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INTRODUCTION

Pharmacognosy is concerned with the study of crude drugs of vegetable and animal origins. The term materia medica is used to refer to all substances used in medicine such as pure chemical compounds, herbal drugs, mineral substances, and biological preparations like vaccines and sera. Pharmacognosy involved a comprehensive study of individual drugs and elucidation of general principles. The word "Pharmacognosy" was used by C.A. Seydler in 1815 (Greek : *Pharmakon* = drug; *Gnosy*=knowledge). The subject deals with biological, biochemical, therapeutic, and economic features of natural drugs and their chemical constituents. At present pharmacognosy involves the study of crude drugs and their natural derivatives. Thus, Digitalis and its isolated glycoside, digoxin; Datura and its isolated alkaloid, atropine; Opium and its purified compound morphine, all are treated as the subject of pharmacognosy. For studying a drug, the following points must be considered :

1. **Biological Source** : The biological source of a drug is mentioned in Latin language which also include the family to which it belongs. After the Latin name, the name of the botanist responsible for the classification is mentioned in abbreviated form. The plant family to which the drug belongs determines certain of its characters.
2. **Habitat** : The principal areas of collection and routes of transport are considered under this head.
3. **Plant Habit** : The general structure of the plant and morphology of crude drugs are studied.

4. **Cultivation, Collection and Preparation for Market**: These factors require particular attention when they affect the appearance or quality of the product.
5. **Morphology and Sensory Charactors** : A knowledge of the fine details of macroscopical sturcture is of vital importance in the examination of powdered drugs.
6. **Histology** : Microscopical characters such as cell structure and arrangement, starches, epidermal trichomes, calcium oxalate crystals and fibres are studied under this head.
7. **Commercial Varieties, Substitutes and Adulteration:** With a knowledge of the diagnostic characters of official drugs, a critical examination may be made of commercial samples to determine their quality, substances known to be potential substitutes or adulterations.
8. **Chemical Constituents** : The pharmacological active constituents, the percentage of the more potent components; constituents of affecting the mode of preparation, the identity and the class of such compounds are considered.
9. **Evaluation of Drugs** : The purity and quality of drugs are determined.
10. **Uses** : Various medicinal uses and toxic effects are studied.

PHARMACOGNOSY AND MODERN MEDICINE

Modern pharmacognosy has been developed rapidly due to the improvement made in the technology of isolation processes which include the development of techniques such as column, paper, thin layer, gas-liquid, high performance liquid and droplet counter current chromatographic procedures. These methods have allowed the rapid isolation of compounds previously difficult to obtain by classical procedures. The most important factor has been the development of new spectroscopic techniques which are used to identify structures of the isolated compounds.

Simultaneous advancement in the fields of chemistry, biochemistry, biosynthesis and pharmacology has developed pharmacognosy. Various active compounds have been isolated from plants which are used in modern medicine. With the advancement of synthetic organic chemistry most of the active constituents of plants used in medicine have

been synthesized. However, in spite of phenomenal progress in the area of development of new drugs from synthetic sources and appearance of antibiotics as major therapeutic agents, plants continue to provide basic raw material for some of the most important drugs. Although more than 100 plants are used in modern medicine in various parts of the world, the list of most important ones along with their pharmacological properties is given in Table - 1.

Table 1. Important Active Constituents of Plants Used in Medicine.

Plants	Active Constituents	Pharmacological Activity
1. *Dioscorea* sp. *Agave* sp., *Solanum* sp.	Steroidal hormones	Anti-inflammatory, antiarthritic, hormonal
2. *Papaver somniferum*	Morphine, Codeine, Papaverine	Sedative, antitussive, smooth muscle relaxant
3. *Cinchona* sp.	Quinine Quinidine	Antimalarial, antiarrhythmic
4. *Datura* sp., *Hyoscyamus niger*, *Duboisia* sp.	Hyoscyamine Hyoscine Atropine	Parasympatholytic
5. *Digitalis lanata*	Digitoxin Digoxin Lanatosides	Cardiotonic
6. *Rauwolfia* sp.	Reserpine Rescinamine Deserpidine	Hypotensive Vasodialator
7. *Catharanthus roseus*	Ajmalicine	Vasodialator
8. *C. roseus*	Vincristine, Vinblastine	Anticancer
9. *Camellia sinensis* (Tea)	Caffeine	CNS stimulant

(Contd.)

Plants	Active Constituents	Pharmacological Activity
10. *Erythroxylum coca*	Cocaine	Anaesthetic
11. *Ephedra* sp.	Ephedrine	Sympathomimetic
12. *Pilocarpus jaborandi*	Pilocarpine	Parasympatho-mimetic
13. *Cephaelis acuminata, C. ipecacuanha*	Emetine	Antiamoebic
14. *Claviceps purpurea*	Ergometrine Ergotamine Ergotoxine	Oxytocic, Vascocontrictor, Vasodialator
15. *Plantago ovata*	Psyllium mucilage	Laxative
16. *Vinca minor, Voacanga africana*	Vincamine	Vasodialator
17. *Glycyrrhiza glabra*	Glycyrrhetic acid	Anti-inflammatory
18. *Cassia angustifolia, C. acutifolia*	Sennosides	Laxative
19. *Berberis* sp.	Berberine	Antidiarrhoreal
20. *Podophyllum peltatum*	Podophyllotoxin	Anticancer
21. *Colchicum autumnale*	Colchicine	Gout
22. *Theobroma cacao*	Theobromine	CNS stimulant, diuretic
23. *Coffea arabica*	Theophylline	CNS stimulant, diuretic

In addition to pure constituents the crude extracts of Belladonna, Ipecac, Opium, Henbane, Stramonium, Cascara sagrada, Glycyrrhiza, Rhubarb, Valerian, Podophyllum, Capsicum oleoresin, Digitalis and Aloe are used in modern medicine. Besides these, the essential oils of Japanese mint, Peppermint, Eucalyptus, Anise seed, Clove, Cinnamon leaf, Lemongrass and Camphor are also utilized in modern medicine.

Liver and stomach preparations of animals are used in therapy of pernicious anaemia. Bile secreted in liver is used in biliary secretion and parenterally as sodium salt to increase diuresis.

AYURVEDA AND DRUG DEVELOPMENT

Ayurveda is an ancient Indian system of health-care, both physical and mental, and literally means, science of life. Health in *Ayurveda* has been defined as a well balanced metabolism plus a happy state of being . Disease has been considered four fold,

1. body,
2. mind,
3. external factors and
4. natural intrinsic causes.

In Ayurveda treatment is done by a salubrious use of drugs, diets and practices.

Pharmaceutics occupies an important place in *Ayurveda*. Medicinal preparations are invariably complex mixtures, being derived from plant and animal products as well from minerals and metals.

Utilization of plants is mentioned in *Rigveda* and *Atharvaveda*. *Charaka Samhita* (900 B.C.) is the first recorded treatise on Ayurveda. It consists of eight sections divided into 150 chapters, and describes 341 plants used in medicine. The other treatise on Ayurveda is *Sushruta samhita* (600 B.C.) with special emphasis on surgery. It has six sections covering 186 chapters and describes 395 medicinal plants, 57 drugs of animal origin, and 64 minerals and metals as drugs. The next important authorty in Ayurveda was Vagabhatta of Sind, who practised during about 7th centrury A.D. His manuscript entitled *'Astanga Hridaya'*, is considered unrivalled for principles and practice of medicine. The manuscript is divided into six sections covering 120 chapters and contains 7444 verses. Madhava of Vijayanagar (12th century A.D.) comprised *Madhava Nidana* which consisted 69 chapters and 1552 verses. Sarangdhara (14th century), the author of *Sarangdhara Samhita*, systematized Ayurvedic *Materia media*. This book consists of three parts, 32 chapters, and 2500 verses. Bhava Mishra of Magadha wrote his treatise *Bhava Prakashan* in 1550 A.D. which contained 10,831

verses; nearly 470 medicinal plants are mentioned. In addition, about 70 pharmacy lexicons have been written. *'Raja Nighantu'* by Narhari Pandita and *'Madanpala Nighantu'* by Madanpala are considered as masterpieces on medicinal herbs.

Kashmir-born Dridhobala (9th century A.D.), a well known physician of India, re-constructed and re-edited the great Ayurvedic medical treatise *Charaka Samhita*. Another famous scholar of 9th century A.D. was Ugraditya Charya Jain, a native of Deccon, who wrote a treatise under the title *Kalyana Karaka*. He has described the use of mercury and many other compounds. Vrinda (1000 A.D.) composed a book of medicinal chemistry called *Siddhayoga*. The book describes methods for the preparation of various metallic drugs. Chakarapanidatta (1066 A.D.) wrote *Chikitsa Sarsamgraha* which described uses of more metals for curing diseases. A treatise called *Chikitsa Sarsamgraha* was written by Vangasena in 1200 A.D. The book describes uses of mica, iron, mercury, sulphur and copper.

CONTRIBUTION OF UNANI MEDICINAL SYSTEM TO PHARMACY

In the seventh and eighth centuries the Arabs conquered a great part of the ancient civilized world and extended their empire from Spain to India. Like the Romans, they respected the cultures of the conquered people. During the reign of Abbasid Caliph Harun al-Rashid (786-814 A.D.) Baghdad achieved fame as a city of learning. Some Indian physicians were invited to Baghdad, received the favours of the Caliph and settled there.

Juhanna ibn Masawaih (777-857 A.D.) translated the Greek manuscripts into Arabic and wrote a medical book. He modified the effects of certain remedies recommended as mixtures. The first London Pharmacopoeia was largely based on his formulae.

Manaka, a popular Indian physician at Baghdad, translated some books from Sanskrit into Arabic or Persian and composed *Kitab tafsir isma al-Aqaqir* which included a list of drugs and herbs of Indian origin.

The work of Persian born Abu Bekr Muhammad Ibn Zakaria or Rhaze (841 - 926) has been very much used in the European world. He wrote about one hundred medical books. His book, *Kitab al-Hawi*, has been used as a medical

encyclopaedia. Abu'l Qasim al-Zahrawi or Albucasis, born in Spain in 936 A.D., practised as physician - pharmacist - surgeon and wrote on surgery and pharmaceutical subjects. Abu Mansur (C.970), a Persian pharmacologist, was the author of Arab Pharmacopoeia in which he described 466 vegetable drugs, 75 meneral drugs and 44 animal drugs. Al-Biruni (973-1050) of Khwarizm made great contribution towards the development of pharmacy. He defined pharmacognosy and pharmacology first of all, studied the natural products and their sources and mentioned 720 drugs in an alphabetical order in his book *al - Saidana fil tibb.*

Abu Ali al-Husain bin Abdallah or Avicenna (980 - 1037), born in Bukhara, was called as the "Prince of Physicians". His book, *'Qanun fil Tibb'*, was used as a guide and authority up to 17th century. Ali ibn Abbas (994 A.D.), a persian medical author, wrote a medical encyclopaedia, *Kitab al Maliki.* Seville-born Abu Mervan or Ibn Zuhr or Avenzoar (1113-1199) was a medical botanist and pharmacist. His main work was on diet, which is incorporated in the book *al-Aghdhiya.* Abu'l-Walid Muhammad ibn Ahmad or Ibn Rushd, born in 1126 A.D. at Cardova in Spain, composed a medical book *Kitab al-Kulliyat.* Rabbi Moses (1135 - 1208) was a Jewish scholar and physician who wrote dietetic rules in a book. It describes diet and regimen including *Rhubarb* and *tamarind* pills. The publications of Spanish-born Ibn al-Baytar (1197-1248) gave the most comprehensive list of drugs. He mentioned detailed outlines for the preparation of rose water and recommended the use of Colocynth, Croton oil, Nutmeg and Pyrethrum. Ibn Serabi, an important pharmacist of the Muslim world, was famous for writing on medieval pharmacy. Abu'l Qasim-al-Iraqi (1300 A.D.) deseribed the preparation and properties of an anaesthetic powder in his book *Uyun al-Haqaiq.*

The Arabs greatly improved pharmaceutical products and made them more elegant and palatable. Their pharmacy and Materia Medica were followed for a long time. The use of sugar is a chracteristic of Arab Pharmacy. Many drugs of India or of the East, such as Musk, Cloves, Cubebs, Dragon's blood, Galanga root, Betel nut, Sandalwood, Rhubarb, Nutmeg, Tamarind, Cassia bark, Croton oil, and Nux vomica were introduced by Arabs into Egypt. Alcohol, Jalap, Syrup, Aloe, Cinnamon, Camphor (Kafur), Anise, Zingiber, Myrrh, Styrax, Coffea, etc. are the Arabic names

which are common in English. In the 7th century A.D. Arabs founded trading centres on the Malabar coast of South India. Through these centres they purchased spices, dyes, drugs and perfumes and introduced these articles in Iran, Turkey, Egypt and other countries.

It was in the 8th century that Arab Pharmacy and Medicine became two separate branches. This separation was made compulsory by law in 11th century and governmentally supervised stores were established in Baghdad. An inspector was appointed to check and ensure the supply of genuine herbs, and for inspecting the preparation of formulations for patients. There was deterrent punishment for adulteration of medicines and fake prescriptions. In Middle Ages schools of pharmacy were established for a regular pharmaceutical education. They discovered new and potent medicaments. If the new drugs proved bitter in taste, the ingenious Arab pharmacists devised chemical and mechanical methods to make them tolerable. The candy-coated pills were first employed by Avicenna who always tried to keep their patients cheerful. Arab pharmacists mixed rose-water and perfumes with medicines. They invented tinctures, confections, syrups, pomades, plasters, and ointments to ease the physicians task. The use of hashish and *bhang (Cannabis sativa)* and the behaviour of addicts of these drugs are described in the *Arabian Nights*. They invented the apothecary, which they called 'Saidala'. Ibn al-Attar, the son of a druggist, referred to the Sandalwood for therapeutic uses. In the reign of al-Mansur's son the drug shops were run by educated and morally responsible apothecaries.

Alchemy was developed along with medicine. The idea of "elixir of life", an "all-cure" was developed. The Arab pharmacists from the 9th century invented valuable techniques and apparatuses and included in their stock many of the commodities required in different branches of technology. Their pharmaceutical preparations consisted of powders, suspensions, syrups, electuaries, distilled medicinal waters and many other forms exceeding seventy in number. Some typical apparatuses were designed for manufacturing the medicines. Akbar the Great sent many Unani physicians all over India and paid attention to the profession of pharmacy. Most of the physicians were interested in medicinal plants and mentioned their preparations, properties, therapeutic effects, mode of administration and reactions in

their books. Ilyas bin Shehab described many Indian drugs and herbs in his book *Rahat al - insan* during the rule of Firoz Shah Tughlaq (1351-1368 A.D.).

FUTURE OF HERBAL DRUGS

Plants are still a potent source of therapeutic agents. They are popularized due to their effectiveness, easy availability, low cost and comparatively being devoid of serious toxic effects. Some herbal drugs like *Achyranthes aspera* (diuretic), *Acorus calamus* (tranquilizer), *Artemisia vulgaris* (cardiac tonic), *Butea frondosa* (anthelmintic), *Bacopa monnieri* (memory), *Boerhaavia diffusa* (anti-inflammatory), *Cassia fistula* (cathartic), *Centella asiatica* (intelligence), *Curcuma longa* (anti-inflammatory), *Eugenia jambolana* (hypoglycemic), *Euphorbia thymifolia* (antiasthmatic) and *Sida rhombifolia* (anabolic) have been proven to exhibit the respective pharmacological actions. A derivative of artemisinin, prepared from *Atemisia annua*, is effective against resistant strains of *Plasmodium falciparum* where synthetic antimalarials fail to cure the disease. A derivative of podophyllotoxin obtained from *Podophyllum hexandrum* and *P. emodi* and taxol isolated from *Taxus baccata* have been approved as an anticancer agents in USA. A flavonoid, isolated from *Silybum marianum*, has been approved as drug against various liver disorders in Germany and other western countries. Iridoid glycosides, called valepotriates, obtained from Valeriana species, have been used as tranquilizer and sedative in Germany and other European countries. Total saponins from the Indian plant *Commiphora mukul*, often referred as guggulipid, have been approved as hypolipidaemic agent for lowering blood cholesterol.

AYURVEDIC MEDICINAL SYSTEM

Like all systems of Indian sciences, the origin of Ayurveda has been taken from the gods. Ayurveda was first perceived by Brahma, and he taught this science to Daksa - Prajapati, who taught it to the Aswni-Kumaras, and they taught it to Indra and so on. All the four Vedas are replete with references to various aspects of medicine. Many miraculous achievements in the field of medicine and surgery are mentioned in Vedas. The concept of digestion, metabolism, anatomical descriptions and discussion about several diseases are available. Different

types of bacteria causing diseases are also described. The process of delivery, cauterization, toxins, control of evil sprites, rejuvenation therapies and aphrodisiacs have been mentioned. Medicinal plants, the different parts and their therapeutic effects are also described. Ayurveda believes in the existence of soul in the individual's body and in the unity of the body and the mind. Mental perversions affect the physical functions, and morbidity of the body affects the mental activities. Intellectual blasphemy, unwholesome conjunction of sense organs with their objects and vagaries of weather and time are causative factors of diseases. Forcible stimulation of natural strength, negligence in treatment, loss of good conduct, avoidance of health activities, malice, fear, anger, etc. are some examples of intellectual blasphemy. Unwholesome conjunction of sense organs include vision, sound, smell, taste and touch. Cold, heat and rain are characteristic features of seasonal diseases. *Rasa*, *rakta*, *mamsa*, *medas*, *asthi*, *majja* and *sukra* are the seven basic tissue elements. There are thirteen groups of enzymes which are responsible for digestion and metabolism in the body.

Principles of Ayurveda

Life in the purview of Ayurveda connotes a combination of body, sense organs, mind and soul. It is a system of health care which treats each person. The "TRIDOSHIC" concept is the fundamental principle in Ayurveda.

There are three basic constituents of the physiological systems according to this concept. These constituents are called "DOSHAS". They are the ultimate irreducible basic metabolic elements constituting the body and mind of the living organism. They are classified into VATA, PITTA and KAPHA. They correspond primarily to elements of air, fire and water. They determine the life processes of growth and decay.

Vata

The biological air humour is called "Vata" (air). It is primarily dry, cold and light. It is most important, or primary, of the three biological humours. It governs the other two and is responsible for all physical processes in general. It sustains effort, exhalation, movement and the discharge in impulses, the equilibrium of tissues and the coordination of senses. When aggravated, Vata (air) causes emaciation, debility,

liking of warmth, tremors, distension, constipation, insomnia, sensory disorientation and incoherent speech. Vata is located in the colon, thighs, hips, ears, bones and organ of tough.

Pitta

The biological fire humour is called Pitta, sometimes also translated as bile. It is responsible for all chemical and metabolic transformation in the body. Pitta exists mainly in the acid form as fire and cannot exist directly in the body without destroying it. Pitta is primarily hot, moist and light. It governs digestion, heat, visual perception, hunger, thirst, lustre, complexion, understanding, intelligence, courage and softness of the body. Pitta in excess causes yellow colour of stool, urine, eyes and skin, hunger, thirst, burning sensation and difficulty in sleeping. High Pitta results in accumulation of internal heat or fever with inflammation and infections. Pitta is located in small intestine, stomach, sebacious glands, blood, lymph, organs and vision. Its primary site is in small intestine.

Kapha

The biological water humour is called Kapha, sometimes also translated as phlegm. Etymologically it means 'that which holds things together'. It provides substance and gives support and makes up the bulk of our bodily tissues. It also governs emotional traits as love, compassion, modesty, patience and forgiveness. Kapha is primarily cold, moist and heavy. It gives stability, lubrication, holding together of the joints and such qualities as patience. Kapha is the material substratum and support of the other two humours and also gives stability to the emotional nature. Excessive Kapha causes depression of the digestive fire, nausea, lethargy, heaviness, white colour, chills, looseness of the limbs, cough, difficult breathing and excessive sleeping. High Kapha results in the accumulation of weight and gravity in the body, inhibits normal function and causes hypoactivity through excessive tissue accumulation.

Treatment

Vata is treated by mild application of oils, mild sweating and purification methods. Pitta is treated with the ingestion of ghee (clarified butter), by purgation with sweet and cold

herbs, by sweet, bitter and astringent foods and herbs, by applying cool, delightful and fragrant essential oils, by amounting the heat with Camphor, Sandalwood, Vetivert oils, etc. Kapha is treated by strong emetic and purgation methods according to the rules by all kinds of exercises, by smoking of herbs and by doing physical hard work.

Thus herbal medicine plays a major role in the treatment of Vata, Pitta and Kapha.

Ayurvedic Therapies

There are many different therapies applied in Ayurveda. They can all be defined in two groups viz :

(i) Tonification (supplementation-make heavy).

(ii) Reduction (elimination-to lighten)

Reduction therapies decrease body weight and are indicated for overweight accumulation of toxins and aggravated humours. It is indicated in acute stage of disease, when the attack is strong, and primarily for Kapha.

Tonification methods nourish deficiencies in body and are indicated in underweight, debility or tissue weakness. They are indicated in chronic diseases, in convalescence or after reduction methods have been used, and primarily for Vata. A mixed therapy is required for Pitta.

Ayurvedic methods of diagnosis are extremely simple. Stress is given on urine, stool, semen, flatus, vomiting, sneezing, eructation, yawning, hunger, thirst, tears, sleep and heavy breathing for diagnosis of a disease. Ayruveda also stresses upon the use of a wholesome diet along with the use of drugs for the successful treatment of diseases. Knowledge of the site of manifestation of the disease is essential for successful treatment. Pulse is examined in the early morning when the patient is in empty stomach. Pulse examination is carried out through the help of the radial artery.

In Ayurveda drugs are classified depending on their taste, attributes, potency, taste after digestion, and therapeutic effect. Four types of therapies - elimination therapy, alleviation therapy, psychic therapy and surgery, are used for the treatment of diseases. In addition to single drugs, compound formulations are generally used by Ayurvedic physicians in the form of pills, powders,

decoctions, infusions, linctus, alcoholic preparations, medicated ghee, fractional distillation, collyrium, etc. Several pharmaceutical processes are followed for the preparation of medicines for easily administration; making the products delicious to the taste, easily digestable and assimilatable, therapeutically more efficacious, rendering them non-toxic and more tolerable and for preservation of medicines for a longer time. Ayruvedic drugs are administered both externally in the form of ointment, dusting powder, collyrium, ear drops and eye drops, and internally as tablets, pills, powder, syrups, etc. Along with medicines some regimens like sleep, walk, rest, physical exertion, etc. are also prescribed to the patients.

UNANI SYSTEM OF MEDICINE

Like Ayruveda, the Unani system of medicine is based on ancient principle. So there is a similarity between *Ayurveda* and *Tibb* regarding the contemplation of the same dogmatisms and traditionalism. The most important similarity is the principle of four elements which is identical to *Ayruveda's Panchbhuta* principle. According to four elemental principles of *Tibbi* discipline all the universal inanimate and animate things are produced from *Al-Nar* (Fire), *Al - hawa* (Air), *Al-ma* (Water) and *Al-ardh* (Earth). According to Ayruveda, all of the universal objects are made of *Panchbhuta* and body has its root and support of Doshas (*Tridosha* viz. *Vata, Pitta* and *Kapha),* Dhatus (seven metals : *Rasa, Rakta, Mansa, Meda, Asthi, Majja and Sukra)* and Mala (*Sweda, Mutra,* and *Purisha*). When these remain in the equilibrium and in normal functioning, then the health of an individual is maintained. In the same manner *Tibb* also maintains this view that the human body is composed of seven natural principles or components of the body known as *Al - umur Al - tabiyah.* The loss of the any one of these components may lead to diseases, or even death of the individual. These are as follows :

1. *Al - arkan* or *al - anasir* (Elements)
2. *Al - mizaj* (Temperament)
3. *Al - akhalt* (Humours - body fluids)
4. *Al a'za'* (Organs or members)
5. *Al - arwah* (Pneuma or vital spirit)
6. *Al - quwa* (Faculties or Powers)

7. *Al - at'al* (Functions)

In addition to these seven components, the essential causes influencing the human body are :

1. Atmospheric air
2. Foods and drinks
3. Physical or bodily movement and repose
4. Mental or Psychic movement and repose
5. Sleep and wakefulness
6. Evacuation and retention.

These factors essentially influence each and every body. Nobody could escape from these factors so long he is alive.

Some of the non essential causes are not concerned with every body and do not necessarily influence each and every human body. These are habit, habitat, profession, sex, temperament, other social factors, cosmic and terrestrial influences, etc. These factors influence to those only who come across them, therefore, they are considered non-essential. These are as :

1. Geographical conditions of the country and town and other related matters,
2. Residential conditions and related matters,
3. Occupation and related matters
4. Habits and related matters
5. Age and related matters
6. Sex and related matters
7. Any other factor antagonistic to nature and bodily health, e.g., micro-organisms, ionizing radiations, electricity and other natural forces.

The temperaments of persons are accordingly expressed by the words sanguine, phlegmatic, choleric and melancholic according to the preponderance in them of humours - blood, phlegm, yellow bile and black bile, respectively. The humors themselves are assigned temperaments - blood is hot and moist; phlegm cold and moist; yellow bile hot and dry; and black bile cold and dry.

Every person is supposed to have a unique humoral constitution which represents his healthy state. To maintain the correct humoral balance there is power of self preservation of adjustment called *Quwwat-e-Mudabbira* (Medicatrix naturae) in the body. If this power weakens

imbalance in the humoral composition occurs, and this causes disease. In Unani medicine great reliance is placed on this power. The medicines used in this system, in fact, help the body to regain this power on the optimum level and thereby restore humoral balance, thus retaining health. The correct diet and digestion are also considered to maintain humoral balance.

Therapeutics

In Unani system of medicine various types of treatment are employed, such as Ilaj bit - Tadbeer (regimental therepy), Ilaj bil-Ghiza (dietotherapy), Ilaj bid-Dawa (pharmacotherapy) and jarahat (surgery).

The regimental therapy includes venesection, cupping, diaphoresis, diuresis, Turkish bath, massage, metastasis, cauterization, purging, emesis, exercise, leeching, etc. Dietotherapy aims at treating certain ailments by administration of specific diets or by regulating the quantity and quality of food, whereas pharmacotherapy deals with the use of naturally occurring drugs of herbal, animal and mineral origin. Similarly, surgery has also been in use in this system for quite long. The naturally occurring drugs used in this system are symbolic of life and are generally free from side-effect. If such drugs are toxic in crude form, then they are processed and purified in many ways before use. In Unani medicine although general preference is for a single drug, compound formulations are also employed in the treatment of various complex and chronic disorders. Since in this system, stress is laid on a particular temperament of an individual, the medicines administered are such as go well with the temperament of the patient, thus accelerating the process of recovery and also eliminating the risk of drug reaction.

Unani medicine aims of combating disease and preservation and promotion of health through curative, preventive, and promotive measures. For the treatment of various common and stubborn diseases, medicines obtained from natural sources e.g., plants, animals and minerals, are used in this sysem. Unani medicines are not only cheap and easily available, but are also effective and free from side effects.

Unani system of medicine has grown by experiences of

nations and countries like Egypt, Iraq, India, China, etc. Diagnosis of a disease is carried out by knowing past history of the patient and examination of pulse and other body organs. The Unani pharmaceutical preparations consist of powder, suspension, syrups, electuries, distilled medicinal waters and many other forms exceeding seventy in number.

HOMOEOPATHIC MEDICINAL SYSTEM

Homoeopathic medicinal system was started by the chemist, physician and pharmacist Samuel Hahnemann (1755-1843) of Germany who was dissatisfied with the side effects of the then current regimens of medication. He initiated the treatment of a disease with a low dose of those drugs which themselves produced similar symptoms of the disease in normal individuals. A medicine produces some symptoms in healthy state and if the identical symptoms are present in a sick person, then the patient will get relief with a minor dose of the medicine. According to Hahnemann, there is no any normal and natural method for diagnosis of a disease except its symptoms. This principle of the treatment of 'like with like' is quite the reverse of the allopathic system.

In any medicinal system there is no co-relation between the cause of the disease and human potency. According to homoeopathic medicinal system until the potency governing on the body of a human being is powerful and controls the functions of all organs, then the person will not be affected by a disease. A disease produced in the body and brain will effect on other body organs. The habits of telling lie, theft, deceit, evil, narcosis, under diet, anger, etc. are symptoms of mental diseases. After collecting the information about a disease, stress is given on mental disorders. Any symptom of a disease can not be complete without the governing power of the body.

Hahnemann's original observation involved Cinchona, which produced, in normal individuals, symptoms similar to those of malaria, for which the drug was used. In the same way, Belladonna on administration produced symptoms associated with Scarlet fever. If the symptoms of a disease are considered a manifestation of the body's own defence mechanism against the disease, then the homoeopathic treatment serves to stimulate such inherent defensive and

curative processes. Hahnemann prepared a list of drugs with their effects on healthy individuals. A patient's symptoms could then be matched as closely as possible against the drug pictures and the appropriate treatment prescribed. In this way Nux vomica and Gelsemium root (yellow jasmine) became drugs for the treatment of influenza and the common cold.

Hahnemann observed that in the initial stages of treatment with the appropriate drugs at normal dosage rates, the illness appeared to be worsen in the beginning as the symptoms are inhanced by the drug. Therefore, subsequent doses are lowered. He observed that as the dose of a drug was reduced, its potency was enhanced. Thus, this process was no longer referred to as dilution but as potentiation. Thus, the homoeopathic treatment arrived at in conjunction with the patient's very detailed case history and constitutes the use of often very active drugs in extremely low doses. For the higher potencies of homoeopathic drugs the possibility of a current scientific explanation becomes non-existent, because individual doses at the dilution of the sixth or eight decimal may no longer contain a single molecule of the drug. Homoeopathic remedies have the distinct advantage that they are without side-effects.

Homoeopathic medicines are used in the form of mother tinctures, small pills, powder and distilled water. The patient should not take any kind of food or drink prior or after one hour of the dose.

For prescribing the medicine it is essential that information about characteristics of elements, mental symptoms and other symptoms should be collected. The medicine with more pronounced characters should be prescribed. If there is no relief then according to elements any medicine belonging to anti-soric, anti-cycotic and anti-syphilic category should be prescribed in one or two doses prior to the earlier medicine. Sora, syphilic and cycosis are related with the production of air, bile and cough as mentioned in Ayurveda. Diseases produced by air are identical to those which are produced by entering *sora*, e.g., mental exitement by bile and of syphilic and cycosis, respectively. These disorders are sometimes combined with each other. In some diseases the air and bile predominate

and in others, cough and bile are in excess. In homoeopathy, diseases are not produced by the attack of microorganisms. Weak body potency is responsible for disease. This body potency becomes weak due to sora, syphilic and cycosis. Therefore, they are searched in the body.

Hahnemann's fundamental propositions peculiar to Homoeopathy may be said, as :

(a) that the action of drugs are demonstrable by observing the subjective symptoms, objective symptoms and pathological changes that occur when they are administered to healthy human subject.

(b) that the action of drugs so observed in a healthy human being constitutes their therapeutic potentiality with respect to the sick individual.

(c) that a similarity between disease processes in a particular individual and the known effects of a particular drug in healthy human being (known as drug proving of Homoeopathy) will lead to its successful application in the treatment of diseased individual (i.e. to bring a change in the altered dynamis).

(d) the conception of dynamis (vital force-active-driving force) is applicable in respect of health, disease and cure.

There are three essential processes involved in preparation of remedies : (a) Serial dilution (b) Succession (c) Trituration. Dilution is the meant by which we reduce the toxicity of the original crude drug. Serial dilution means that each dilution is prepared from the dilution that immediately proceeded it. Succession and trituration are the methods by which mechanical energy is delivered to our preparations in order to imprint the pharmacological message of the original drug upon the molecules of the diluent.

From the pharmaceutical point of view there are two main classes of original substance : (a) Soluble (b) Insoluble.

In the class of soluble substances mother tinctures (alcohol or water extraction) of the plant material are used. The symbol is used to denote the mother tincture of any soluble substance. For soluble substance alcohol and water are applied. At each stage rhythmical violent agitations are carried out, either by hand or machine, and this is known

as "Succession". Insoluble natural substances are prepared in a different way. The diluent in one sense is lactose. The physical process applied at each stage is known as 'Trituration', it is a prolonged circular grinding with mortar and pestle. Once this trituration has obtained 6 x or 1/10, this be dispersed into alcohol water diluent. Thereafter, it is treated like a soluble substance.

These two major scales of preparing medicine are denoted as 'c' for centesimal scale and 'x' for decimal scale.

Centesimal scale involves a serial dilution 1/100, whereas decimal involves a serial trituration 1/10.

For the preparation of the homoeopathic potencies of a liquid drug substance three scales are in use, i.e. (a) Decimal (b) Centesimal and (c) Millesimal.

For the preparation of potencies from solid drug substances, (a) Decimal and (b) Centesimal scales are in use. When trituration attains the 6 x potency, then only it will be fit to be converted into liquid potency.

SIDDHA SYSTEM OF MEDICINE

Siddha is extensively practised in the southern parts of Tamil Nadu and in the neighbouring states.

Siddha is an ancient system of medicine. In treatment it uses minerals and metals mainly, but some products of vegetable and/or animal origin are also used. Work relative to Siddha contained atleast 3500 formulae written in Tamil initially on palm leaves.

Siddha medicine is essentially a psychosomatic system of medicine. Unlike Ayurveda importance is given more to minerals and metals rather than herbs in pharmaceutics. Herbs are used only to triturate and calcinate the metals into their basmam and sindooram.

As the world is made up of five elements or panchabutas, so also the human body. The human body is composed of earth and water, the soul is made up of air and ether and heat and fire combine them and make them to live together.

Hence, medicines for the human body are prepared based on the theory of panchabutas (metals of gold, lead, copper, iron and zinc). Gold and lead are used for the maintenance of the body. Iron, the only metal attracted by

the electric power of magnet, and zinc, used for generating electricity, are employed in the medicine which are administered for the extension of life. Copper is used for the preservation of heat in the body. All the metals are used only after proper detoxification.

Siddha gives more attention to the disorders of the elements of the intrinsic factors of body than to the extrinsic ones.

The materia medica of Siddha science contains vegetables, minerals and marine elements and the three cordinal humours. All the drugs contain one or more of these humours.

The raw drugs are used either individually or in combination with other drugs. They are subjected to specific processes and the products are administered purification methods which include detoxification. A preparation contains several crude drugs.

SCOPE OF PHARMACOGNOSY AND PHYTOCHEMICAL INDUSTRY IN INDIA

Since indiscriminate use of synthetic drugs and antibiotics have resulted into serious symptoms all over the world, the demand of plant based raw materials for pharmaceuticals has increased enormously. Moreover, the synthetic drugs and intermediary chemicals are extremely expensive. The World Health Organization has emphasized the utilization of indigenous systems of medicines based on the locally available raw materials, i.e., medicinal plants. Furthermore, approximate one third of all drugs are plant-based and if bacteria and fungi are also included, nearly sixty per cent of pharmaceuticals are of plant origin. Our country is rich in large number of such plants that either be used directly or as the source of active principles in formulaion of drugs curing dreaded diseases. India as a whole is the richest source of medicinal plants which are distributed in almost all parts of the country. The herb collectors and small traders collect the drugs for the manufacturers of Ayurvedic and Unani medicines. But there is a shortage of these materials for maintaining the sustained supply to the plant based drug industries. It is also not proper under the present situation to be dependent only on natural resources to keep the wheel

of the industries running all the time in view of the fast depleting natural wealth. This calls for the domestication and cultivation of these plants as well as increment of the drug production with uniformly high potency. At the same time increased demand of plant raw materials has led to over exploitation of wild plants resulting into serious hazard. This necessiates the urgent need of their systematic cultivation for constant supply to the user industries.

Domestication and cultivation of some of the important plants are necessary to cope up the demand of constant supply for the phytochemical industries. These plants include *Adhatoda vasica, Claviceps purpurea, Costus speciosus, Digitalis lanata, Dioscorea deltoidea, Hyoscyamus niger, Mentha piperita, Ruta graveolens, Santalum album, Solanum khasianum, S. lancinatum, Eucalyptus* species, etc.

There are many drugs which are imported to India. These include Balsam of Tolu, Peru Balsam, Benzoin, Storax, Copaiba, Asafoetida, Ipomoea, Colocynth, etc. If the cultivation of these drugs producing plants is carried out in India, sufficient foreign exchange can be saved.

As mentioned earlier, a derivative of artimisinin from *Artemisia annua*, podophyllotoxin obtained from *Podophyllum hexandrum (P. emodi)*, silymarine flavanoid isolated from *Silybum marianum* seeds and total saponins from the Indian plant *Commiphora mukul* have been approved as drugs in various countries.

One of the new areas is medicine during the recent years has been the use of adaptogenic drugs from plants. Most of these drugs are used as general tonic and stimulants to improve the defence mechanism of the body and protect the body against stress and infection. These drugs also help the body to improve and tone up metabolism in old age and in persons weakened by serious diseases. These drugs, although not accepted in modern medicine, are now sold widely in Europe, USA and Asia mostly as health foods. Ginseng (*Panax* sp.), and Siberian Ginseng *(Eleutherococcus senticosus)*, Korean ginseng *(Panax ginseng)*, American Ginseng *(P. quinquefolium)*, Ashwagandha *(Withania somnifera)*, Brahmi *(Centella asiatica* and *Bacopa monnieri)* and Satwar *(Asparagus racemosus)* are used as adaptogenic drugs.

Inspite of the tremendous advance in medicine, there is a number of diseases for which modern medicine has no

cure. In such cases it treats only symptoms to provide relief to patients. These include viral diseases, such as herpes (genitalis, simplex, zoster, etc.), muscular dystropy, parkinsonism, alcoholism, obesity, smoking, stress, genetic diseases, arthritic diseases, liver disorders, cancer, aids, etc. Recent trends have shown that plant drugs have the answer to such cases. Recently, a number of formulations based on Ayurvedic medicine have come to the market for control of liver disorders and some of these have been found effective against these diseases. There is a considerable scope to screen such plants for active constituents which may be used in future for treatment of such incurable diseases.

QUESTIONS

1. What is the importance of alternative systems of medicine in India ? Giving principles of Ayurveda, explain the role that modern pharmacognosy can play in proving effective drugs (Delhi University, 1988, Supple).
2. Giving historical background discuss the scope of pharmacognosy. What is its relevance in the modern drug scene (Delhi University, 1987) ?
3. Define Pharmacognosy and give its brief history and relationship with various allied sciences. (Jamia Hamdard, 1992).
4. Name the traditional systems of medicine practised in our country. Give the official source, chemical nature and uses of four traditional drugs which you have studied.
5. Discuss the development of Pharmacognosy giving the historical background. What are scopes of this discipline in providing authentic drugs ?
6. Discuss the basic principles of Ayurvedic and Unani systems of medicine. How is knowledge of pharmacognosy relevant to these medicines ?
7. What do you know about modern concept of pharmacognosy ?

2

CLASSIFICATION OF CRUDE DRUGS

Higher plants, microbes and animals are the main sources of crude drugs. However, enzymes and antibiotics used in modern medicine are obtained from animals and microbes. For the study of crude drugs, they may be classified according to morphological, taxonomical, chemical and pharmacological characters. Each of these systems has its own merits and demerits. Morphological classification is more helpful to identify and detect adulteration. For studying evaluationary developments, the drugs are classified according to taxonomical classification. The activity of a drug is due to its chemical constituents and, therefore, the drugs are divided according to the presence of chemical components. Pharmacological classification of drugs is more relevant to study therapeutic utility of the drugs.

1. MORPHOLOGICAL CLASSIFICATION

Under morphological classification the drugs are arranged according to the part of the plant used such as leaves, stems, roots, barks, flowers, seeds, etc. The drugs obtained from the direct parts of the plants and containing cellular tissues are called as organized drugs, e.g. rhizomes, barks, leaves, fruits, entire plants, hair and fibres. The drugs which are prepared from plants by some intermediate physical processes such as incision, drying, or extraction with a solvent and not containing any cellular plant tissues are called as unorganized drugs, e.g. Aloe juice, Opium latex,

Agar, Gambier, Gelatin, Tragacanth, Benzoin, Honey, Beeswax, Lemongrass oil, etc. (Table 1).

The main drawback of morphological classification is that there is no co-relation of chemical constituents with the therapeutic actions. Usually this classification is adopted in the practical classes.

Table 1 : Gross Classification of Drugs on the Basis of Morphological Characters.

Plant Parts	Drugs
1. Organized Drugs	
Wood	Quassia, Sandalwood, Red Sandalwood.
Leaves	Digitalis, Eucalyptus, Gurmar, Pudina, Senna, Spearmint, Squill, Tulsi, Vasaka, Coca, Buchu, Hamamelis, Hyoscyamus, Belladonna, Tea.
Barks	Arjuna, Ashoka, Cascara, Cassia, Cinchona, Cinnamon, Kurchi, Quillaia, Wild Cherry.
Flowering Parts	Clove, Pyrethrum, Saffron, Santonica, Chamomile.
Fruits	Amla, Anise, Bael, Bahera, Bitter Orange peel, Capsicum, Caraway, Cardamom, Cassia, Colocynth, Coriander, Cumin, Dill, Fennel, Gokhru, Hirda, Lemon peel, Psoralea, Senna pod, Star anise, Tamarind, Vidang.
Seeds	Bitter Almond, Black Mustard, Cardamom, Colchicum, Ispaghula, Kaladana, Linseed, Neem, Nutmeg, Nux vomica, Physostigma, Psyllium, Strophanthus, White Mustard.
Roots and Rhizomes	Aconite, Ashwagandha, Calamus, Calumba, Colchicum corm, Dioscorea, Galanga, Garlic, Gentian, Ginger, Ginseng, Glycyrrhiza, Podophyllum, Ipecac, Ipomoea, Jalap, Jatamansi, Male fern, Picrorhiza, Piplamul, Rauwolfia,

Plant Parts	Drugs
	Rhubarb, Sassurea, Senega, Shatavari, Turmeric, Valerian, Squill, Serpentary, Indian Podophyllum, Krameria, Derris, Indian Valerian.
Plants and Herbs	Andrographis, Bacopa, Banafsha, Belladonna, Cannabis, Centella, Chirata, Chondrus, Datura, Ephedra, Ergot, Hyoscyamus, Kalmegh, Lobelia, Punarnava, Shankhpushpi, Stramonium, Vinca, Yeast.
Hair and Fibres	Cotton, Hemp, Jute, Silk, Flax.
2. Unorganized Drugs	
Dried Latex	Opium, Papain.
Dried Juice	Aloe, Kino.
Dried Extracts	Agar, Alginate, Black Catechu, Pale Catechu, Pectin.
Gums	Acacia, Guar gum, Indian gum, Sterculia, Tragacanth.
Resins	Asafoetida, Benzoin, Colophony, Copaiba, Guaiacum, Guggal, Mastic, Myrrh, Peru Balsam, Sandarac, Storax, Tolu Balsam, Tar, Coal Tar.
Fixed Oils and Fats	Arachis, Castor, Chaulmoogra, Coconut, Cottonseed, Linseed, Olive, Sesame, Almond, Theobroma, Lard, Cod-liver, Halibut liver, Kokum butter.
Waxes	Beeswax, Spermaceti, Carnauba wax.
Volatile Oil	Turpentine, Anise, Coriander, Peppermint, Rosemary, Sandalwood, Cinnamon, Lemon, Caraway, Dill, Clove, Eucalyptus, Nutmeg, Camphor.
Animal Products	Beeswax, Cantharides, Cod liver oil, Gelatin, Halibut liver oil, Honey, Shark-liver oil, Shellac, Spermaceti wax, Wool fat, Musk, Mylabris, Lactose.
Fossil Organisms and Minerals	Bentonite, Kaolin, Kiesselguhr, Talc.

2. TAXONOMICAL CLASSIFICATION

Taxonomical classification is based on the principles of natural relationship and evolutionary development. They are grouped in phyllum order, family, genus and species. As all the entire plants are not used as drugs, therefore, it is of no significance of this division from identification point of view. This system also does not co-relate in between the chemical constituents and biological activity of the drugs. The taxonomical classification is summerized in Table 2.

Table 2. Taxonomical Classification of Drugs

Phyllum	Order	Family	Drugs
Angiosperms (Monocotyledons)	Liliflorae	Liliaceae	Scilla, Colchicum, Asparagus
		Dioscoreaceae	Dioscorea
	Microspermae	Orchidaceae	Vanilla
Angiosperms	Papaverales,	Papaveraceae	Opium
(Dicotyledons)	Rosales	Rosaceae	Almond, Quillaia, Rose oil
		Leguminosae	Balsam of Tolu, Glycyrrhiza, Senna
	Rutales	Rutaceae	Bael, Lemon, Orange peel
	Rhamnales	Rhamnaceae	Cascara bark
	Malvales	Malvaceae	Sida
	Umbelliflorae	Umbelliferae	Coriander, Caraway, Dill, Fennel
	Gentianales	Loganiaceae	Nux-vomica
		Gentianaceae	Chirata
		Apocyanaceae	Kurchi, Rauwolfia, Strophanthus
	Tubiflorae	Convolvulaceae	Shankhpushpi
		Labiatae	Mentha, Ocimum

Phyllum	Order	Family	Drugs
		Solanaceae	Belladonna, Capsicum, Datura, Hyoscyamus
		Scrophulariaceae	Digitalis
	Plantaginales	Plantaginaceae	Plantago
	Dipsacales	Valerinanceae	Valerian
	Companulales	Lobeliaceae	Lobelia
		Compositae	Artemisia, Kuth
Bryophyta and Pteridophyta (Liverworts, Mosses and Ferns)	Filicales	Polypodiaceae	Male Fern
Gymnosperms	Genetales	Ephedraceae	Ephedra
	Coniferae	Pinaceae	Colophony
Thallophyta (Bacteria, Fungi, Lichens)			
Rhodophyta	Gelidiales	Gelidiaceae	Agar

3. CHEMICAL CLASSIFICATION

The biological activity of a drug is due to the presence of certain chemical constituents in the drug. Plants and animals synthesize chemical compounds such as fats, carbohydrates, proteins, volatile oils, alkaloids, resins,etc. and some of these are pharmacologically active constituents. A single active constituent may be isolated from the crude drug and used as a medicinal agent. More than 75 pure compounds derived from higher plants find their place in modern medicine. For example, the important traditional active plant principles are codeine, atropine, ψ-ephedrine, hyoscyamine, digoxin, hyoscine, digitoxin, pilocarpine, theobromine, theophylline, quinidine, quinine, emetine, caffeine, papaverine and colchicine. These active constituents are differentiated from the inert compounds like starch, cellulose, lignin, cutin, etc. The active constituent may be present in a very low concentration in the drug. The chemical classification of drugs is dependent upon the grouping of drugs with identical chemical constituents as shown in Table 3.

Table 3. Chemical Classification of Drugs

Chemical Constituents		Drugs
1. Carbohydrates		
	Gum	Acacia, Tragacanth, Guargum, Sterculia
	Mucilages	Plantago seed
	Others	Starch, Honey, Agar, Pectin, Bael, Cotton
2. Glycosides		
	Anthraquinone	Aloe, Cascara, Rhubarb, Senna,
	Saponins	Quillaia, Arjuna, Glycyrrhiza, Dioscorea
	Cyanophore	Wild Cherry bark,
	Isothiocyanate	Mustard
	Cardiac (Steroidal)	Digitalis, Strophanthus, Scilia
	Bitter	Gentian, Calumba, Quassia, Chirata, Picrorhiza, Kalmegh
3. Tannins		Pale Catechu, Black Catechu, Ashoka bark, Galls, Myrobalan, Behera, Amla
4. Volatile oils		Cinnamon, Nutmeg, Fennel, Dill, Caraway, Coriander, Cardamom, Orange peel, Mint, Clove, Ginger, Valerian, Saffron, Banafsha, Tulsi, Anise, Lemongrass, Jatamansi, etc.
5. Lipids		
	Fixed oils	Castor, Olive, Peanut, Cottonseed, Almond, Shark liver,
	Fats	Theobroma, Lanolin
	Waxes	Beeswax, Spermaceti
6. Resins		Colophony, Podophyllum, Jalap, Cannabis, Capsicum, Turmeric, Ginger, Myrrh, Asafoetida, Storax, Balsam of Tolu, Balsam of Peru, Benzoin
7. Alkaloids		
	Pyridine and Piperidine	Lobelia, Nicotiana, Areca nut
	Tropane	Coca, Belladonna, Datura, Hyoscyamus, Stramonium, Henbane

(Contd.)

Chemical Constituents	Drugs
Quinoline	Cinchona,
Isoquinoline	Opium, Ipecac, Calumba
Indole	Ergot, Nux vomica, Rauwolfia, Catharanthus, Physostigma,
Amines	Ephedra
Steroidal	Kurchi, Veratrums
Purine	Tea, Coffee
Diterpene	Aconite
8. Proteins	Gelatin, Ficin, Papain
9. Vitamins	Yeast
10. Triterpenes	Rasna, Colocynth

4. PHARMACOLOGICAL CLASSIFICATION

In Pharmacological classification the drugs are grouped according to their therapeutic uses. Thus cardiotonic drugs include Digitalis, Squill and Strophanthus. Senna leaves and Castor oil are termed as purgative drugs. A particular drug containing known chemical constituents can be grouped according to its therapeutic use. The main drawback of this classification is that a drug can be placed in various classes according to its therapeutic use. Thus Cinchona can be grouped in antimalarial and antiarrhythmic catagories. The classification of drugs based on pharmacological action or therapeutic uses is given in Table 4.

Table 4 : Classification of Drugs Based on Pharmacological Action.

Pharmacological Action	Drugs
Anticancer	Vinca, Podophyllum, Taxus
Anti-inflammatory	Colchicum corm and seed, Turmeric
Antiamoebic	Ipecac root, Kurchi bark
Anthelmintic	Artemisia, Male Fern, Quassia wood, Vidang, Chenopodium oil
Antiasthmatic	Ephedra, Lobelia, Vasaka, Tylophora
Antispasmodic	Belladonna, Datura, Hyoscyamus
Astringent	Catechu, Tannic acid, Myrrh, Myrobalan, Ashoka bark

(Contd.)

Pharmacological Action	Drugs
Analgesic	Opium, Cannabis
Bitter tonics	Quassia wood, Nux-vomica, Gentian, Picrorhiza, Chirata, Kalmegh
Carminatives and Flavours	Cinnamon bark, Cardamom seed, Nutmeg fruit, Clove, Umbelliferous fruits, Peppermint, Saffron, Asafoetida, Oleo-gum resin, Mint, Tulsi, Ginger, Vanilla
Purgatives	Cascara bark, Senna, Rhubarb, Aloe, Castor oil, Plantago seed husk
Expectorant	Benzoin, Balsam of Tolu, Glycyrrhiza, Vasaka
Cardiotonic	Digitalis, Squill, Strophanthus
CNS Action	Ergot, Belladonna, Stramonium, Hyoscyamus, Ephedra, Physostigma
Hallucinogens	Cocaine, Cannabis
Tranquillizer	Rauwolfia roots.

QUESTIONS

1. Describe various systems of classification of crude drugs. Write their merits and demerits.
2. What are organized drugs ? Name five organized drugs containing glycosides as their main components. Give their biological sources and important diagnostic features.
3. What are the different systems of classifications of crude drugs ? Discuss the system based on the chemical constituents in detail.
4. Explain various classification of crude drugs. What are the advantage and disadvantage of morphological classification ?
5. Erumerate the different systems of classification of drugs. What is biochemical system of classification and what is its importance ?
6. Give the pharmacological classification of plant drugs.

3

DRUG CONSTITUENTS

The medicinal value of a crude drug depends on the presence of one or more chemical constituents of physiological importance. They may be glycosides, alkaloids, organized resins, enzymes, etc. A vegetable drug is composed of a number of tissues such as cells, fibres, vessels and other structures. The cell walls may consist of cellulose, lignins, tannins or cork cells. The cells of aromatic drugs like Cinnamon and Coriander contain volatile oils occurring in specialized cells or glands. The glycosides and alkaloids may occur in solution in the cell sap and deposit in the cells later on. The total contents of the cells are not used as physiological importance. For example, calcium oxalate occurs as a crystalline deposit and protein may occur as solid aleurone grains. Both these components are rejected in the preparation of a tincture or extract of the drug.

The unorganized drugs possess no cellular structure but consist of extracts, exudation, secretions and other products of the plants. The value of gums, gum-resins, oleo-resins, starch, fixed oils, catechu, and opium depends on the whole of the material present. The constituents of drugs of medicinal value generally belong to one of the following group: glycosides, enzymes, anthraquinone derivatives, alkaloids, tannins and other phenols, proteins, carbohydrates, gums, resins, fixed oils, fats, waxes and volatile oils.

CARBOHYDRATES

Carbohydrates are plant products which contain carbon,

hydrogen, and oxygen. The ratio of hydrogen and oxygen is the same as occurred in water, e.g. dextrose $C_6H_{12}O_6$ and sucrose $C_{12}H_{22}O_{11}$. Carbohydrates are widely distributed in plants; provide storage and transport of energy and are building blocks of the cell wall. They are classified as : mono- and oligosaccharides (True sugars); polysaccharides (Nonsugars), and the derived carbohydrates (gum, mucilage and pectin).

Polysaccharides consists of numerous units of monosaccharides. They are not sweet in taste. Starch, cellulose and dextrins are polysaccharides.

Gum, mucilage and pectin are derived carbohydrates which are composed of acid or ester forms. Gums are polyuronides formed due to combination of sugar and uronic acid units. Gums are used as emulsifier, suspending agents, tablet binders and thickeners.

Chemically, mucilages are similar to gums but differ in the nature of sugar and acid residue. They may contain sulphate groups or their salts. They form a clear colloidal solution and are used mainly as suspending agent. Mucilage is present in Agar, Plantago seeds and Linseed.

Pectins are consisted of methoxylated polygalacturonic acids. They are present in the inner portion of the rind of Citrus fruits and in apples. They swell in water and form stiff jellies.

GLYCOSIDES

Glycosides are compounds which upon hydrolysis give rise to one or more sugars (glycone) and a compound which is not a sugar (aglycone or genin). The aglycone is usually a compound containing one or more hydroxyl groups. The glycoside is formed by the elimination of a molecule of water between a hydroxyl group of the aglycone and a hydroxyl group of the sugar. The aglycone may be an alcohol (Salicin), anthraquinone derivative, phenol, aldehyde, acid, ester, or other compound.

The other important glycosides are anthraquinone glycosides, cardiac glycosides, cyanophore glycosides and isothiocyanate glycosides.

SAPONINS

Saponins are an important group of glycosides which are

widely distributed as plant constituents. The most important saponin-containing drugs are Quillaia and Senega. Most of the saponins are neutral and soluble in water. Like other glycosides, saponins are hydrolyzed to form a sugar (usually dextrose) and an aglycone, generally known as sapogenin. The sapogenins are insoluble in water, but soluble in weak alcohol. Their aqueous solutions form froths on shaking; produce stable emulsion on shaking with oils and fats; absorb and retain in solution a volume of gas (e.g., CO_2) several times greater than absorbed by an equal volume of water; an aqueous solution added to red blood corpuscles causes haemolysis, i.e., disintegration and solution of the corpuscles to form a clear red liquid.

ANTHRAQUINONE DERIVATIVES

The laxative action of certain drugs is attributed to derivatives of anthraquinones, C_6H_4 $(CO)_2$ C_6H_4. Various derivatives are obtained by replacing the hydrogen atoms by alkyl, hydroxyl and other groups. Many such derivatives occur in nature and often are combined with a sugar forming a glycoside. For example:

Chrysophanol : a dihydroxy methyl anthraquinone present in Rhubarb.

Emodin : a trihydroxy methyl derivative present in Cascara and Rhubarb.

Aloe-emodin : the primary alcohol derived from chrysophanol, present in Aloe, Rhubarb and Senna.

Rhein : the acid derived from aloe-emodin, present in Rhubarb and Senna.

The anthraquinone derivatives are often orange red coloured compounds. For their detection the filtrate is shaken with benzene or chloroform and set aside to form two layers. The organic layer is separated and shaken with an equal volume of solution of ammonia. A pink to reddish colour is developed.

LIPIDS-FIXED OILS, FATS AND WAXES

The term lipid is used for fixed oils, fats and waxes. Fixed oils are liquid at normal temperature while fats are solids or semi-solids at this temperature. Chemically, they are esters of glycerol with long chain fatty acids. These esters are termed as glycerides.

Fixed oils and fats are nonvolatile, insoluble in water and are lighter than it and form a permanent stain on a paper. They are sparingly soluble in cold alcohol (except Castor oil), but soluble in other organic solvents like petroleum ether, diethyl ether, chloroform, etc.

Waxes are esters of a higher alcohols (e.g. cetyl alcohol) with higher fatty acids. They are insoluble in water, soluble in many organic solvents and can be saponified by alcoholic alkali.

VOLATILE OILS

Volatile oils are flavouring constituents which evaporate on exposure at ordinary temperature. They are present in various plant parts such as flower petals (Saffron), fruits (Fennel), bark (Cinnamon), etc. They are secreted in particular secretory cells like glandular hairs, modified parenchyma cells, vittae or in lysigenous or schizogenous cavities.

Volatile oils are colourless liquids or crystalline or amorphous solids. They are slightly soluble in water, but highly soluble in ether, alcohol and other organic solvents. Like fixed oils they do not form permanent strains and cannot be saponified by alkalies.

Chemically, volatile oils are the mixture of monoterpenes and sesquiterpenes. They may be simple hydrocarbons, alcohols, ketones, aldehydes, phenols, ethers, oxides, esters, acids, aromatic or aliphatic compounds.

Phenolic volatile oils are present in drugs like Thyme, Clove, Creosote and Pine tar. They have antibacterial, antifungal and antiseptic properties.

RESINS, GUM-RESINS AND OLEO-RESINS

The resins are derived from living natural sources and most of them are plant products (except Shellac). The resinous exudation may consist almost entirely of resins (e.g. Benzoin), or it may be associated with volatile oil (e.g., Turpentine, Copaiba); or resin associated with gum(gum resin). If a considerable amount of volatile oil is present, the substance is called an oleo-gum-resin (e.g. Myrrh). The resins or oleo-resins, which contain benzoic or cinnamic acid either free

or combined, are commonly called balsams (e.g. Benzoin, Balsam of Tolu, Balsam of Peru, Storax).

All resins are practically insoluble in water, soluble in organic solvents (e.g. alcohol) and terpentine oil.

A solution of a resin in a volatile solvent, on painting on a smooth surface, is dried rapidly and completely to form a hard transparent film. This film should not be darken with age or become impaired upon exposure to light or moisture.

Resins are not single chemical compounds, but are mixtures of various substances of complex chemical characters.

Resins are used as purgative, cathartic, hydragogue, sedative, counter-irritant, anthelmintic, expectorant and laxative. Externally they are used as mild antiseptic in the form of cerates, ointments and plasters.

TANNINS AND OTHER PLANT PHENOLS

Tannins are complex phenolic compounds which are soluble in water and have an astringent and bitter taste. They are soluble in water; have an astringent taste; yield purple, violet, or black precipitates with iron compounds; are precipitated by a number of metallic salts like potassium dichromate, lead acetate and lead subacetate; combine with skin and hide to form leather and with gelatin and isinglass to form an insoluble compound; combine with alkaloids to form tannates, most of which are insoluble in water, and they yield a bulky precipitate with phenazone.

The tannin containing drugs are Cinchona, Clove, Catechu, Cinnamon, Hamamelis, Krameria, etc.

A considerable number of plant substances are phenolic compounds, e.g. the anthraquinone derivatives, morphine and the resinotannols. They form coloured compounds with ferric chloride. Certain plant pigments are also phenolic. For example,

1. *Hydroxy flavone glycosides* : They are derived from flavones or the related compound xanthones. These glycosides themselves are colourless, but form yellow salts. They occur in Clove, Hamamelis, Catechu, Buchu, Senega, Gentian, Digitalis and Stramonium. They yield a dull green or reddish-brown colour with ferric chloride.

2. *Anthocyanins* : They are phenolic plant pigments which may be red, blue, or purple. The exact colour depends upon the hydrogen ion concentration of the solution. For example, haematien is a reddish coloured anthocyanin of logwood which changes to blue upon addition of lime water.

Simple phenolic compounds are found in many plants and have different pharmaceutical uses. Vanillin is the aglycone of the glycosides of Vanilla pods and is used in confectionary and in perfumary. Similarly, eugenol (Clove), salicin, and arbutin are simple phenolic compounds.

ALKALOIDS

Alkaloids are complex substances, occurring in plants or animals, are basic or alkali-like and possess physiological activity. The term is usually restricted to compounds having one or more heterocyclic rings containing nitrogen. They are considered as derivatives of pyridine, quinoline or isoquinoline and contain carbon, hydrogen, oxygen, and nitrogen but a few are without oxygen. Mostly alkaloids are solid colourless crystalline products but few alkaloids, which generally do not possess oxygen, e.g., nicotine, coniine, spartein, are volatile colourless liquids. Some alkaloids are coloured, e.g. berberine (yellow) and sanguinarine (red).

Alkaloids combine with acids to give salts and are used in this form. A water-soluble alkaloidal salt or other compound is more useful than one insoluble in water. Alkaloids are fairly soluble in organic solvents, e.g. chloroform, ether, alcohol and benzene.

In plants alkaloids are found in various parts as in seeds (strychnine), in fruits (Piper), in leaves (Belladonna, Datura), in roots (Rauwolfia), in rhizomes and roots (Ipecac), in corm (Colchicum) and in bark (Kurchi, Cinchona).

ENZYMES AND OTHER PROTEINS

Enzymes are defined as organic catalysts produced by plants and animals with molecular weight from 13,000 to 8,40,000. At ordinary temperatures they bring about chemical changes, both synthetic and analytic. Most enzymes are insoluble in alcohol, ether, and other organic solvents, but are soluble in water. In some cases the enzymes are combined with the

protoplasm which must be killed by an organic solvent (e.g., $CHCl_3$, toluene) or by mechanical means before extraction of the enzyme. Some enzymes do not pre-exist in the tissues, but are formed from substances termed *'zymogens'*. In nature, decomposition of the zymogen is carried out by a complex substance, known as *kinase*, to form the enzyme when needed.

The term *substrate* is used to a substance which reacts with the enzyme. In nature, enzyme and substrate are sometimes present in the same cell and the reaction may take place continuously. In other cases, enzymes and substrate are found in different cells. The reaction starts on diffusion of one of the substance; the reaction is controlled by the plant. Some enzymes are combined with the protoplasm, and this represents one method of preventing diffusion.

The rate of chemical change brought about by enzyme is affected by certain factors. For examples, some substances, like *paralysers*, partially or entirely, inhibit the action of the enzymes. The substances, called *co-enzymes*, are required for the action. The substances known as *accelerators* or *activators*, greatly accelerate the rate of reaction.

Temperature is another important factor in enzyme action. For each enzyme there is a particular temperature, called the optimum temperature and lies between 35°-45°C, at which reaction proceeds most rapidly. Most of the enzymatic reactions are inhibited below 10°C, and destroyed by heating to 100°C.

Enzymes are usually soluble in water. They are usually accompany with glycosides. Some drugs like Wild Cherry, Almonds, Mustard and Wintergreen, owe their value not to the glycoside present, but to its decomposition products by the enzymes.

Some important enzymes of medicinal importance are pancreatin of pancereas used to treat pancreatitis; trypsin of ox pancrease used to cure wounds, ulcers, abscesses and fistulas and as anti-inflammatory agent; chymotrypsin of pancreas of ox used identically as trypsin; fibrinolysin utilized to treat venous thrombosis and pulmonary embolism; pepsin of the gastric juice employed to treat achylia gastrica; hyaluronidase found in microorganisms, leaches, snake venom and mammalian testes, and used to facilitate the administration of fluids by hydronermolysis.

Papain is the dried and purified latex of the fruit of *Carica payaya* and used as a digestant. Chymopapain is a nonpyrogenic proteolytic enzyme obtained from the latex of *Carica payaya* and employed in the treatment of herniated lumbar intervertebral discs. Bromelains is a mixture of protein-digesting and milk-clotting enzymes obtained from the juice of the pineapple, *Ananas comosus*. It is used as adjunctive therapy to reduce inflammation and oedema and to reduce tissue repair.

Gelatin is obtained from animal collagen and is a pharmaceutical aid. Other protein based drugs are Absorbable Gelatin sponge and film, microfibrillar collagen surgical sutures, penicillamine, heparin sodium, heparin calcium, protamine sulphate and levodopa.

PEPTIDE HORMONES

Hormones are secreted by endocrine glands of animals. Thyroxine, conjugated oestrogens, insulin, epinephrine, oxytocin, vesopressin and gonadotropins are important mammalian hormones released directly into the blood. Thyroxin hormone of thyroid gland is used to treat thyroid insufficiency. Menopausal symptoms in females and dysmenorrhea are treated with conjugated oestrogens. Insulin, a polypeptide hormone secreted by the beta cells of the islets of Langerhans of pancrease gland, is employed to cure diabetes. Adrenal medulla of mammmals secretes the hormone epinephrine (adrenaline) which is utilized as vasoconstrictor to cure acute asthma. Oxytocin, a polypeptide hormone secreted by posterior pituitary gland, causes contraction of uterine muscles, stimulates the ejection of milk in lactating mothers, induce labour in pregnant women and stop haemorrhage after child birth. Another peptide hormone of the posterior lobe of pituitary gland, vasopressin, is used in the treatment of intestinal paralysis and diabetes. Gonadotropins are secreted by the interior lobe of the pituitary gland which control the production of sex hormones. They are employed to cure infertility and in cryptoichidism.

MICRO-ORGANISMS

Microorganisms (microbes) are the viruses, bacteria and rickettsiae which are sources of many biological substances

of immunization importance. These drugs possess immunity against various infectious diseases. Immunity is acquired by administration of a vaccine, toxoid or antitoxin like diphtheria. Vaccines are suspended micro-organisms which may be obtained from viruses, bacteria and rickettsiae. On introduction into body, a vaccine stimulates the production of antibodies against pathogenic microbes. Viral vaccines are prophylactic agents used against polio, smallpox, rabies, influenza, measles and mumps. Rickettsial vaccine, prepared from gram-negative microorganisms, is the typhus vaccine which produces active immunity against typhus fever. Bacterial vaccine is the suspension of pathogenic bacteria in sodium chloride or other solvent. Bacteria vaccine includes Typhoid vaccine, Cholera vaccine, Plague vaccine, Pertussis vaccine (for whooping cough) and BCG vaccine (for tuberculosis).

The waste products of bacteria, called toxins, are dissolved in the surrounding culture medium after excretion. On treatment with formaldehyde their toxic properties are reduced but their antigenic property is not effected. These products are called fluid toxoids which are precipitated with alum, aluminium hydroxide or aluminium phosphate. The toxoids are used to induce artificial activity immunity in susceptible individual. For example, tetanus toxoid and diphtheria toxoid are the microbial products used to produce immunity in young children against diphtheria, tetanus and whooping cough.

MARINE PRODUCTS

Marine products are used a thickening, emulsifying and suspending agents. Carrageenan from *Chondrus crispus* (Irish Moss) and alginates from species of *Laminaria. Ascophyllum, Ecklonia, Nereocystis* and *Macrocystis* are used in adhesive formulations and as stabilizers, ingredients of ointment bases, suspending agent and tablet disintegrating agents. Agar, obtained from species of *Gelidium* and *Gracilaria,* is used as laxative, emulsifier, suspending agent and in the preparation of vaginal capsules, suppositories and nutrient media in bacteriological culture. Spermaceti, a solid waxy substance obtained from the oil of the sperm whale, *Physeter macrocephalus,* is used as a pharmaceutical aid for creams, ointments, cerates, soaps, cosmetics, etc. Shark liver oil, a fixed oil obtained from the liver of shark fish, *Hypoprion*

brevirostris, is nutritive and used as a tonic and to treat xerophthalmia occurring due to deficiency of vitamin A. The marine fungus, *Cephalosporium acremonium*, produces the antibiotic cephalosporin C identical to penicillins. The strongly basic protein of low molecular weight, protamine, is obtained from the testes of the fish salmon. It is used as a heparin antagonist. Pralidoxine is produced from electric eel which acts as antidote for certain types of insecticide poisoning in humans. The Japanese drived red algae, *Digenea simplex*, contains the amino acid known as kainic acid from which an anthelmintic drug is prepared. Cod-liver oil is the source of vitamins A and D.

An anticoagulant agent has been isolated from the sea-anemone, *Rhodactis howesii*. Very potent anticancer agents, named dolastin 1-9, are present in Indian ocean sea-hare. The marine annelid, *Lumbriconeris heteropoda*, is toxic to some insects. The richest natural source of prostaglandin is the soft coral *Plexaura homomalla*. Many toxins occur throughout the complete range of marine life; they include irritants, CNS stimulants and depressants, haemolytic substances and protoplasmic poisons. Extracts of various marine algae contain vitamin C, folic acid, folinic acid, niacin and vitamin B.

VITAMINS

Vitmains are organic compounds which are not synthesized within the body. They are essential in small amounts for the maintenance of normal health. The lack of specific vitamins causes diseases such as beriberi, rickets, scurvy and xerophthalmia. Vitamin B_2 (niacin) and pantothenic acid act as coenzymes. Vitamin B_{12} and folic acid take part in the biosynthetic transfer of 1-carbon unit. In the biosynthesis of hydroxyproline, vitamin C is required. Vitamin B_1 and B_6 are involved in the metabolism of carbohydrates. Many vitamins take part in metabolic oxidation-reduction reactions.

Vitamin A is obtained from animal products and it is involved in vision, growth and tissue differentiation. Vitamin B is a complex mixture of compounds. Liver and yeast are the main sources of the B vitamins. Vitamin C (ascorbic acid) prevents scurvy and is used as antioxidant. Good dietary sources of vitamin C are citrus fruits, tomatoes, strawberries,

fresh fruits and vegetables. Vitamin D is essential for the absorption and utilization of calcium. It is obtained from fish liver oils, milk, cereals and synthesized in the body in sunshine. Vitmain E, a mixture of tocopherols, is widely distributed in plant oils, vegetables, grains, eggs and meats. Its deficiency causes muscular dystrophy, coronary disease and sterility. Vitamin K is widely distributed in diary products and many fruits and vegetables. It is necessary for normal clotting of blood.

ANTIBIOTICS

Antibiotics are the chemical substances produced by microorganisms and they have the capacity, in low concentration, to inhibit microorganisms through an antimetabolic mechanism. Penicillin G, obtained from a strain of *Penicillium chrysogenum*, is an agent acting against many pathogenic gram-positive bacteria and used to treat syphilis. Cloxacillin, dicloxacillin, methicillin, nafcillin and oxacillin are semisynthetic penicillins which are used for treatment of staphylococcal infections. Ampicillin has special clinical value for the treatment of infections caused by *Haemophilus influenza*, *Salmonella* species and *Shigella* species. Clavulanic acid is a fermentation product of *Streptomyces clavuligerus* and it controls many infectious diseases. Other antibiotics are cephalosporins (from *Cephalosporium acremonium*), chloramphenicol (from *Streptomyces venezuelae*), lincomycin (from *S. lincolnensis*), cycloserine (from *S. orchidaceus*), dactinomycin (from *S. parvullus*), vidarabine (from *S. antibioticus*), polymyxin B (*Bacillus polymyxa*), colistin (*B. polymyxa*), tyrothricin (*B. brevis*), vancomycin (*S. orientalis*), bleamycin (*S. verticillus*), tetracyclines (*S. aureofaciens*), mitomycin (*S. caespitosus*), erythromycin (*S. erythreus*), amphotericin B (*S. nodosus*), navamycin (*S. natalensis*), griseofulvin (*Penicillium griseofulvum*), rifampin (*S. mediterranei*), novobiocin (*S. niveus and S. spheroides*), stgreptomycin (*S. griseus*) neomycin, and paromomycin (*Streptomyces fradiae* and *S. rimosus* var. *paromomycinus*), kanamycin (*S. kanamyceticus*), gentamicin (*Micromonospora purpurea*), tobramycin or nebramysin factor 6 or nebrarius), amikacin (semisynthetic antibiotic derived from kanamycin A by acylation), netilmicin (*Micromonospora inyoensis*) and spectinomycin (*Streptomyces spectablis* and *S. flavopersicus*).

MISCELLANEOUS DRUGS

Ichthamol is a black tarry distillate obtained from bituminous schists containing fossil fish and possesses antiseptic and stimulant properties. Diatomaceous earth (siliceous earth, kieselguhr), made of shells of fossilized unicellular algae, is utilized in face powders, filtering aids, dentifrices and as chromatographic adsorbent.

Liver and stomach of healthy animals are converted into suitable preparations which are used as replacement therapy in pernicious anemia. Bile contains sodium salts of bile acids-dehydrocholic, taurocholic and deoxycholic acids. Bile acids, obtained from ox bile, are used in deficiency of biliary secretion and parenterally as sodium salts to increase diuresis. Carmine, a colouring principle obtained from cochineal insects, cantharidin, an irritant constituent of cantharidin insects, heparin, wool fat and lanolin are the other animal products which are used in some formulations and in cosmetics.

QUESTIONS

1. Give an account of the non-living cell content in plants with specific reference to the various microchemical tests for their identification.
2. Give a comparative account of chemical constituents present in crude drugs.
3. Describe biological sources and uses of the drugs in which the following chemical constituents are present: (a) Digitoxin (b) Atropin (c) Euginol (d) Curcumin.

4

DRUG ADULTERATION

An adulterated drug means one which does not conform to the official requirements. Adulteration involves incorporation of impurities. spoilage, deterioration, admixture, sophistication and substitution. The genuine drugs are substituted with spurious, inferior, defective or harmful substances. The spoiled or deteriorated drugs represent the greatest percentage of drug adulteration. In some cases the dealers substitute the drugs with cheap materials in case of scarcity or when the price of a drug is high. The adulteration may be due to faulty collection, imperfect perparation and incorrect storage as described hereunder :

FAULTY COLLECTION : In some cases the proportion of medicinally-active constituent reaches a maximum at a particular season, stage of development, or age. But collection of correct part of genuine plant without regard to time factors causes adulteration. The following are some examples:

(i) Season

Drug	**Season of Maximum Activity**
Solanaceous leaves	Flowering stage of the drug (Summer)
Wild Cherry bark	Autumn
Colchicum corm	Early summer
Male fern	Late autumn.

(ii) Stage of development and age

Drug	Stage and Age of Maximum Activity
Linseed	When fully ripe
Coriander	When fully grown and ripe
Wild Cherry bark	Bark of young stems
Belladonna root	Root of 3-4 years old.

Sometimes adulteration is done by collection of other less valuable part of a genuine plant. For example :

Drug	Official Part	Less Valuable Parts
Buchu	Leaves	Stems
Clove	Flower-buds	Flower-stalks
Senega	Root	Stems
Serpentary	Rhizome and roots	Sub-aerial stem

Ignorance or neglect on the part of collectors may lead to unintentional collection of drugs from the allied or foreign species. Such plants may bear a superficial resemblance to the genuine plant. In place of the genuine drugs, substituted products are available in the market. These substituents are identical in appearance. Some example are as :

Drug	Official Source	Source of Adulteration
Aconite	*Aconitum napellus*	*Aconitum deinorrhizum* and other species of *Aconitum*
Buchu	*Barosma betulina*	*Barosma crenulata, Barosma serratifolia*
Cascara sagrada	*Rhamnus purshiana*	*Rhamnus californica*
Myrrh	*Commiphora molmol*	*Commiphora erythaea* var. *brescens*
Belladonna leaf	*Atropa belladonna*	*Scopolia carniolica Phytolacca decandra Ailanthus glandulosa*
Indian Belladonna	*Atropa officinalis, acuminata*	Roots of *Althaea* leaves of *Phytolacca acinosa, Solanum nigrum*

(Contd.)

Drug	Official Source	Source of Adulteration
		and other species of *Solanum* and *Datura*
Pale Catechu	*Uncaria gambier*	*Acacia catechu*
Chamomile	*Anthemis nobilis*	*Chrysanthemum parthenium*
Digitalis	*Digitalis purpurea*	*Verbascum thapsus; Symphytum officinale; Primula vulgaris; Digitalis thapsi*
Tragacanth	*Astragalus gummifer*	*Sterculia urens* and other species of Sterculia.
Chirata	*Swertia chirata*	*Swertia angustifolia* S. *alata, Rubia cordifolia* and *Andrographis paniculata*
Cinnamon	*Cinnamomum zeylanicum*	*Cinnamomum cassia*
Balsam of Tolu	*Myroxylon balsamum*	Mixture of vanillin, Rosin, cinnamic and benzoic acids
Kalmegh	*Andrographis paniculata*	Chirata *(Swertia chirata)*
Ispaghula	*Plantago psyllium*	*Salvia aegyptica, P. arenaria, P. lanceolate, P. major.*
Linseed oil	*Linum usitatissitmum*	Vegetable oils of rape-seed, cottonseed, soya-bean, sunflower and saf-flower and rosin, mineral and fish oil.
Ipecac	*Cephaelis ipecacuanha*	*Richardia scabra, Cryptocoryne spiralis, Psychotria emetica, Manettia ignita, Hybanthus ipecacuanha, Asclepias curassavica, Anodendron paniculatum, Calotropis gigantea,* etc.

(Contd.)

Galanga	*Alpinia officinarum*	*Acorus calamus*

Drug	Official Source	Source of Adulteration
Saffron	*Crocus sativus*	Flower and floral parts of some *Compositae* family, e.g., *Calendula* species, *Carthamus tinctorius;* corn silk.
Saussurea oil	*Saussurea lappa*	Elecampane oil
Punarnava	*Boerhaavia diffusa*	*Trianthema portulacastrum*
Rauwolfia	*Rauwolfia serpentina*	*Rauwolfia beddomei, R. densiflora, R. micrantha, R. perakensis, R. nitida, R. tetraphylla; Ophiorrhiza mungos* and *Clerodendrum* species
Nux-vomica	*Strychnos nux-vomica*	*S. potatorum* and *S.* nux-*blanda*
Pyrethrum	*Chrysanthemum cinerariaefolium*	*C. leucanthemum*
Datura	*Datura stramonium*	*Xanthium strumarium, Carthamus helenioides, Chenopodium hybridum.*
Cardamom	*Elettaria cardamomum*	Orange seeds, Unroasted coffee grains
Calamus	*Acorus calamus*	*Alpinia galanga; Aconitum* species
Areca nut	*Areca catechu*	Sogo palm nuts (*Metroxylon* sps.), tapioca *(Manihot esculenta),*
sweet		potato *(Ipomoea batatas),* nuts of *Caryota urens.*
Liquorice	*Glycyrrhiza glabra*	*Abrus precatorius*
Ashoka bark	*Saraca indica*	*Trema orientalis* bark
Kurchi bark	*Holarrhena antidysenterica*	*Wrightia tinctoria* bark
Devadru bark	*Polyalthia longifolia*	*Saraca indica* bark

(Contd.)

Hindisana leaves	*Cassia angustifolia*	*Cassia auriculata* leaves

IMPERFECT PREPARATION : Collection of other and less valuable parts of the genuine plant may cause adulteration. For example, stems are collected with leaves. The adulteration done by non-removal of inert or undesirable parts of the drugs is illustrated by the following examples:

Drug	Official Composition	Inert and Undesirable Part
Ginger	Rhizome freed from cork	Cork
Male fern	Rhizome and leaf bases	Roots and dead portions
Orange and Lemon peels	Outer part of the pericarp	Inner white spongy part of pericarp
Ipecac	Roots or rhizomes	Aerial stem
Fennel	Fruit	Undeveloped or mould attack fruits
Saffron	Stigma and style-tops	Parts of corolla
Quillaia	Inner part of the bark	Rhytidome
Tamarind	Fruits freed from the brittle outer part	Outer part of pericarp
Pyrethrum	Flower heads	Stem and leaf

Neglect of proper conditions for drying leads adulteration in the following drugs :

Drug	Faulty Treatment
Colchicum corm	Drying at a temperature above 65°C which accelerates the rate of hydrolysis of colchicine.
Digitalis	Leaving in a wilted condition for long period, thereby providing suitable conditions for the decomposition of the glycosides by enzymes, or drying above

(Contd.)

60°C thereby promoting hydrolysis of the glycosides.

Drug	Faulty Treatment
Gentian	Allowing excessive fermentation before drying in which sugars are converted to alcohol and carbon dixoide and the proportion of water-soluble extract is reduced below the official minimum.
Cod-liver oil	Excessive heat used in separating the oil from the livers affect the proportion of vitamins, odour and colour.

INCORRECT STORAGE : Incorrect storage spoils many drugs. The quality, value or usefulness of the drug has been impaired or destroyed by the action of moisture, light, temperature and microorganisms (fungi and bacteria) and the article becomes unfit for human consumption. Many examples of spoilage are found in food industry. All drugs which are unfit for human or animal consumption are legally considered as adulterated. The impairment of the quality or value of an article by the abstraction or destruction of valuable constituents by distillation, extraction, aging, moisture, heat, fungi, insects or other means deteriorate the drugs considerably. A few examples are :

Drug	Storage Conditions
Cascara sagrada	To be collected at least one year before being used.
Male fern	To be used after the internal green colour is lost.
Digitalis, Belladonna leaf, Hyoscyamus and Stramonium	To be preserved in a dry place or a container which prevents excess of moisture to prevent enzymatic hydrolysis.
Cod-liver oil	Protected from light, which would decompose the vitamin A.
Volatile oil	Protected from light, and stored in well-closed containers in a cool place.
Lard	Protected from moisture.
Squill	Powdered squill hardens by absorption of moisture.
Coffee	Caffeine is lost by over-heating.
Ergot	Protected from molds.

DELIBERATE ADULTERATION

Substitution of exhausted drugs : Many drugs are extracted on a large scale for the isolation of an active constituent or volatile oil, or for the preparation of an extract. The exhausted material may be used entirely or in part as a substitute for the genuine drug. This extraction procedure does not bring any change in the morphology of the drug. Some example are :

Drug	Constituent Removed
Clove	Volatile oil
Umbelliferous fruits	Volatile oil
Indian hemp	Resin
Glycyrrhiza	Glycyrrhizin and other water-soluble matter
Jalap	Resin
Balsam of Tolu	Balsamic acid
Ginger	Gingerol, volatile oil and resin
Tea	Caffeine
Cardamom	Volatile oil
Saffron	Volatile oil
Cardamom powder	Hulls powder

Sometimes foreign matters are added which are cheap in comparison with the drug and are usually dense and inconspicuous upon cursory examination. Replacement wholly or in part by a fictitious mixture of similar composition is occasionally a cause of adulteration. Admixture with non-plant substances resembling to a particular drug is commonly practised. For example :

Drug	Foreign or Fictitious Matters
Cochineal	Barium sulphate, barium carbonate, lead carbonate and animal charcoal.
Myrrh	Quartz and other mineral matter
Resins and Copaiba	Colophony.
Black pepper	Seeds of papaya

(Contd.)

Drug	Foreign or Fictitious Matters
Saffron	Materials coloured with coal-tar dye, oil and glycerine
Papain	Arrowroot starch, dried milk of cactus, gutta-parcha, rice flour and pepsins.
Nux-vomica powder	Olive stone powder
Pyrethrum powder	Lead chromate, Turmeric and fustic
Coca leaves	Novacaine, boric acid, sodium carbonate and bicarbonate, lime chalk, starch, lactose and quinine.
Honey	Cane sugar, corn syrup and artificial invert sugar.
Asafoetida	Gum arabic, gum-resins, rosin, gypsum, red clay, chalk, barley or wheat flour, slices of potato, etc.
Clove	Clay material
Caraway	Clay material
Lemon oil	An admixture of citral and other terpenes.
Balsam of Peru	An admixture of synthetic benzyl benzoate, Storax, Benzoin and Balsam of Tolu.
Nutmeg	Broken kernels moulded with clay; shaped pieces of wood.

CONFUSION OF COMMON VERNACULAR NOMENCLATURE

Common vernacular names of different plants in different regions of India cause this type of adulteration. In different regions the same plant is known by different names. Sometimes different drugs are known by the same name. For example, the drugs *Trianthema portulacastrum* and *Boerhaavia diffusa* are known by the common name "Punarnava". In most of the states "Brahmi" is obtained from the plant *Hydrocotyle asiatica* while in eastern parts of India the plant *Herpestis monniera* is used as "Brahmi". The plants *Evolvulus alsinoides*, *Convolvulus microphyllus* and *Clitoria ternatea* are sold by the name "Shankhpushpi". Similarly for

"Boch" the rhizomes and roots of *Acorus calamus*, *Alpinia officinarum* and *Anacyclus pyrethrum* are available. Rasna is also a controversial drug and three different plants-*Pluchea lanceolata*. (in north India), *Vanda roxburghii* (in Bihar and Bangal) and *Alpinia officinarum* (in south India) are sold as Rasna. Other examples are :

Agaru (*Aquilaria agallocha* in Sanskirt. and Bangali; *Commiphora roxburghii*, in Telgu and Sanskrit; *Excoecaria agallocha* in Sanskirt)

Akasbel (*Cassytha filiformis*, Mumbai; *Cuscuta reflexa* in Hindi).

Al (*Morinda umbellata*, Mumbai, *Morinda citrifolia*, M.P. and south Maharastra).

Babuna (*Matricaria chamomilla* in Punjabi and Mumbai; *Cotula anthemoides* in Hindi and Punjabi; *Corchorus depressus* in Punjabi).

Banda (*Viscum album* in Hindi; *Dendrophthoe falcata* in Hindi and Punjabi; *Hedera helix* in Punjabi).

Bhangra (*Indigofera linifolia* in Mumbai and Bengali; *Eclipta alba* in Hindi; *Wedelia calendulacea* in Hindi; *Sonchus arvensis* in Punjabi).

Chitra (*Plumbago indica* in Hindi and Mumbai; *Berberis asiatica* in Nepal; *Drosera lunata* in Punjabi).

Gaozaban (*Onosma bracteatum* in Bengal and Urdu; *Macrotomia benthami* in Punjab and Indian Market; *Anchusa strigosa* in Indian Market).

Hing (*Ferula narthex* in Hindi, Bengal and Mumbai; *F. foetida* in Hindi and Mumbai).

Kasni (*Cichorium endivia* in Hindi and Mumbai; *C. intybus* in Hindi, Bengali, Mumbai, Telgu).

Luban (*Boswellia serrata* in Hindi and Mumbai; *Styrax benzoin* in Hindi, Mumbai and Bengal).

QUESTIONS

1. Define adulteration. How will you evaluate a drug by chemical tools?
2. What do you mean by adulteration? Describe different means of adulteration in crude drugs. Support your answer with suitable examples.
3. What is adulteration? How are crude drugs adulterated by faulty collection and incorrect preparation.

5

EVALUATION OF DRUGS

Evaluation of drugs deals with the correct identification of the plant and determination of quality and purity of the crude drugs. Actual collection of the drug is done from the identified plant or animal. For this purpose research gardens have been maintained. The characters of an unknown sample are compared with the authentic monographs written in the pharmacopoeia. The high quality of the drug is maintained by collection of the drug from the correct natural source at proper time; preparation of samples of the collected drugs by proper cleaning, drying and to free from dirt, and proper preservation of the cleaned, dried and pure drug.

The evaluation of a drug is done by studying its organoleptic, microscopic, biological, chemical, and physical properties.

ORGANOLEPTIC EVALUATION

Organoleptic evaluation means study of a drug with the help of organs of sense which includes its external morphology, colour, odour, taste, sound of its fracture, etc.

Morphological Characters : To study morphology of a drug, its shape and size, colour and external markings, fracture and internal colour, odour and taste are examined. The organized drugs are classified into :

1. **Barks :** Which are tissues in a woody stem outside the inner fascicular cambium, e.g., Cinnamon, Cinchona, Quillaia, Ashoka and Kurchi.

2. **Underground Structures** : Which may be rhizomes, roots, bulbs, corm, and tubers; they are often swollen due to storage of carbohydrates and other chemicals, e.g., roots (Podophyllum, Liquorice, Jatamansi, Rauwolfia), rhizomes and stolons which are underground stems and have buds, scale leaves and scars, (Ginger, Turmeric, Dioscorea).
3. **Leaves** : These are photosynthetic organs arising from a node on a stem. The shape, margin, base, apex and venation of leaves help in the identification of the drugs. Senna, Tulsi, Vasaka and Digitalis leaves can be easily identified.
4. **Flowers** : These are reproductive organs of a plant and possess different shapes, size and colour, e.g., Saffron, Banafsha, Pyrethrum.
5. **Fruits** : Fruits arise from the ovary and contain seeds, e.g. Cardamom, Colocynth, Almond, Vidang, Bahera, Amla and Bael.
6. **Seeds** : Seeds are developed from the ovules in carpels of the flowers and characterized by the hilum, micropyle and sometimes raphe. The seed drugs are Ispaghula, Linseed, Nux-vomica, Psoralia.
7. **Herbs** : The whole aerial part is sometimes used as a drug, e.g. Brahmi, Chirata, Kalmegh, Pudina, Shankhpushpi, etc.

The shape of a drug may be cylindrical (Sarsaparilla), sub-cylindrical (Podophyllum), conical (Aconite); fusiform, ovoid or pyriform (Jalap), and terete or disk-shaped (Nux-vomica). The drug may be simple, branched, curved or twisted. The length, breadth and diameter are measured in millimeters or centimeters. In case of conical drugs the size of both parts is mentioned.

External markings are mentioned as :

1. furrows, ridges, etc.,
2. wrinkles,
3. annulations,
4. fissures,
5. nodules,
6. projections,
7. scars of leaf, stem-base, root, bud, bud-scale, etc.

The fractures may be complete, incomplete, short, fibrous, splintery (breaking irregularly), brittle (easily broken), tough and weak.

Sensory Characters : Colour, texture, odour and taste are useful in the evaluation of drugs. This method is especially applicable to drugs containing volatile oils or pungent principles (e.g. Capsicum), and to the detection of the effects of inadequate drying or damp storage. The external colour varies from white to yellowish grey, brown, orange or brownish black. The colour of some drugs changes if they are dried in sunlight in place of shade.

The odour of a drug may be either distinct (characterisic) or indistinct. The terms used to define odour are aromatic, balsamic, spicy, alliaceous (garlic-like), camphoraceous (camphor-like), terebinthinate (turpentine-like) and others. Leaves of different species of *Mentha* can be distinguished by smell. Clove and exhausted clove are differentiated by odour. Deteriorated Cantharides have ammonical smell while spoiled Ergot has rancid and ammonical smell.

Taste is a particular sensation production by certain substances when these come into contact with taste buds present in epithelial layer of the mouth. The taste may be sour (acidic), salty (saline), sweet (saccharine), bitter, alkaline and metallic. Substances possessing no taste are mentioned as tasteless. The tastes due to a characteristic odour are grouped as aromatic, balsamic, spicy, alliaceous, camphoraceous and terebinthinate. The taste produced by distinctive sensations to the tongue are classified as mucilaginous, oily, astringent (producing a contraction of the tissues of the mouth), pungent (warm biting sensation), acrid (unpleasant, irritating sensation) and nauseous (causing vomiting).

The drugs like Ginger and Capsicum have pungent taste; Gentian, Chirata and Kalmegh have bitter taste; Glycyrrhiza and Honey are sweet in taste. Linseed and Isphagula are mucilaginous; fixed oils have bland taste; calcium oxide is astringent; Podophyllum, Kaladana, Jalap and Ipomoea are acrid; while Ipecac, Acorus, and *Tylophora indica* contain nauseous taste.

Glycyrrhiza has hard and fibrous fracture due to the presence of fibrous and woody tissues. Aconite has a horny fracture due to gelatinization of starch.

Colour of drugs are standardized and determined by the Inter-Society Colour Council-National Bureau of Standard method. For example, reserpine is described as a "white or pale buff to slightly yellowish, odourless crystalline powder".

MICROSCOPIC OR ANATOMICAL EVALUATION

Schleiden (1847) used microscope for the examination of drugs. Microscopic examination of section and powder drugs, aided by stains, helps in distinction of anatomy in adulterants. Further, microscopical examination of epidermal trichomes and calcium oxalate crystals is extremely valuable, especially in powdered drugs. In the powdered drugs the cells are mostly broken, except lignified cells. The cell contents such as starch, calcium oxalate crystals, aleurone, etc. are scattered in the powder. Some fragments are specific for each powder which may consist of parts of cells or groups of cells.

Plant parts are made up of specific arranged tissues, spores (Lycopodium) or hairs (Lupulin). Histological characters are studied from very thin transverse, or longitudinal sections properly mounted in suitable stains, reagents or mounting media.

The size, shape and relative positions of the different cells and tissues, chemical nature of the cell walls and of the cell contents are determined. The basic arrangement of tissues in each drug is fairly constant. Fibres, sclereids, tracheids, vessels and cork are least affected by drying. Starch, calcium oxalate, epidermal trichomes and lignin are examined carefully.

Microscope is also used for a quantitative evaluation of drugs and adulterated powders. This is done by counting a specific histological feature such as stomatal index, vein-islets and vein termination numbers, palisade ratio, etc. These features are compared with the standard samples.

Palisade Ratio : The average number of palisade cells beneath each epidermal cell is called as palisade ratio. It is determined from powdered drugs with the help of camera lucida.

Stomatal Number : The average number of stomata per square millimeter of the epidermis is known as stomatal number. The range and average value for each surface are recorded.

Stomatal Index : The percentage proportion of the number of stomata form to the total number of epidermal cells of a leaf is termed the stomatal index :

S.I. = S/E+S x 100; where S = number of stomata per unit area, E = number of ordinary epidermal cells in the same unit area.

Stomatal number varies considerably with the age of the leaf but the stomatal index is highly constant for a given species.

Vein-Islet Number : The word 'Vein-islet' is used for the minute area of photosynthetic tissue encircled by the ultimate divisions of the conducting strands. *Vein-islet number* is defined as the number of vein-islets per square mm calculated from four contiguous square mm in the central part of the lamina, midway between the midrib and the margin. The average range of vein-islet numbers for Senna are : *Cassia senna* (26), *C. angustifolia* (21); for Coca: *Erythroxylum coca* (11), *E. truxillense* (20); for Digitalis. *Digitalis purpurea* (3.5) *D. lanata* (2.7); *D. lutea* (4.4), *D. thapsi* (1.2).

Veinlet Termination Number : It is defined as the number of veinlet terminations per mm^2 of leaf surface. A vein termination is the ultimate free termination of a veinlet or branch of a veinlet. By this character different Coca leaves and Senna leaflets are differentiated.

LYCOPODIUM SPORE METHOD

Lycopodium (syn. Club-moss spores, Lycopodium seeds; vegetable sulphur) consists of the spores of the clubmoss, *Lycopodium clavatum* Linn. (Fam. Lycopodiaceae, Phyllum Pteriodophyta); grows in the North America, Russia, Poland, India and Pakistan. The sporangial spikes are cut and dried and the spores are separated by shaking. Lycopodium is a light yellow, extremely mobile and flammable powder without odour or taste. It contains about 50% fixed oil, which consists mainly of glycosides of lycopodiumoleic acid; sugars (3%), phytosterin and alkaloids of the annotine type.

Lycopodium spores are exceptionally uniform in size (about 25 μm) and 1 mg of lycopodium contains an average of 94,000 spores. The number of spores per milligram is determined by direct counting and by calculation based on

specific gravity and dimensions of the spores. It is possible to evaluate many powdered drugs if well-defined particles may be counted as in case of pollen grains or starch grains; or if single layered tissues or cells of the area of which may be traced at a definite magnification and the actual area calculated; or if characteristic particles of a uniform thickness, the length of which can be measured at a definite magnification and the actual length calculated. Mounts containing a definite proportion of the powder and lycopodium are used and the lycopodium spores counted in each of the fields in which the number or area of the particles in the powder is determined.

In this method the moisture content of the powdered material is determined. A mixture of weighed quantity of the powder and lycopodium spores is suspended in a suitable viscous liquid. A drop of this suspension is mounted and examined with a 4 mm objective. The number of lycopodium spores and the number of characteristic particles are counted in 25 various fields. The same experiment is repeated with a second similar suspension. From the mean of these results and a knowledge of the weights of lycopodium and powder in the mixture, the number of characteristic particles in 1 mg of the powder may be determined.

By employing lycopodium spore method the number of pollen grains in pyrethrum powder (1000-2000/mg), starch granules in wheat powder (400 granules/mg) and starch grain in Ginger (261400 grains/mg) have been determined.

Lycopodium spore method is also used to determine size of a particular type of particle in powders such as epidermal fragments of leaves, single layer of scalerenchyma, or isolated fibres. The procedure is almost the same as used for counting of particles. The particle size is traced with the help of camera lucida and the spores are counted. The tracings are cut out and weighed and their area calculated by weighing a sheet of known area of the paper used. This area divided by the magnification used $(420)^2$ gives the actual area of the particles in a certain weight of the powdered drug, which is calculated from the number of spores counted and the weight of spores and powder in the suspension. By this method epidermal area of Indian Senna stalk (100 cm^2), sclerenchyma layer in Linseed, fibres in the Cinnamon bark and number of beaker cells in testa of Cinnamon seed have been measured.

CHEMICAL EVALUATION

Chemical evaluation involves the determination of active constituents by a chemical process. Chemical tests are used to identify certain crude drugs to determine purity. Chemical tests for alkaloids, carbohydrates, steroids. phenolic compounds, saponins, proteins, amino acids, fixed oils and volatile oils are performed. Titrimetric assay, iodine value, saponification value, acid value, acetyl value, ester value, peroxide value, hydroxyl value and ash value are determined. Tropane alkaloids in Datura, Belladonna and Stramonium are determined by Vitali-Morin reaction. Potassium chlorate and hydrochloric acid are used to estimate emetine in Ipecac. Strychnine in Nux-vomica is detected with ammonium vanadate and sulphuric acid. Bornträger's test is useful for detecting anthraquinone glycosides, present in Senna, Rhubarb, Cascara and Aloe. Alkaloid contents can be evaluated by determining total alkaloidal contents by acid-base titration.

Preparation of an extract by an appropriate solvent is sometimes applied to determine the quality of drugs. The solvent may extract a single constituent, e.g. fixed oil from crushed Linseed. Further examples of the use of extractive tests are in cases of Gentian, Colocynth seeds, Indian hemp, Ginger, Calumba, Rhubarb, Glycyrrhiza and Myrrh.

Drugs containing volatile oils are examined for authenticity and quality by determining the percentage of volatile oil yielded by steam distillation in a suitable apparatus. Standards for content of volatile oil in drugs usually allow a somewhat smaller percentage from powdered drugs as compared with the whole drug due to inevitable loss on grinding, volatilization and decomposition.

On ignition of crude drugs a residue of mineral substances or ash remains, derived from the cell wall and cell contents. The ash value is useful in determining authenticity and purity of drugs. For a number of official drugs, a limit is placed on the yield of acid-insoluble ash, i.e. the ash remaining after extraction of the total ash with dilute acid. This residue consists chiefly of silica, partly derived from the constituents of the cells and their walls and partly from foreign mineral matters, mainly soil. Acid-insoluble ash limits are imposed especially in cases where foreign silica may be present or when the calcium oxalate

contents of the drug is high. Pharmacopoeial limits for acid insoluble ash vary from 0.5 (Agar) to 12 percent (Hyoscyamus). Glandular trichomes present in Hyoscyamus have a capacity of retaining clay and thus the acid insoluble ash value is higher in such cases. In case of Glycyrrhiza the total ash figure is of importance which indicates the care taken in the preparation of the drug. For the determination of total ash values the carbon must be removed below 450°C, since alkali chlorides would be lost due to volatile at high temperature. The total ash usually consists of carbonates, phosphates, silicates and silica. In case of Ginger a minimum percentage of water-soluble ash is determined to detect the presence of exhausted ginger.

PHYSICAL EVALUATION

Physical constants such as elasticity in fibres, viscosity of drugs containing gums, swelling factor of mucilage containing materials, froth number of saponin drugs, congealing point of volatile and fixed oils, melting and boiling points and water contents (loss on drying at 110°C) are some important parameters used in the evaluation of drugs. Ultraviolet light is also used for determining the fluorescence of extracts of some drugs (Gambir, Senna) and colours of alkaloids as : aconite (light blue), berberine (yellow), emetine (orange) and quinine (dense fluorescence in dilute sulphuric acid). The florescence of Belladonna leaf and root, Wild Cherry bark and Jalap is due to the presence of a coumarin, β-methyl asculetin. Pale Catechu shows fluorescence in alkaline solution due to gambir-fluorescin. Aloe exhibits a green fluorescence in a solution containing borax. Many other drugs show a marked intensity of colour or a characteristic colour under UV light. Rhubarb is differentiated from Rhapontic, Chinese or Indian Rhubarb by its marked fluorescence in UV light.

Physical constants are extensively applied to the active principles of drugs, such as alkaloids, volatile oils, fixed oils, etc. Solubility expresses number of ml of solvent require to dissolve one gram of the drug. For example, 1 g of codeine sulphate is soluble in 30 ml of water, and in 1300 ml of alcohol. Alkaloids and other nitrogenous compounds are soluble in dilute hydrochloric acid. Melting points are recorded for solid fixed oils (fats) and alkaloids.

Most of the monoterpenes have asymmetric carbon.

Therefore, they are optical active. For example, Peppermint oil has optical rotation as -18° to -32°. Specific gravity is important with nutgalls. The galls that will not sink in water are considered to be inferior quality. In Jalap, the specific gravity should be higher than water. This constant is also important for volatile oils and lipids. Refractive index is particularly important in volatile oils and fixed oils. It is in between 1.45-1.46 for Peppermint oil at 20 degree.

Spectrocopic analysis (UV, IR, NMR, Mass), and radioimmuno assays are applied more frequently to the active individual drugs components. Chromatographic techniques such as paper, column, thin-layer, gas-liquid (GLC) and high performance liquid chromatography (HPLC) provide information about the chemical constituents present in the drug.

The foreign organic (animal, animal excreta, insects, fungi, bacteria, or mould) and inorganic matters should be in pharmacoepeal limits. They are determined by sedimentation or floatation method. If the drug is not prepared properly, the total ash value will be more.

BIOLOGICAL EVALUATION

The drugs, which cannot be assayed satisfactorily by chemical or physical means, are evaluated by biological methods. Tests are carried out on intact animals, animal preparations, isolated living tissues or micro-organisms. Since living organisms are used, the assays are called 'biological assays'. Biological standardization procedures are generally less precise, more time consuming and more expensive to conduct than chemical assays. Therefore, they are generally used if the chemical identity of the active principle has not been fully elucidated; if, no adequate chemical assay has been derived for the active principle as in case of insulin; if the drug is composed of complex mixture and activity, e.g. Digitalis; if the purification of crude drug is not possible, e.g. separation of vitamin D from irridiated oils; and if the chemical assay is not a valid indication of biological activity.

A biological assay measures the actual biological activity of a given sample. In any one test the animals of only one strain are used. For some assays a specific sex must be used. The male rat has faster growth rate than the female. Therefore, use of both male and female in a growth test

should be avoided. Bioassays are conducted by determining the amount of a solution of unknown potency required to produce a definite effect on suitable test animals or organs under standard conditions. To minimize the source of errors resulting from animal variation, standard reference preparations are used in certain bioassay procedures.

Bacteria such as a *Salmonella typhi* and *Staphylococcus aureus* are used to determine antiseptic value of certain drugs. In another microbiologic methods the living bacteria, yeast and molds are used for assaying vitamins and to determine the activity of antibiotic drugs. Mice are used to test Rabies vaccine, Diphtheria toxoid and other biologics. The 'rat line test' is utilized for the assay of vitamin D preparation. Guinea pigs are employed to test the toxicity and antigenicity of diagnostic Diphtheria toxin and tetanus toxoid. Oxytocic activity of vasopressin injection is also tested on guinea pigs. Oxytocic injection is assayed on young domestic chickens by injecting into an exposed crural or brachial vein and observing changes in blood pressure. Digitalis glycosides are assayed on pigeons by transfusing the drug through the alar vein into the blood stream and noting the lethal effects. Cats are utilized in tests for drugs with depressor activity and glucagon injection. Mydriatic drugs such as atropine are evaluated on cat's eye. Curare alkaloids, e.g. tubocurarine chloride, and pyrogens in antibiotic solutions are assayed on rabbits. Ophthalmic preparations are tested on rabbit eyes. Dogs are the test animals to determine pressor activity in drugs and to assay Veratrum viride preparations. Anthelmintic drugs (Male fern) are evaluated on earthworms. Evaluation of Ergot is carried out on cock's comb or rabbit intestine or its uterus. Human beings are also used to note the activity of drugs in clinical trial.

There are some disadvantages of bioassays. Quantitative accuracy is usually less than observed with most chemical analyses. Techniques and interpretations involved vary with different operators. The effect measured in the test animals is different from that observed in treating patients.

A simple bioassay utilizing brine shrimp *(Artemia salina)* is available for determining new biological activities in plant extracts. The eggs of this creature, which serve as food for tropical fish, are allowed to hatch in a brine solution. Th

shrimp are exposed to different concentrations of the test material and an LC_{50} (median lethan concentration) value in μg/ml is calculated. A broad range of compound show toxic effect to the shrimp. The procedure is rapid, reliable and cheap. Another procedure, called potato-disc assay, involved observation of the inhibition of crown gall tumors induced on potato discs by *Agrobacterium tumefaciens* by plant extracts or isolated compounds. This method is used for detecting in preliminary fashion anticancer activity.

QUESTIONS

1. (a) Describe the various non-living cell contents. How will you test them chemically or microscopically ?
   (b) What chemical tests will characterize (i) lignified cell wall and (ii) suberized and cutinized cell walls.
2. What do you understand by the term 'Evaluation of Drugs'? Discuss the usefulness of qualitative and quantitative microscopic evaluation giving suitable examples to illustrate your answer.
3. Explain palisade ratio, stomatal number, stomatal index, veinislet number, vein termination number and give suitable examples where these parameters have helped in the crude drug evaluation.
4. Give the importance of vein islet number, stomatadal index, palisade ratio and lycopodium spores in quantitative evaluation of pharmacognostic drugs. Give suitable examples to support the answer.
5. Give the importance of ash valve, calcium oxalate, trichomes and lycopodium spore method in adulteration. Support your answer with suitable examples.
6. Why is it necessary to evaluate the drugs ? What different methods will you use to evaluate crude drugs ?
7. Describe various organoleptic methods with suitable examples used for the evaluation of drugs.
8. Discuss morphological and chemical methods of evaluation of herbal drugs.