the number of useful medicinal plants is divided unevenly between the phyla **Gymnospermae,** which yields some useful oils, resins, and the alkaloid ephedrine, and the **Angiospermae**, which is divided into **Monocotyledons** and **Dicotyledons** (both provide many useful drugs but especially the **Dicotyledons**).

Of the other divisions of the plant kingdom, the fungi provide several useful drugs, especially antibiotics, and are important in pharmacy in several other ways.

Alginates are a source of a limited number of drugs (e.g., agar and alginic acid). However, the full pharmacological importance of this large group of aquatic plants is still to be realized. At the moment, lichens and mosses contribute little to medicine, and the **Pteridophytes** are pharmaceutically best known for the taenicide ferns and lycopodium.



- Footnotes

- Cryptogamae is a nonflowering, non-seed-bearing Plant
- Phanerogamae is Spermatophyta (Flowering, Seed bearing)
- Thallophyta: Here, the plant body is not differentiated into root, stem, or leaf.
- Bryophyta: Plants of False root and leaves
- Pteridophyta: Those with True roots and Leaves, ex. Ferns
- Bacteriophyta: These are unicellular organisms
- Lichen: is a symbiotic association of an algae and a fungal partner

Figure 1: "Engler Botanical Scheme"

Among the many important pharmaceutical aspects of the **Bacteriophyta** are the production of antibiotics, their use in effecting various chemical conversions of added substrates, and their employment in genetic engineering as, for example, in the production of human insulin and the transformation of higher plant cells by incorporation of part of the DNA of a bacterial plastid into the plant genome.

Land animals provide such traditional pharmaceutical materials as gelatin, wool fat, beeswax, and cochineal and are a source of hormones, vitamins, and sera.

- **Angiosperm and Gymnosperm**

The angiosperms are vascular seed plants where the ovule (egg) is fertilized and develops into a seed in an enclosed hollow (ovary). The ovary is usually enclosed in a flower, that part of the angiospermous plant that contains the male or female reproductive organs or both. Fruits are derived from the maturing floral organs of the angiospermous plant and are characteristic of angiosperms. Monocotyledons, commonly called monocots, are flowering plants whose seeds typically contain only one embryonic leaf or cotyledon. The **dicotyledons**, also known as **dicots**, are flowering plants whose seeds have two embryonic leaves or cotyledons.

Gymnosperms are a group of vascular seed plants; the seeds do not develop enclosed within an ovary but are usually exposed on the surfaces of reproductive structures, such as cones, that initially produce the spores.

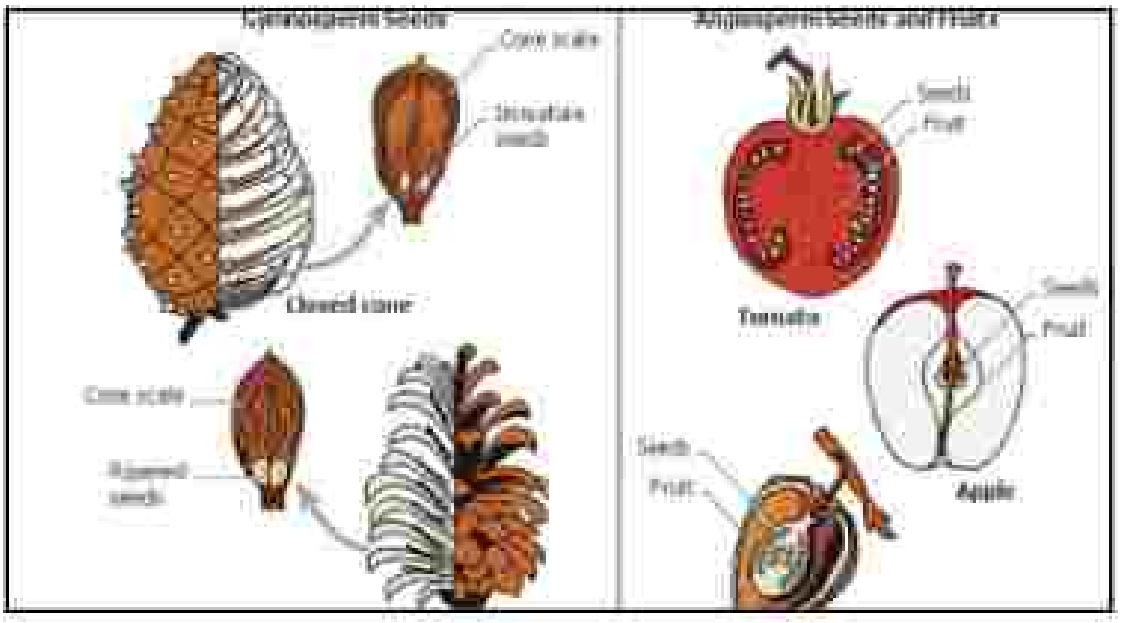


Figure 2: "Angiosperm and Gymnosperm differences"

Figure 3: "Dicot and monocot differences"

2. Production of Crude drugs: Cultivation, Collection, Drying and storage

Crude drugs, which reach the market and pharmaceutical industries, will have passed through different stages that have some effect on the nature and number of active constituents responsible for therapeutic activity. Those stages are to be concerned more with making a drug useful to mankind.

2.1. Cultivation of Crude Drug

Cultivation produces improved quality of plants. It helps select the species, varieties, or hybrids that have the desired phytoconstituents due to the controlled environmental growth; better plant product is obtained, making the collection and processing steps easier than wild sources. Cultivation results in obtaining plants with maximum secondary metabolites. It leads to industrialization in the country by the regular supply of plants. Serves as a useful tool for research purposes.

The advantages of cultivation may be briefly summarized as follows:

A. It ensures the quality and purity of medicinal plants. Crude drugs derive their utility from their chemical contents in them. If uniformity is maintained in all operations during cultivation, drugs of the highest quality can be obtained. Cultivation of rhizomes demands adequate fertilizers and proper irrigation—systematic cultivation raises a crop with a maximum content of volatile oil and other constituents. The examples of ginger, turmeric, and licorice can be cited to illustrate this point. If the cultivated plants are kept free of weeds, the contamination of crude drugs can be conveniently avoided.

B. Collection of crude drugs from cultivated plants improves yield and therapeutic quality. However, it is a skilled operation and requires some professional excellence; if the collection of crude drugs for the market is done from cultivated plants by skilled and well-experienced personnel, the high

yield and therapeutic quality of drugs can be maintained. For example, the collection of latex from poppy capsules and oleoresins from Pinus species, if done by experienced persons, can result in a better yield of crude drugs.

C. Cultivation ensures a regular supply of a crude drug. In other words, cultivation is a method of crop-planning. Planning crop cultivation regularizes its supply, and as a result, the industries depending upon crude drugs do not face the problem of shortage of raw material.

D. The cultivation of medicinal and aromatic plants also leads to industrialization to a greater extent. The cultivation of cinchona in West Bengal has led to the establishment of the cinchona-alkaloid factory near Darjeeling.

E. Cultivation permits the application of modern technological aspects such as mutation, polyploidy, and hybridization.

➢ Environmental Conditions Affecting Plant Growth

For cultivation success, it is necessary to study the conditions under which the plant flourishes in the wild state and reproduce these conditions or improve on them. These conditions are:

- **Temperature:**

Temperature is a major factor controlling the development and metabolism of plants. Although each species has adapted to its natural environment, plants can frequently exist in various temperatures. Many tropical and subtropical plants will grow in temperate regions during summer but lack frost resistance to withstand the winter.

- **Rainfall**

The important effects of rainfall on vegetation must be considered about the annual rainfall, its distribution throughout the year, its effect on humidity and its effect coupled with the water-holding properties of the soil. Variable results have been reported to produce volatile oils under different rainfall conditions and may sometimes be coupled with developing glandular hairs. Continuous rain can lead to a loss of water-soluble substances from leaves and roots by leaching; this is known to apply to some plants, producing alkaloids, glycosides, and even volatile oils. This could account for low yields of some active constituents in wet seasons from plants whose general condition appears good.

- **Day length and radiation characteristics**

Plants vary greatly in the amount and intensity of the light they require. In the wild state, the plant will be found where its shade requirements are met, and under cultivation, similar shade must be provided. In certain cases, research has shown that light is a factor that helps to determine the amount of glycosides or alkaloids produced. With *Belladonna, stramonium, and Cinchona ledgeriana*, full sunshine gives a higher alkaloid content than shade. It has been proved that even the length of the day affects metabolite production. The plants kept in long-day conditions may contain more or less constituents compared to those kept in short days. For example, peppermint has produced menthone, menthol, and traces of menthofuran in long-day conditions and only menthofuran in short-day conditions.

- **Altitude**

Altitude is a very important factor in the cultivation of medicinal plants. Tea, cinchona, and eucalyptus are cultivated favorably at 1,000–2,000 meters. Cinnamon and cardamom are grown at a height of 500–1000 meters, while senna can be

cultivated at sea level.

- **Soil**

Every plant species has its own soil and nutritive requirements. Soils' physical, chemical, and microbiological properties are their three important basic characteristics. Soil provides mechanical support, water, and essential foods for the development of plants. Soil consists of air, water, mineral matter, and organic matter. Variations in particle size result in different soils ranging from clay, sand, and gravel.

Particle size influences the water-holding capacity of soil. The type and amount of minerals play a vital role in plant cultivation. Calcium favors the growth of certain plants; whereas, with some plants, it does not produce any effects. The plants can determine their soil pH range for their growth; microbes, which grow well at a certain pH, should be considered.

Nitrogen-containing soil has great momentum in raising the production of alkaloids in some plants. Depending upon the size of the mineral matter.

- **Propagation from Seeds**

The seeds must be collected when they are perfectly ripe to ensure success. If not planted immediately, they should normally be stored in a cool and dry place, not kiln-dried. Some seeds, such as cinnamon, cocoa, and nutmeg, rapidly lose their power of germination if allowed to dry or stored for quite short periods.

Long storage of all seeds usually decreases the percentage that germinates. Although seeds are naturally sown at the season when they ripen, it is frequently more convenient, especially for the less hardy exotic species, to defer sowing until the spring. In some cases, however, immediate sowing of the fresh seed is advisable.

- **Plant Growth Regulators**

The growth and development of plants are regulated by several chemical substances, which exert a complex interaction to meet the plant's needs. Five groups of plant hormones are well established: auxins, gibberellins, cytokinins, abscisic acid and its derivatives, and ethylene. These substances are of wide distribution and may occur in all higher plants. They are specific in their action, are active in deficient concentrations, and regulate cell enlargement, cell division, cell differentiation, organogenesis, senescence, and dormancy. The essential role of these substances is illustrated by cell and tissue cultures; without the addition of suitable hormones, no development or cell division occurs. The effects of these very active substances on the production of secondary metabolites, particularly to produce plants containing an enhanced proportion of active constituents, are of interest to pharmacognosists.

In such studies, how the results are recorded is all-important, particularly as the treatment may also influence the size of the test plant compared with the controls.

2.2. Collection

The collection is the most important step, which comes after the cultivation of drugs. Drugs may be collected from wild or cultivated plants, and the task may be undertaken by casual, unskilled native labor (e.g., ipecacuanha) or by skilled workers in a highly scientific manner (e.g., digitalis, belladonna, and cinchona). Several factors have to be considered in the collection of plant material; these are:

- **Season of collection:** The season at which each drug is collected is usually a matter of considerable importance, as the amount, and sometimes the nature, of the active constituents is not constant throughout the year. This applies, for example, to the collection of Rhubarb, which is reported to contain no anthraquinone derivatives in winter but anthranols, which, on the arrival of warmer weather, are converted by oxidation into anthraquinones; also, the

contents of C-glycosides, O-glycosides, and free anthraquinones in the developing shoots and leaves of *Rhamnus purshiana* fluctuate markedly throughout the year.

- **Age of the plant at the time of collection:** The age of the plant is also of considerable importance and governs not only the total quantity of active constituents produced but also the relative proportions of the components of the active mixture.
- **Time of collection:** There is increasing evidence that the composition of several secondary plant metabolites varies appreciably throughout the day and night. In some cases—for example, with digitalis and the tropane alkaloid-containing plants, which have been extensively studied—the evidence has been somewhat conflicting in this respect. However, this may be largely due to the methods of analysis employed; thus, throughout the day, the overall amount of alkaloid or glycoside may not change to any extent, but there may be an interconversion of the various alkaloids or glycosides present. Daily variations of the poppy, hemlock, and ergot alkaloids have been reported.
- **Parts of the plant to be collected:** Generally speaking, leaves are collected as the flowers are beginning to open, flowers just before they are fully expanded, and underground organs as the aerial parts die down. Leaves, flowers, and fruits should not be collected when covered with dew or rain. Anything that is discolored or attacked by insects or slugs should be rejected. Barks are usually collected after damp weather, as they separate most readily from the wood. For collecting gums, gum resins, etc., dry weather is indicated, and care should be taken to exclude vegetable debris as far as possible. Underground organs must be freed from the soil. Shaking the drug before, during, and after drying or brushing it may be sufficient to separate sandy soil, but washing is necessary in the case of clay or other heavy soil.

2.3. Drying

Before marketing a crude drug, it is necessary to process it properly to preserve it longer and acquire better pharmaceutical elegance. This processing includes several operations or treatments, depending upon the source of the crude drug (animal or plant) and its chemical nature. Drying consists of removing sufficient moisture content of the crude drug to improve its quality and make it resistant to the growth of microorganisms. Drying inhibits partially enzymatic reactions. Drying also facilitates the pulverizing or grinding of a crude drug. In certain drugs, some special methods are required to be followed to attain specific standards; these include:

- **Need For Enzymatic action**: If enzymic action is to be encouraged, slow drying at a moderate temperature is necessary. Examples of this will be under '*Orris Rhizome*,' 'Vanilla Pods,' 'Cocoa Seeds,' and 'Gentian Root.' If enzymic action is not desired, drying should occur as soon as possible after collection.
- **Time of Drying Process:** Drugs containing volatile oils are liable to lose their aroma if not dried or if the oil is not distilled from them immediately, and all moist drugs are liable to develop mold. For these reasons, drying apparatus and stills should be as near the growing plants as possible. This has the advantage that freightage is much reduced, as many fresh drugs contain a considerable amount (60–90%) of water. Rapid drying helps flowers and leaves retain their color, and aromatic drugs their aroma.
- **Duration of Drying Process:** The drying process varies from a few hours to many weeks, and in the case of open-air drying, depends very largely on the weather. Exactly how far drying is to be carried is a matter of practical experience. If leaves and other delicate structures are over-dried, they

become very brittle and tend to break in transit. Drugs such as aloes and opium may require further drying after importation.

- **Temperature:** The temperature in each case is governed by the drug's constituents and physical nature. Generally, leaves, herbs, and flowers may be dried between 20 and 40 C, and barks and roots between 30 and 60 C.
- **Method of Drying Process Used:** Depending upon the type of chemical constituents, a method of drying can be used for a crude drug. Drying can be of two types:

✓ **Natural Drying (Sun-Drying)**

In case of natural drying, it may be either direct sun-drying or in the shed. If the natural color of the drug (digitalis, clove, senna) and the volatile principles of the drug (peppermint) are to be retained, drying in a shed is preferred. If the contents of the drugs are quite stable to the temperature and sunlight, the drugs can be dried directly in the sunshine (gum acacia, seeds, and fruits).

✓ **Artificial Drying**

Drying by artificial means includes drying the drugs in (a) an oven, i.e., tray dryers, (b) vacuum dryers, and (c) spray dryers.

a. Tray dryers

The drugs, which do not contain volatile oils and are quite stable to heat or need enzyme deactivation, are dried in tray dryers. In this process, hot air of the desired temperature is circulated through the dryers. This facilitates the removal of the water content of the drugs (belladonna roots, cinchona bark, tea, and raspberry leaves and gums are dried by this method).

b. Vacuum dryers

The drugs, sensitive to higher temperatures, are dried by this process, e.g.,

Tannic acid and digitalis leaves.

c. **Spray dryers.**

Few drugs are highly sensitive to atmospheric conditions, and the temperature of vacuum-drying is dried by the spray-drying method. The technique quickly dries economically important plant or animal constituents rather than crude drugs. Examples of spray drying are papaya latex, pectin, tannins, etc.

2.4. Storage

Preservation of crude drugs needs sound knowledge of their physical and chemical properties. A good quality of the drugs can be maintained if they are preserved properly. All the drugs should be preserved in well-closed and possibly filled containers. They should be stored on the premises, which are waterproof, fireproof, and rodent proof.

Several factors affect the quality of the stored crude drugs. These are:

- **Moisture content**: Several drugs absorb moisture during storage and become susceptible to microbial growth. Some drugs absorb moisture to the extent of 25% of their weight. The moisture not only increases the bulk of the drug but also causes impairment in the quality of the crude drug. The excessive moisture facilitates enzymatic reactions resulting in the decomposition of active constituents, e.g., digitalis leaves and wild cherry bark. Gentian and Ergot received mold infestation due to excessive moisture.
- **Radiation and Light:** Radiation due to direct sunlight also destroys active chemical constituents, e.g. ergot, cod liver oil and digitalis.
- **Temperature:** Temperature is also a very important factor in the preservation of the drugs, as it accelerates several chemical reactions leading to the decomposition of the constituents. Hence, most of the drugs need to be

preserved at a very low temperature. The costly phytopharmaceuticals must be preserved at refrigerated temperatures in well-closed containers.

- **Oxygen:** Atmospheric oxygen is also destructive to several drugs, and hence, they are filled in well-closed containers, or the air in the container is replaced by an inert gas like nitrogen, e.g., shark liver oil, papain, etc.
- **The form or shape of the drug:** This also plays a very important role in
- preserving crude drugs. Colophony in the entire form (big masses) is preserved nicely, but if stored in powdered form, it oxidizes or loses solubility in petroleum ether. When stored in powdered form, Squill becomes hygroscopic and forms a rubbery mass on prolonged exposure to air.
- **Microbial Contamination:** Apart from protection against adverse physical and chemical changes, preservation against insect or mold attacks is also important. Different types of insects, nematodes, worms, molds, and mites infest the crude drugs during storage. They can be prevented by drying the drug thoroughly before storage and also by giving treatment of fumigants. The common fumigants used for the storage of crude drugs are methyl bromide, carbon disulfide, and hydrocyanic acid.

3. Deterioration of crude drugs

The factors that must be considered about drug deterioration are moisture content, temperature, light, and oxygen, when these conditions are suitable, living organisms (bacteria, molds, mites, and insects) will rapidly multiply, using the drug as a source of nutrients. Drugs affected in this way are excluded by national pharmacopeias. As mentioned, the air-dry drugs contain about 10–12% moisture. In some instances (e.g., digitalis), this may be sufficient to activate enzymes in the leaves and bring about the decomposition of the glycosides. Other drugs, such as powdered squill

containing mucilage, quickly absorb moisture and become a sticky mass. The containerized shipment of drugs, which is now common practice, can lead to spoilage due to excessive moisture condensation on the inner metal walls. It is a particular problem with cargoes in transit from humid, moist climates to temperate regions. An increase in temperature, in combination with moisture, may accelerate enzyme activity; a large rise in temperature will lead to a loss of volatile constituents (e.g., essential oils from dried plant material). Direct sunlight can cause the decomposition of certain constituents (e.g., vitamins in cod liver oil) and produce bleaching of leaves and flowers. Oxygen assists in the resinification of volatile oils and the rancidification of fixed oils.

- **Bacterial attack**

Their presence is indicated by a mass of hyphae that bind the particles of the drug and by a characteristic smell. Deterioration of drugs is only one aspect of the importance of molds in Pharmacognosy. Bacterial attack of crude drugs is less obvious unless chromogenic species are involved or effects are produced, such as dustiness in cotton wool by the attack on the fibers. Although not a cause of deterioration, certain pathogenic bacteria such as salmonellae and Escherichia coli are tested for in some crude drugs taken internally (digitalis, sterculia, tragacanth, gelatin). Also, as plant materials, which have been dried under normal conditions, contain viable bacteria and mold spores in variable amounts, the pharmacopeias set limits for the total viable aerobic count per gram of drug.

- **Control of Infestation**

The detection, prevention, and eradication of mites and insect infestation are important hygienic and economic considerations for all who must store and use crude drugs. Effective preventive measures involve good hygiene in the warehouse (removal of spillages, old debris and packaging materials, elimination of sources of

infections such as floor cracks and crevices), effective stock control (regular inspection, rotation of stock, early recognition of infestation), optimum storage conditions (maintenance of cool, dry environment) and good packaging (woven sacks and bags, multi-ply paper sacks stitched at the seams, paper, polythene film, flimsy cardboard are all penetrable by insects and mites).

4. Practice Questions

- What are the differences between Angiosperms and Gymnosperms, and to which phyla do they refer?
- What are the four important stages in crud drug production? Name them and explain one of these stages.
- What are the types of drying processes?
- What are the factors that must be considered in drug deterioration?

The End