PREFACE

With its grounding in the "guiding pillars of Access, Equity, Equality, Affordability and Accountability," the New Education Policy (NEP 2020) envisions flexible curricular structures and creative combinations for studies across disciplines. Accordingly, the UGC has revised the CBCS with a new Curriculum and Credit Framework for Undergraduate Programmes (CCFUP) to further empower the flexible choice based credit system with a multidisciplinary approach and multiple/ lateral entry-exit options. It is held that this entire exercise shall leverage the potential of higher education in three-fold ways – learner's personal enlightenment; her/his constructive public engagement; productive social contribution. Cumulatively therefore, all academic endeavours taken up under the NEP 2020 framework are aimed at synergising individual attainments towards the enhancement of our national goals.

In this epochal moment of a paradigmatic transformation in the higher education scenario, the role of an Open University is crucial, not just in terms of improving the Gross Enrolment Ratio (GER) but also in upholding the qualitative parameters. It is time to acknowledge that the implementation of the National Higher Education Qualifications Framework (NHEQF) and its syncing with the National Skills Qualification Framework (NSQF) are best optimised in the arena of Open and Distance Learning that is truly seamless in its horizons. As one of the largest Open Universities in Eastern India that has been accredited with 'A' grade by NAAC in 2021, has ranked second among Open Universities in the NIRF in 2024, and attained the much required UGC 12B status, Netaji Subhas Open University is committed to both quantity and quality in its mission to spread higher education. It was therefore imperative upon us to embrace NEP 2020, bring in dynamic revisions to our Undergraduate syllabi, and formulate these Self Learning Materials anew. Our new offering is synchronised with the CCFUP in integrating domain specific knowledge with multidisciplinary fields, honing of skills that are relevant to each domain, enhancement of abilities, and of course deep-diving into Indian Knowledge Systems.

Self Learning Materials (SLM's) are the mainstay of Student Support Services (SSS) of an Open University. It is with a futuristic thought that we now offer our learners the choice of print or e-slm's. From our mandate of offering quality higher education in the mother tongue, and from the logistic viewpoint of balancing scholastic needs, we strive to bring out learning materials in Bengali and English. All our faculty members are constantly engaged in this academic exercise that combines subject specific academic research with educational pedagogy. We are privileged in that the expertise of academics across institutions on a national level also comes together to augment our own faculty strength in developing these learning materials. We look forward to proactive feedback from all stakeholders whose participatory zeal in the teaching-learning process based on these study materials will enable us to only get better. On the whole it has been a very challenging task, and I congratulate everyone in the preparation of these SLM's.

I wish the venture all success.

Professor (Dr.) Indrajit Lahiri
Vice-Chancellor

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NETAJI SUBHAS OPEN UNIVERSITY

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Course Type: Skill Enhancement Course (SEC)

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Unit 1 ❑ History, Scope and Importance of Medicinal Plants

Structure

1.0 Objective

- In this unit you will get an overview of different systems of indigenous medicinal sciences and use of indigenous medicinal plants in India.
- You will become acquainted with some common indigenous medicinal plants and their traditional uses.
- You will learn about different pharmacopoeias, their significance in ensuring quality of drugs in India and other countries.

1.1 Introduction

The history of medicine in India can be traced to the remote past. The earliest mention of the medicinal use of plants is found in the Rig Veda, perhaps the oldest repository of human knowledge, written between 4500 and 1600 B.C. Uses of 67 medicinal plants have been found in the Rig Veda. But in the Atharva Veda (2000 B.C.-1500 B.C.)

mention has been made about 290 plants for curing the diseases. Charaka (1000 B.C.) and Sushruta (800 B.C.), the two eminent physicians in India mentioned in their Samhitas about 700 plant species as therapeutic agents.

Later in the literature of Buddhist period (550 BC-470 BC) mention of many medicinal plants was made. In other old civilizations of the world viz. Mesopotomian, Sumerian (3000 B.C.-1970B.C.), Babylonian and Assyrian (1970 B.C.-539 B.C.), plants were used as medicine and amulet or Kabaj. In India, before independence, Dr. U.C. Dutta (1877) in his 'Materia Medica of the Hindus' mentioned the uses of many medicinal plants. Chopra (1933) described about 225 medicinal plants and their products sold in the markets. Kirtikar and Basu (1935) described about 604 plant species for the treatment of various ailments. Later Chopra et al. (1956, 1969) included about 1800 plant species in the Glossary of Indian Medicinal plants'.

1.2 Scope and Importance

All traditional ethnic societies depend, by and large, for healthcare and treatment of diverse ailments and diseases primarily on plant materials growing in their vicinity. The list of different plants used for medicinal purposes by the ethnic communities of India is quite large. A gross survey has revealed that nearly 7500 wild plant species are used for the purpose, of these about 950 species appear to modern people, as new claims and worthy of scientific scrutiny. Chemical investigation and biological screening of about 300 wild plant species have already been carried out. These have enabled scientists to isolate many known and unknown compounds with potential biological activities. In this way new drug may be developed.

Most of the drugs obtained from plant sources show little or no side effects. The safety and efficacy of the drugs may be proved through pharmacological studies. A large number of drugs examined in this way has been shown to possess significant activity. Another important feature of medicinal plants is Market Scenario. This can be stated as -

(i) Domestic Scenario : Medicinal plant market in the country is today unorganized due to many problems. Medicinal plants are a living resource, exhaustible if overused and sustainable if used with care and wisdom. At present 95% collection of medicinal plants is from the wild sources. There is a vast, secretive and largely unregularized trade in medicinal plants, mainly from the wild. Confusion also exists in the identification of plant materials. Adulteration is also common in such cases.

(ii) Global scenario : According to the report of World Health Organisation (WHO), a large population of the world relies on the traditional systems of medicines, largely plant based to meet their primary health care. India at present (2000) exports herbal materials and medicines to the tune of Rs. 446 crores only while it has been estimated that this was raised to Rs. 3000 crores till 2005. The Chinese export based on plants including raw drugs, therapeutics and other estimated to be around Rs. 18000-22,000 crores. So the medicinal plants area can become a huge export opportunity after fulfilling domestic needs. The principal herbal drugs that have been finding a good market in foreign countries are Aconite, Acorus, Aloe, Belladona, Cassia (Senna) Cinchona, Digitalis, Dioscoria, Ephedra, Plantago (Isabgol), etc.

1.3 Indigenous Medicinal Plants

Uses of plants as a source of food, fodder, shelter, clothing, and in many other materialistic maneuvers are well known from the prehistoric era. Apart from such uses, plants were also utilized to cure diseased conditions in them, as the animals do in their natural environment. Based on positive experiences, and side by side progression of civilization, development in the field of science and scientific researches, worldwide interest in scientific exploitation of indigenous medicinal plants came into the present-day version. In India, uses of indigenous medicinal plants and development of the indigenous medicinal system resulted under the banner of 'Ayurveda' during the period between 1000 B.C. to 200 B.C. i.e. the post-Vedic era and Buddhist era.

By the 'indigenous medicinal plants' we mean a group of medicinal plants occurring naturally in a fairly large geographical area, without any influence of human. In India, different ethnic communities have their own medicines for almost all diseases afflicting the human body. In practice, the tribes living in diverse ecological regions use different medicinal plants for the same ailment. Such tribal people accumulated required data through trial-and-error exercises, and then transmitted their findings trans-generationally in a word-of-mouth version. It is presumed that ethnic peoples discovered herbal drugs for some upsets by keenly observing the reactions of some animals like the monkey, dog, mongoose, bird etc. when they were afflicted by wounds or for other ailments. In this way clinical sense of the ethnic communities or indigenous medicinal sciences developed gradually through the ages. Different indigenous medicinal sciences were developed through centuries in India includes Ayurveda, Siddha, Unani, Yoga, Homeopathy, Naturopathy mainly. Other traditional systems of medicine include Chinese

systems (e.g. acupuncture, diet and herbal therapy, cupping etc.), Japanese (kampo, moxibustion, massage, dietetics), Korean, Tibetan (sowa rigpa) systems of medicine etc. In all the systems mentioned above, indigenous medicinal herb played an important role and are still being used as household remedies for different ailments.

1.3.1 Uses of Indigenous Medicinal Plants

India is home to more than 8,000 species of medicinal plants, and has a rich history of traditional healing systems using such plants. For example, Ashwagandha (*Withania somnifera*), tulsi (*Ocimum sanctum / O. tenuiflorum*), giloy (*Tinospora cordifolia*), ginger (*Zingiber officinale*), turmeric (*Curcuma longa*), cinnamon (*Cinnamomum zeylanicum*), black pepper (*Piper nigrum*), black cumin (*Nigella sativa*), amla (*Emblica officinalis*), garlic (*Allium sativum*), flax seeds (*Linum usitatissimum*) etc. have been traditionally used as herbal remedies for multiple diseases since ancient times.

Herbal medicine is still the chief support for about 75–80% of the world population for primary health care because of better cultural acceptability, better compatibility with the human body, and lesser side effects. As such, it plays an important role in rural areas, and various local drugs are still being used as household remedies for different ailments. However, increasing use of traditional therapies demands more scientifically sound evidence for the principles behind therapies and for effectiveness of medicines. Local healers have information and understanding on a wide range of medicinal plants that are useful to cure the common ailments, in particular, skin diseases, stomach disorders, respiratory infections, piles, rheumatism, fever and so on.

As mentioned earlier, the indigenous medicinal plants have been used for centuries by various cultures around the world for their healing properties. Some common uses and benefits of such plants are mentioned below for your reference -

1. **Anti-Inflammatory Properties**: useful in treating conditions such as arthritis and other inflammatory disorders.
2. **Pain Relief**: plants that contain compounds like natural analgesics, provide relief from headaches, muscle pain, and joint pain.
3. **Digestive Health**: ginger, peppermint, and mint are often used to treat digestive issues including indigestion, nausea, and bloating.
4. **Antimicrobial Effects**: many indigenous plants have antimicrobial properties, helping to treat infections and boost the immune system. For example, garlic, turmeric etc.
5. **Skin Conditions**: plants like aloe, chamomile are used to treat skin irritations, cuts, burns, eczema.

6. **Respiratory Health**: Eucalyptus and thyme are commonly used for their decongestant and soothing effects on respiratory conditions like colds, coughs, and asthma.
7. **Mental Health and Well-being**: Some indigenous plants, such as *Hypericum perforatum* are used to treat depression and anxiety, while others like *Lavandula* spp. are used for their calming effects.
8. **Blood Sugar Regulation**: Several plants inclusive of *Momordica charantia* may help in managing diabetes by regulating blood sugar levels.
9. **Heart Health**: Herbal tea and infusions made from *Crataegus* spp. have been used to support cardiovascular health.

Besides aforementioned uses and benefits, indigenous plants often play role in cultural rituals and traditional healing practices, providing not just physical healing but also spiritual and emotional supports. Available evidences hold up the diverse applications of indigenous medicinal plants, emphasizing the worth of preserving traditional knowledge and biodiversity.

Following list highlight the diverse applications of some common indigenous medicinal plants emphasizing their importance in natural remedies for several diseases and disorders -

Common Name	Scientific Name	Some Uses
Amla / Amlaki	*Emblica officinalis*	Antioxidant, Antistress, Constipation, Fever
Ashoka	*Saraca indica*	Menstrual irregularities, Uterine stimulant
Aswagandha	*Withania somnifera*	Stress Tolerance, Immunity, Joint pains, Skin health
Babool	*Acacia arabica*	Oral care, Bleeding gums, Wounds
Bach	*Acorus calamus*	Anti-viral, Anti-cancer, Antibacterial, Antifungal, Antiulcer, Anti-ischemic heart disease, Anti-inflammatory, Anti-oxidant, Antidiabetic, Anti-anxiety, Anti-rheumatisms

Common Name	Scientific Name	Some Uses
Bael	*Aegle marmelos*	Dysentery, Diabetes, Coolant, Gut health improver, Anti-cancerous
Bhang	*Cannabis sativa*	Narcotic drug used for malaria, Blood poisoning, Anthrax, Dysentery, Pain killer, Anti-dandruff, Cancer, HIV/AIDS, Weight loss, Muscle atrophy
Brahmi	*Bacopa monniera*	Enhances memory, Relives anxiety
Chalta	*Dillenia indica*	Curing dandruff, wound healing, bone fracture
Chatim	*Alstonia scholaris*	Skin ulcers, Abdominal pain, Fever, Increasing lactation
Dalchini	*Cinnamomum zeylanicum*	Antibacterial, Antiseptic
Fennel	*Foeniculum vulgare*	Constipation, Eyesight disease
Ghrita kumari	*Aloe vera*	Ulcers, Burn injuries, Jaundice, Acne, Women's health
Ginseng	*Panax pseudoginseng*	Dyspepsia, Asthma, Palpitation
Haldi	*Curcuma longa*	Bone fracture, Anti-tumor, Anti-bacterial, Cardiovascular care
Jatamansi	*Valariena jatamansi*	Blackening of hairs, Cure for pyorrhoea
Kalmegh	*Andrographis paniculata*	Indigestion, Acne, Diarrhoea
Ketaki	*Costus speciosus*	Obesity, Hyperlipidaemia, Diabetes
Motha ghas	*Cyperus rotundus*	Fever, Diabetes, Solar Dermatitis
Neem	*Azadirachta indica*	Skin health, Eye disorders, Bloody nose, Intestinal worms

Common Name	Scientific Name	Some Uses
Papaya	*Carica papaya*	Dog bite, ear ache, Digestive
Pippal	*Piper longum*	Asthma, Cough, Indigestion
Punarnava	*Boerhaavia diffusa*	Anaemia, Liver Diseases, Wounds, Kidney health
Rasun	*Allium sativum*	Treatment of fevers, Diabetes, Rheumatism, Intestinal worms, Colic, Flatulence, Dysentery, Liver disorders, Tuberculosis, Facial paralysis, High blood pressure
Senna	*Cassia angustifolia*	Laxative, Constipation, Irritable Bowel Syndrome, Weight loss
Shatamuli	*Asparagus racemosus*	Infertility, Loss of libido, Uterine health, Improves lactation, Urinary and Kidney problems
Supari	*Areca catechu*	Obesity, Hyperlipidaemia, Diabetes, Irregular menstruation
Thankuni	*Centella asiatica*	Improves memory, Brain health, Hair care
Ulatkambal	*Abroma augusta*	Gynaecological problems, Irregularity in periods
Vasaka	*Adhatoda vasica*	Cough, Asthma, Bronchitis

In recent past, healthcare industries are facing challenges in combating various new ailments including epidemics throughout the world. Various scientific fields have explored new remedies taking advantages of the traditional knowledge pertaining to control of diseases using medicinal herbs. Use of natural resources comprising indigenous medicinal plants and associated crude extracts are thus came up as the chief source for newer drug alternatives. For example, compounds derived from garlic (*Allium sativum*) have the potential to decrease expression of proinflammatory cytokines and to reverse the immunological abnormalities to more acceptable levels. It is suggested as a beneficial preventive measure before being infected with SARS CoV 2 virus.

Furthermore, garlic extracts have demonstrated significant virucidal activity against Hepatitis A virus, while *in-vitro* study has shown that *Plumbago indica* and *Allium sativum* extracts can inhibit influenza A (H1N1) pdm09 virus by inhibiting viral nucleoprotein synthesis and polymerase activity.

1.4 Pharmacopoeia

Pharmacopoeia is a legal and official book issued by recognized authorities, usually appointed by Government of each country. It comprises list of pharmaceutical substances, formulae along with their description and standards and as such, provides directions for the identification of samples and preparation of compound medicines. This is why, pharmacopoeia is a legislation of a nation which sets standards and mandatory quality indices for drugs, raw materials used to prepare them and various pharmaceutical preparations. All most all the countries have their own pharmacopoeias e.g. Argentine, Austrian, Chinese, French, British, Indian, Russian, Japanese, International and so on. All the pharmacopoeias consist of the three main section -

a) **Introduction**: This section points out pharmaceutical progress after publication of last edition because it summarises the various changes / addition / deletions in the current edition.

b) **Monographs of the official drugs**: It furnishes descriptions of pharmaceutical preparations and include information details like *Title or official name, Chemical formulae, Atomic and Molecular weight, Definition, Category, Dose, Strength, Description, Solubility, Tests methods for identification, Standard i.e. quantity purity, Limits of impurities, Assay methods, Conditions for storage and Storage containers, Labelling* etc.

c) **Appendices**: It gives provision for S*tandards for apparatus required for Biological tests and assays, Microbiological tests and assays, Physical tests and determinations, General information, Reagents and Solutions, Indicators, Reference substances, Calculation of results, Tables*.

Pharmacopoeia help the practicing pharmacists and physicians aiming to provide unbiased concise reports on the actions and uses of most of the world's drugs and medicines. Every publication of pharmacopoeia monographs is accurately structured on the basis of updated needs of today's pharmacist by contributing details of new compounds, and by deleting some of the previous monographs which are not in continued use. In pharmacopoeia, distinguishing features of drugs are updated, renewed,

and discussed for the treatment of infections, including development of antiviral, antiprotozoal and antibacterial therapy. Side by side, it come up with novel approaches in advancement of cardiovascular drugs and the other areas like antimalarial drugs, anti-neoplastic substances, anti-parkinsonism agents etc.

In brief, the pharmacopoeia prescribes only minimum standards for pharmaceuticals, but with more stringent standards the manufacturer may supply these substances. Hence, a drug has to obey strictly the standards prescribed by any one of the pharmacopoeias.

1.4.1 British Pharmacopoeia (BP)

The British Pharmacopoeia (BP) is the national pharmacopoeia of the United Kingdom, published on behalf of the Health Ministers of the U. K., on the recommendations of the Commission on Human Medicines, in accordance with section 99(6) of the Medicines Act 1968. It provides the official standards for medicines since 1864 (publication year of 1st British Pharmacopoeia), and supply the only comprehensive collection of authoritative official standards for UK pharmaceutical substances and medicinal products, including all the monographs and texts of the European Pharmacopoeia (Ph. Eur.). The pharmacopoeias that have legal status within the UK are the British Pharmacopoeia (BP), including the BP (Veterinary), and the European Pharmacopoeia (Ph. Eur.).

The BP is published every year in August, and becomes legally effective on 1st January of the following year. The 2nd edition was released in 1867 while the 3rd and 4th editions were published in the year 1885 and 1898 respectively. The Addendum to 2nd and 3rd edition was released in the year 1874 and 1890 respectively.

After publication of the British Pharmacopoeia in 1914, it was realized in Britain that to cope up the increasing technical complexity of drug specifications, a different kind of set up is needed before preparation of the new editions of BP. Hence, the further editions were published in 1928 and 1932. There after the commission recommended to revise the British Pharmacopoeia once in every ten years.

A range of diagnostic materials was included in 1932 revision of BP. An important addition was inclusion of “standards and tests for antitoxins and insulin”. Seven addenda covered the interim between 1932 and next edition of 1948. In 7th edition (1948), the substances newly introduced into medicine, and the generic names were released along with the methods of analysis such as disintegration tests for tablets, sterilization methods etc.

In 1953 edition of BP some major changes were advanced including the titles of drugs and preparations in 'English instead of Latin' (though they retained abbreviated Latin as the synonym), introduction of 'capsules' as new group of formulation, 'implant methods for sex hormones' and their standards.

British Pharmacopoeia from its 2013 edition introduced 'electronic form' in both online and CD-ROM version side by side with printed volume as before. The electronic version used sophisticated search techniques (utilizing more than 1,30,000 hypertext links) to locate information quickly.

The latest edition of the British Pharmacopoeia (BP) is the 2025 edition, which will be legally effective from January 1, 2025. This edition includes 14 new BP monographs; 32 new Ph. Eur. Monographs (including 2 new on Paracetamol Infusion and Paracetamol Oral Solution); 105 amended BP monographs; all monographs from the Ph. Eur. 11th edition and Ph. Eur. supplements 11.1 to 11.8.; a new user-friendly online tools and guides including Webchat.

1.4.2 Indian Pharmacopoeia (IP)

The Indian Pharmacopoeia (IP) is a legal as well as official publication by the Government of India which sets standards for the quality, purity, identity, and strength of medicines used in the country. It serves as the authoritative source for ensuring that the pharmaceutical products meet required safety and efficacy benchmarks, and is legally binding under the Drugs and Cosmetics Act of India, 1940. The Indian Pharmacopoeia Commission (IPC), an autonomous institution under the Ministry of Health and Family Welfare, Government of India is responsible for its publication. Primary importances of the Indian Pharmacopoeia (IP) are:

- **Setting standards**: To ensures that medicines manufactured, imported, or sold in India meet the required safety and efficacy standards. The Indian Pharmacopoeia Commission (IPC) sets standards for the quality of drugs, including active pharmaceutical ingredients (APIs), finished pharmaceutical products (FPPs), and excipients.
- **Reference**: For use of healthcare professionals, pharmacists, regulatory bodies, and pharmaceutical manufacturers who use IP as a reference for quality assurance. Drugs manufactured in India must be labelled with the non-proprietary drug name and the suffix "I.P.". This is similar to the "B.P." suffix for the British Pharmacopoeia and the "U.S.P." suffix for the United States Pharmacopeia.

- **Consumer Safety**: To ensure that drugs adhere to established standards, so that consumers remain protected from substandard or counterfeit medications.
- Indian Pharmacopoeia (IP) also keeps informed its users about new scientific developments in the field of drugs, medicines, and cosmetics.

Before independence of India, the British Pharmacopoeia was considered as the official book of standards for drugs and medicines. Initiative for publishing the First Indian Pharmacopoeia started in the year 1944 under the chairmanship of Col. R. N. Chopra. The Indian Pharmacopoeia list was first published in the year 1946 and got approval in 1948. For the purpose, Government of India constituted a permanent Indian Pharmacopoeia Committee in 1948 for the approval and preparation of the Indian Pharmacopoeia and also established a central Indian Pharmacopoeia Laboratory at Ghaziabad, Uttar Pradesh for updating the pharmacopoeia regularly. Indian Pharmacopoeia was published in fulfilment of the requirements of the Drugs and Cosmetics act, 1940 and rules there under.

After independence, the first edition of the Indian Pharmacopoeia (IP) was published in the year 1955 under the chairmanship of Dr. B. N. Ghosh, but the Supplement for first edition of Indian Pharmacopoeia was published in the year 1960. This Pharmacopoeia contained both western and traditional system drugs commonly used in India. The same policy was continued while preparing the Indian Pharmacopoeia till 1966. After eleven years, under the chairmanship of Dr. B. Mukherji the second edition of Indian Pharmacopoeia was released in 1966 with some modifications. The supplement to the second edition of Indian Pharmacopoeia was published in 1975.

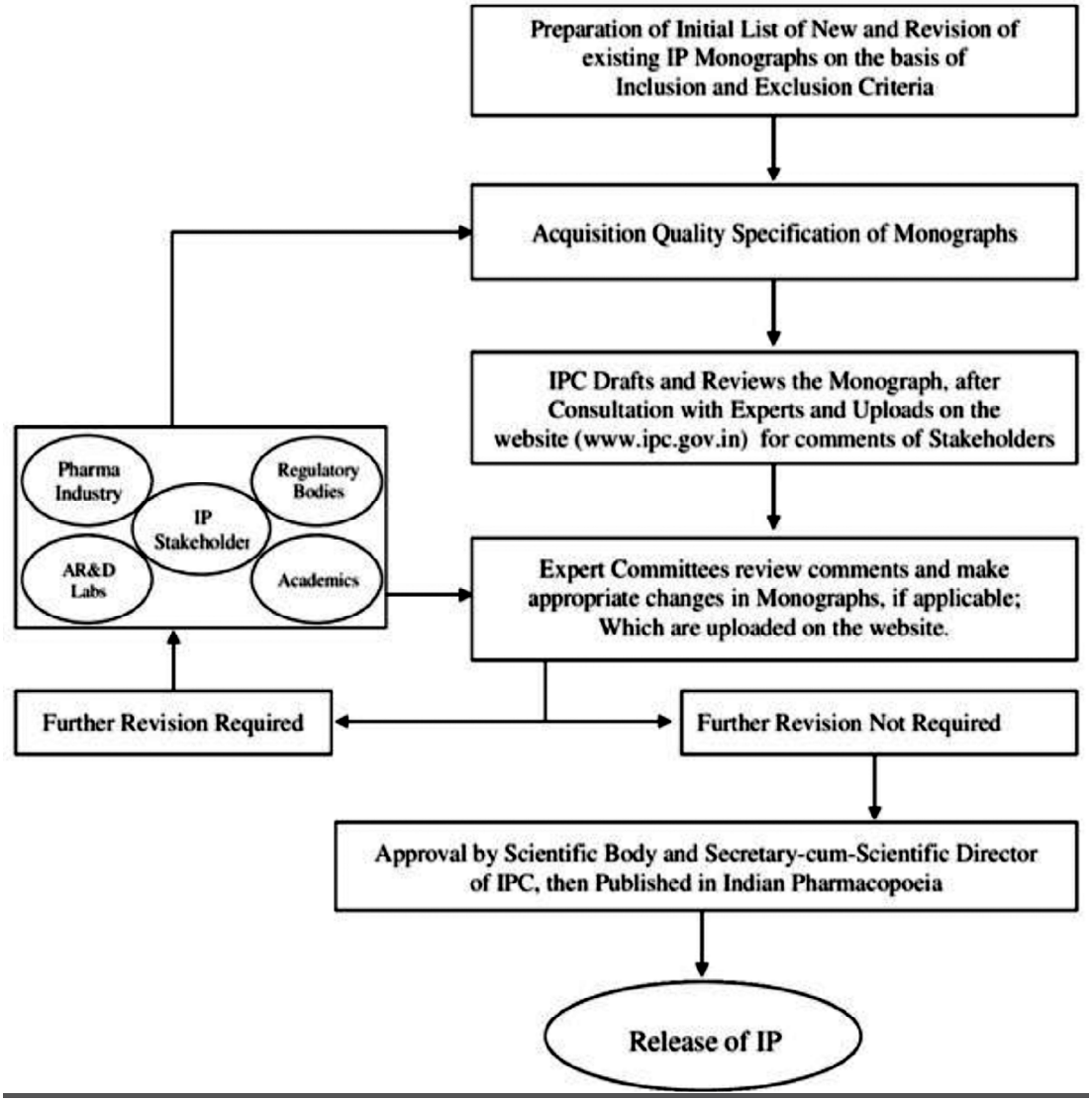
Indian Pharmacopoeia (IP) contains sections focussing the basic objectives as in BP, are -

- **Specifications**: containing details on the identity, purity, and strength of drugs.
- **Procedures**: providing authoritative procedures for analysis.
- **Monographs**: Comprehensive monographs for drugs, inclusive of active pharmaceutical ingredients (chemical and biological drug substances), compounded preparations, excipients, dietary supplements, dosage forms, and medical devices.

Process for IP Monograph Development: IPC works in close coordination with all the stakeholders of IP for the development of monographs. The principle of

"openness, justice and fairness" is kept in mind during compiling and editing the contents of the Indian Pharmacopoeia. The methodology adopted is annexed below:

Monograph Development Process



Highlights of Indian Pharmacopoeia 2022 (9th Edition)

- It is effective from 1st December, 2022
- The addendum to this nineth edition of Indian Pharmacopoeia is published in 2024, in 4 hard bound volumes (with DVD).
- This 9th Edition contained 412 Revised Monographs.
- Total 92 New Monographs included of which 60 on pharmaceuticals, 21 on vitamins, minerals, amino acids, and fatty acids, and 3 on biotechnology-derived therapeutic products.
- In this edition 12 new general chapters and 25 revised general chapters are incorporated.
- The 2022 edition includes additional APIs and FPPs for anti-retroviral and anti-cancer drugs, as well as other drugs used for COVID-19 therapy.
- The IP 2022 eds. introduces two new categories: "phytopharmaceuticals" and "vitamins, minerals, amino acids, fatty acids etc."
- Presented in user friendly format and cross referencing has been avoided
- Improved analytical methods to assess quality attributes.
- This edition promotes the use of *in-vitro* methods as alternatives to *in-vivo* bioassays.
- The IP 2022 clarifies the IP General Chapter 2.5.4 (i) on the uniformity of dosage units.
- Obsolete monographs have been omitted as usual.

Extra Pharmacopoeia (Martindale):

The Extra Pharmacopoeia, originally written by a practicing pharmacist William Martindale in 1883, to provide practical and up to date information concerning drugs and galenical (crude extracts obtained from animal or vegetable crude drugs) included in the British Pharmacopoeia. In the span of three years four editions of Martindale were published. Now it is published by the Pharmaceutical Society of Great Britain, contains information on the drugs presently used in Great Britain.

Extra Pharmacopoeia is an unbiased, invaluable source of information for clinicians, pharmacists, pharmacologists and toxicologists and anyone interested in pharmaceutical or medicine researches. It remains the leading international

resource, respected for its objectivity, reliability, and global coverage. It's unique offerings are :

- Encyclopaedic facts about drugs and medicines
- Over 6,600 monographs on drugs and ancillary substances
- Over 200,000 preparations
- Over 60,000 references
- Over 25,000 manufacturers and distributors
- Enables identification of medicines, the local equivalent, and the manufacturer· Covers herbals, diagnostic agents, radiopharmaceuticals, pharmaceutical excipients, toxins, and poisons
- Evidence-based and extensively referenced

In order to meet the requirements of today's reader the latest edition of Martindale has been markedly changed. It encompasses a significant shift to a more clinical emphasis- an increase in the number of referenced reviews and a massive increased information on proprietary medicines etc. Recently published **41st Edition** (May, 2024) appended –

- Over 130 monographs including New antivirals such as fostemsavir and lenacapavir for multi-drug-resistant HIV infection and bulevirtide for hepatitis D.
- New biological treatments for Type-1 diabetes (teplizumab), non-neovascular (dry) age-related macular degeneration (pegcetacoplan), and spinal muscle atrophy type 1 (onasemnogene abeparvovec).
- New class of drugs for migraine management: the calcitonin gene-related peptide (CGRP) receptor antagonists atogepant, rimegepant, ubrogepant, and zavegepant·
- New content on management of COVID-19 including new monographs for the antivirals molnupiravir, nirmatrelvir, and remdesivir, and for COVID-19 vaccines, and updates to uses of baricitinib and tocilizumab.
- Updated content on malaria and dengue vaccines

1.5 Summary

The earliest mention of medicinal plants is found in the Rigveda (4500-1600 BCE) in which uses of 67 medicinal plants were documented. In Atharva Veda (2000-1500 BCE) about 290 plants were cataloged for curing of diseases. Charaka (100 BCE) and Sushruta (800 BCE), the two eminent physicians mentioned about 700 plant species in their Samhitas. 'Indigenous medicinal plants' are the group of medicinal plants occurring naturally in a fairly large geographical area, without any influence of human. Such plants play an important role in rural areas, and various locally produced drugs are still being used as household remedies for different ailments. Medicinal herbs are still the mainstay of about 75 - 80% of the world population, mainly in the developing countries, for primary health care because of better cultural acceptability, better compatibility with the human body, and lesser side effects. As a rich source of nutrients, antibacterial and antioxidant properties, medicinal herbs are mostly non-toxic in nature and as such the products or remedies made using them are often recommended for utilization of their diverse therapeutic value.

Pharmacopoeia is viewed as a legislation of a nation for setting standards and mandatory quality indices for drugs, raw materials used to prepare them and various pharmaceutical preparations. The Indian Pharmacopoeia (IP) and also the Ayurvedic Pharmacopoeia of India (API) [API not discussed here] are books that establish standards for the quality of drugs and herbal medicines in India. The pharmacopoeias promote the responsible use of herbal medicines by developing standards for their identity, purity, and analysis. The British Pharmacopoeia (BP) is the national pharmacopoeia of the United Kingdom, but considered as standard literature throughout the world including India. Both the BP and IP covers all most same sections like introduction, monograph part, appendices. Pharmacopoeia prescribe only minimum standards for pharmaceuticals, but with more stringent standards the manufacturer may supply these substances.

1.6 Questions

1) Write about the oldest repository of medicinal plants in India.
2) What is meant by indigenous medicinal plant? Name two famous books on indigenous medical science.
3) State the reasons for using herbal medicines throughout the developing as well as developed countries.

4) Mention some healing properties of herbal medicinal plants.
5) Name some common medicinal plants along with their uses.
6) What is pharmacopoeia? Mention the common major sections of it.
7) Write the implication of appendices provided in a pharmacopoeia.
8) What is British pharmacopoeia? Write the year of its first publication.
9) Write a brief account of Indian Pharmacopoeia.
10) Which edition of Indian pharmacopoeia is latest one. Highlight its new additions.
11) What is Extra Pharmacopoeia? Highlight its importance.
12) State the basic consideration and importance of all the pharmacopoeias.
13) Why is Pharmacopoeia considered as legislation of a nation?

1.7 Answers

1) See 1.3; **2)** 1.3; **3)** 1.3.1; **4)** 1.3.1; **5)** 1.3.1 list; **6)** 1.4; **7)** 1.4c; **8)** 1.4.1; **9)** 1.4.2; **10)** 1.4.2; **11)** 1.4.2; **12)** 1.4; **13)** 1.4

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Unit 2 ❑ Ayurveda: History, Origin, Panchamahabhutas, Saptadhatu and Tridosha concepts and Plants used in Ayurvedic treatments

Structure

2.0 Objective

- After studying this unit, you will get an idea about 'Ayurveda' the Indian traditional healing concept using indigenous medicinal plants.
- You will learn about the principles of panchamahabhutas, saptadhatu, tridosha concepts; and about 'Rasayana' the science of lengthening life span.
- You can enrich yourself about the common indigenous medicinal plants and their traditional uses.

2.1 Ayurveda

The term 'Ayurveda' is a combination of two components - Ayu and Veda. Ayu stands for life (age and longevity) and Veda means to know (or knowledge). Ayurveda then

is the knowledge by which a healthy human life in all its aspects - physical, mental, intellectual and spiritual lives to the fullest. Ayurveda is concerned mainly with prolongation of healthy life and prevention of disease and senility and only secondarily with curing of disease (R. C. Majumdar - A concise history of science in India : Medicine Section).

2.2 Scope

The Ayurvedic system of medicine is prevalent in India since the vedic period and as early as the dawn of human civilization. Though this Indian system of medicine has undergone many changes in the course of its long history, it still remains the mainstay of medical relief to a large section of population of the nation.

Ayurveda being a science put into professional practice, with a lot of occasions to try newer drugs locally available, led to the successful use of several other drugs with therapeutic values similar to those of the classical drugs. Ayurveda had never been static. Its practitioners had been innovative and dynamic in the therapeutic practice and carried on clinical trials out of local flora and discovered newer medicine with same therapeutic values as the classical drugs. These newer drugs have been accepted by the then practising profession as substitutes. In fact on study of Ayurvedic literature, one comes accross several references of permitting the use of a substitute drug when the classical drug is not available. This is based on its therapeutic equivalence and clinical efficacy.

Standardization of Ayurvedic drugs is also necessary for the identity, purity and strength of single drugs and compound formulations. Having regard to all these considerations, the Central Council of Ayurvedic Research recommended the constitution of Ayurvedic Pharmacopoeia Committee consisting of experts on Ayurveda and other sciences. A number of volumes of the Ayurvedic Pharmacopoeia and also the formulary for compound formulations have been published.

2.3 History and Origin

There are several versions about the origin of Ayurveda. One story seems to run through all of them. Lord Brahma, the creator of this world observing the suffering of humans, handed down Ayurveda (the knowledge of life) to the sun-god, Surya. Surya passed it on to his twin-sons, the Ashwini Kumar. They taught it to Indra, the

rain-god. Indra finally passed it on to the sage Bharadwaja, a human being and thus the knowledge reached mankind.

The story is, perhaps, symbolic. The sun is the source of energy and therefore may be regarded as the original source of all medical knowledge. The Ashwini Kumars, or the rays of the sun, transmitted this knowledge to Indra, the rain-god. Rains facilitate the growing of food on earth and food nourished the human body and mind. Bharadwaja transmitted the science of Ayurveda to his two distinguished pupils, Punarvasu Atreya and Dhanwantari. Atreya established the school of medicine, Dhanwantari, the school of Surgery, in India.

Atreya had six distinguished pupils - Agnivesha, Bhela, Jatukarna, Parashara, Harita and Ksharapani - all of whom wrote treatises on medicines. None of these works have survived, we know about them from references of later works. The followers of the Dhanvantari school whose works have also been lost are - Vriddha-Susruta, Aupadhenava, Aurabhra, Pauskalavata, Gopuraraksita, Vaitarana and Bhoja. The Charaka Samhita of the school of medicine and the Susruta Samhita of the school of surgery have survived.

In brief, it may be said that the origins of the system of medicine known as Ayurveda predates the Vedas (Pre 5000 BC). In the Vedas we can find the philosophical and practical ideas that went to build the system.

In this connection, we may now discuss about the two famous Ayurvedic physicians.

1. Charaka : Charaka is the foremost among the physicians of Ayurveda. We have no firm dates about the time he lived. According to some authors he lived around 800 BC, a few hundred years later than Punarvasu Atreya and his pupils. Others, taking instance from a Buddhist text, the Tripitaka, which mentions Charaka as the royal physician to the Kushan King, Kanishka (127-151 CE) have put Charaka to have lived in 1st-2nd century CE.

Charaka revised and edited the earlier work of Agnivesha, a direct disciple of Punarvasu Atreya, to make it concise and focused. Charaka's well-known book is known as Charaka Samhita. It comprising over 8000 verses is composed in Sanskrit in poetic metre. The Charaka samhita has eight Sthana or sections, totalling 120 chapters. These are-

(i) Sutrasthana or, general principles (30 chapter)

(ii) Nidanasthana or, pathology (8 chapters)

(iii) Vimanasthana or specific determination (8 chapters)

(iv) Sarirasthana or Anatomy (8 chapters)

(v) Indriyasthana or Sensorial prognosis (12 chapters)

(vi) Chikitsasthana or Therapeutics (30 chapters)

(vii) Kalpasthana or Pharmaceutics and toxicology (12 chapters)

(viii) Siddhisthana or Success in treatment (12 chapters) -the last chapter includes general principles of Panchakarma.

The Charaka Samita is scientific in content and reason based of Yukti-Vyapasraya. This monumental work has held away for almost two millennia and over the centuries has referred to and translated into many languages including Persian, Arabic, Tibetan, Chinese, English and the Indian Vernaculars.

2. Sushruta : As Charaka, the time of Sushruta has not been determined with certainty. There are a number of opinions. One of them puts him before Panini in the 8th Century BCE, there is a reference to the great surgeon Sushruta in his writings. Sushruta also finds mention in the Bower's Manuscript dated 4th of 5th century CE, where he is listed as one of the ten sages residing in the Himalayas. In some later Ayurvedic literature, he is described as a son of Vishvamitra or a descendant of Dhanwantari, the physician of the gods in Hindu mythology. According to one source, he lived in Varanasi and was a pupil of Divodasa, a king of Kashi, who was a great physician and teacher.

Sushruta is famous as the father of surgery, definitely in India and perhaps, worldwide. His great classic on the science of surgery is the Sushruta Samhita, portions of which may have been composed by a person with the same name several centuries later. We also come to know that one Nagarjuna, probably the famous Buddhist scholar who taught at Nalanda University in the 3rd Century CE.

The treatise is composed in Sanskrit and divided into two parts -

The Purva tantra and the Uttara tantra

Purva-tantra : It has 5 sthana or sections and 120 chapter. these are

(i) Sutrasthana - 46 chapters

(ii) Nidanasthana - 16 chapters

(iii) Sarirasthana - 10 chapters

(iv) Kalpasthana - 8 chapters

(v) Chikitsasthana - 40 chapters

Uttara tantra : It has 4 sections and 66 chapters.

(i) Salakya

(ii) Kayachikitsa

(iii) Kumarabhritya

(iv) Bhutavidya

Sushruta classified surgery into eight types and presented 300 surgical procedures in the Samhita. The Samhita also gives descriptions of 125 surgical instruments for performing opthalmic, obstetrics and other operations. Sushruta's biggest contribution is the area of reconstructive surgery. He is recognized as the worlds first plastic surgeon for having given the procedure to reconstruct the human nose. The Sushruta Samhita was also translated into most of the foreign languages where Indian influence has spread.

Other well known Ayurvedic physicians are Jivaka, Nagarjuna, Vagbhatta, Madhava-Kara, Sarngadhara and Bhava Misra.

2.4 Pancha Mahabhutas

According to Ayurveda, the universe is created from five basic elements or Panchamahabhuta and their accompanying principles. Everything in this universe including human body and mind complex is composed of these five basic elements. The macrocosm (Universe) and the microcosm (man and other living creatures) are composed of the same ingredients. The mahabhutas are :

1. **Akasha :** It is defined with space and gives us sound and hearing; it also manifests as pores, cavities and channels in the human body.
2. **Vayu :** It is the basic gaseous element and identified with air. It gives tactile sense or sense of touch and manifests as all forms of movement-physical and physiological including neural. It has the characteristic of lightness.
3. **Agni :** It is the basic thermal element and identified with fire. It gives visibility of shapes and colours, the visual sense and digestion.
4. **Ap :** It is the basic aqueous element and identified with water and liquids. It gives sense of taste and is characterized by malleability, fluidity, viscosity and coldness.
5. **Prithvi :** It is the basic gross element and identified with earth. It gives the sense of smell and manifests as mass, density, opacity and inertia.

2.5 Saptadhatu

According to Ayurveda there are seven (7) fundamental elements or tissues in the human body that support its structure. They are created from the processing of the food, water and air we intake. These seven elements are called Saptadhatus. These are - Rasa, Rakta, Mansa, Meda, Asthi, Majja and Sukra.

(i) Rasa : The word 'Rasa' denotes sap or juice. In the human body it denotes plasma, lymph and such nutritional fluids.

(ii) Rakta : The word 'Rakta' means red. In human body it denotes blood and is the carrier of fire or energy that invigorates the mind and body.

(iii) Mamsa : The word 'Mamsa' literally means flesh. In the human body, it refers to muscle tissue that gives physical strength to the body and courage to the mind.

(iv) Meda : The word 'Meda' means fat. In human body it stands for adipose tissue.

(v) Asthi : The word 'Asthi' means bone. In human body it forms the skeletal system.

(vi) Majja : The word 'Majja' means marrow. In our body it stands for bone-marrow and nerve tissues.

(vii) Sukra : The word 'Sukra' stands for semen and reproductive fluids.

2.6 Tridosha

Ayurveda explains all bodily functions with the movements in the universe. The three main forces of the external world that we experience are the sun, moon and wind. The corresponding three forces in the human body are Pitta (bile), Kapha (phlegm) and Vata (wind). These are collectively known as tridoshas. The five basic elementary principles or Panchamahabhutas come together to give rise to these three energies or governing forces. Tridoshas are three humours in our body e.g. bile, phlegm and wind. The interrelationship of tridosha, panchamahabhuta and the principle are stated in the following table :

Dosha	Mahabhuta	Principle
Pitta (Sun)	Agni-Fire	Transformational force
Kapha (Moon)	Ap (water) and Prithvi (Earth)	Force of lubrication, cohesion and preservation
Vata (Wind)	Akash (Space) and Vayu (Air)	Force of transportation and movement

Pitta comes from Agni, the fire principle and governs all transformative functions with body and mind. It controls digestion, metabolism, assimilation, nutrition etc. and at a more delicate level, intelligence and understanding. There are five types of pitta –

(i) Pachak pitta : Responsible for release of digestive enzymes

(ii) Ranjak pitta : It implies colour, it governs digesion in the liver leading to the formation of blood.

(iii) Sadhak pitta : It governs perception and works through the nervous system.

(iv) Bhrajak pitta : It resides in the skin and controls its temperature and complexion, it also regulates absorption of sunlight, oils and ointments through the skin.

(v) Alochak pitta : It regulates the conversion of sensory stimuli, especially the creation of images on the retina.

Pitta is hot, light, pungent, sharp and acidic in nature. Persons with a predominance of pitta are physically of medium height and weight, with excellent power of digestion and with sharp intellect.

Vata is derived from Akasha and Vayu (the 'space' and 'air' principles) and governs movement within the body and mind.

There are five types of vata :

(i) Prana : It is the life-force and moves from outside to the inside and upwards (intake of breath). Prana is responsible for receiving air, food, water and sensory impressions. It moves from the head to the body.

(ii) Udana : It moves from the inside to the outside, it moves from the centre of the body to the head and is based in the region of the throat. Udana governs exhalation and speech. It also regulates memory, motivation, enthusiasm and will-power.

(iii) Vyana : It moves from the centre to the outer peripheries, it is the centrifugal force in the body, it is centered in the heart and governs cardiac functions as well circulation of blood and sweat.

(iv) Samana : It moves from the periphery to the centre. It is the centripetal force in the body. It regulates the movement of intestine that leads to digestion of food. Samana Vayu maintains the equilibrium in the body.

(v) Apana : It governs downward motions, hence regulates the functions of rectum and urino-genital system. It is responsible for the discharge of urine, faeces, flatus (wind in or from stomach or bowels), menstrual fluids, semen and foetus.

Vata is cold, light, dry and changeful by nature. Persons with a predominace of vata are physically thin light and agile. Emotionally, they are energetic, flexible and adventurous.

Kapha : It is derived from Ap (water) and Prithvi (Earth) and regulates structure and lubrication in the body and mind. It controls body weight, lubrication in joints and other body parts, and the formation of body tissues.

There are five types of 'Kapha' that perform different functions as follows—

(i) Bodhak : This type of Kapha is present in the mouth and helps the taste of food items and their acceptability.

(ii) Kledak : It lines the inside of the stomach and protects it from the hot and penetrating effects of pachak pitta.

(iii) Tarpak : It resides in the brain and spinal column in the form of a protective fluid. It gives us the feeling of peace and contentment.

(iv) Shleshak : This type of kapha lubricates the bones and joint movements within the body.

(v) Avalambak : It is present in the thorax and pelvic region and lubricates the vital organs in this region — the lungs, the upper intestines and the heart.

Kapha is cold, heavy, slow, steady, soft and oily in nature. Persons with predominance of Kapha are physically well built, with good stamina, radiant skin, expressive eyes and a head full of hair. Emotionally, they are calm, thoughtful, steady and predictable.

When the three doshas are in balance, the body-mind complex is said to be in a state of equilibrium and good health prevails. The problem arises when there is an imbalance with one or more of the entities going into deficiency or excess. Harmony is vitiated and menifestation of diseases takes place. Thus the literal meaning of the sanskrit word 'dosha' meaning fault becomes relevant.

2.7 Rasayana

Definition : The word 'Rasayana' means the path or way (ayana) of essence (rasa). In early Ayurvedic medicine it means the science of lengthening life span, and in later period (post 8th century) it refers to Indian alchemy. The science of Indian alchemy or proto-chemistry, is more generally known as 'the science of mercury' or 'Rasasastra'. Early Indian alchemical texts discuss the use of prepared forms of mercury or cinnabar (red mercuric sulphide).

Rasayana arrests physical and mental decay. It deals with therapies that rejuvenate and revitalize our energies to live a long life without senility or feebleness of old age.

Types of Rasayana : There are two types of Rasayana—

1. **Kamya Rasayanas :** These are promoters of normal health. These boost body energy levels, immunity and general health, there are three types of kamya Rasayanas.
   - ***(i) Pranakamya :*** promoter of vitality and longevity
   - ***(ii) Medhakamya :*** promoter of intelligence
   - ***(iii) Srikamya :*** promoter of complexion

2. Naimittika Rasayanas : These help to fight specific diseases.

Chyawanaprasha is one of the traditional rasayanas. Specific adaptogenic herbs are also included in Rasayanas. These are Haritaki (*Terminalia chebula* Retz.) Amlaki (*Emblica officinalis* Gaertn), Shilajit (a type of exudate obtained from rocks), Ashwagandha (*Withania somnifera* Dunal), Tulasi or holy basil (*Ocimum sanctum* Linn.) Guduchi (*Tinospora cordifolia* (Willd) Miers) and Shatavari (*Asparagus racemosus* Willd).

All the plant drugs were found to be safe in both acute and sub-acute toxicity studies. Studies on the mechanisms of action of the plants including Shilajit revealed that they all produced immunostimulation. *Emblica officinalis* strengthened the defence mechanisms against free radical damage induced during stress. *Tinospora cordifolia* offered protection against stress induced gastric mucosal damage. Recent data obtained *Tinospora cordifolia* have led research workers to suggest that it may induce genotypic adaptation.

Rasayana formulations :

Puri (2003) has given detailed account of classical formulations of Rasayana, e.g. Amrit Rasayana, Mukta Panchamrit Rasayana, Brahmi Rasayana, Kamdugdha Ras,

Laxmi Vilas Ras, Makaradhwaja Vati, Madanoday Modak, Laxman vilas Ras, Navajeevan Ras, Smritisagar Ras, Vasant Kusumakar Ras, Suvarna Basant Malati, Visha Rasayana etc.

These classical Rasayana formulae contain a large number of ingredients including minerals, pearls, coral and gems including a specially processed (samskara) mercury (the word Rasa indicates Parada or mercury as an ingredient).

The mineral Materia Medica of Ayurveda is classified under six categories and called Rasasastra. The drugs are called Rasausadhis, comprising of minerals, ashed materials or vasma and organometallic compounds; gems and pearls are also used as medicaments. The six categories are as follows :

(i) Rasa - mainly 'Parada' or mercury
(ii) Maharasa - precious minerals like mica, bitumen, copper sulphate etc.
(iii) Uparasa - secondary minerals, *viz.* alum, sulphur etc.
(iv) Sadharana Rasa - or ordinary minerals like arsenic, ammonium chloride etc.
(v) Loha or metals including iron, gold, copper, silver, lead, tin, brass and bronze.
(vi) Ratna - or gems including pearls, diamonds, lapis lazuli (a bright blue stone) etc.

The word 'Rasa' means also the taste. Rasas or the six tastes are Amla (sour), Madhura (sweet), Tikta (bitter), Katu (pungent or hot), Kashaya (astringent) and Lavana (salty).

In the Astanga-Ayurveda, there are eight separate branches. These are :

(i) Kayachikitsa or therapeutics
(ii) Salyatantra or surgery
(iii) Salakyatantra or diseases of ear, nose and throat (ENT) and also tongue and oral cavity.
(iv) Kumarbhritya or mother and child care (pre-natal & post natal)
(v) Bhutavidya or knowledge of mental diseases, e.g. unmada (insanity), Apasmara (epilepsy), Abasada (depression), etc.
(vi) Agadatantra : Knowledge of toxicology including snake bites and toxins arising from food items and their antidotes.
(vii) Rasayanatantra : the knowledge of tonics for improving physical and mental health.
(viii) Vajikaran - it deals with therapies in the area of virility or enhancement of sexual power in men and also the vitality rejuvenation.

So Rasayanatantra is one of the above-cited Astanga Ayurveda.

2.8 Plants used in Ayurvedic treatments

Different Ayurvedic medicines are mainly prepared from plant materials. In some cases minerals, organometallic compounds, organs, tissues and excreta of animals are also used to prepare medicines. Ayurvedic medicines may be **(i) Monoherbal**, i.e. prepared from single drug, e.g. Aswagandhachurna (powder of root of *Withania somnifera* Dunal) **(ii) Polyherbal**, i.e. prepared from several drugs, e.g. **Triphala** Kvatha Churna (powder of fruits of Haritaki: *Terminalia chebula* Retz, Bibhitaka : *Terminalia belerica* Roxb. and Amalaki : *Emblica officinalis* Gaertn.) **(iii) Herbomineral,** i.e. prepared from plant material and minerals e.g. Dhatrilouha (prepared from fruit of Amalaki and *Louhavasma*- ashed iron).

Some of the plants used in the preparation of Ayurvedic medicines for treatment of different diseases are listed below :

Sl No.	Name of the plant	Part(s) used	Ayurvedic name	used in/as
1.	*Acorus calamus* Linn. (Family Araceae)	Rhizome.	Vacha.	Dyspepsia, colic, bronchitis, fever, as nerve tonic, dysentery etc.
2.	*Abrus precatorius* Linn. (Fam. Fabaceae)	Root & seed.	Gunja, Kunch.	Roots as emetic and alexiteric (antidote) seeds - purgative, emetic, aphrodisiac, used in nervous disorder.
3.	*Asparagus racemosus* Willd. (Fam. Liliaceae)	Root.	Shatamuli, Shatavari.	Refrigerant, demulcent, diuretic, aphrodisiac, antispasmodic, anti dysenteric, galactogogue.

Sl No.	Name of the plant	Part(s) used	Ayurvedic name	used in/as
4.	*Bacopa monnieri* (Linn.) Wettst. (Fam. Scrophulariaceae) (Fig. 1c)	Whole plant, stem & leaf.	Brahmi, Nira-brahmi.	As nerve tonic, in asthma, epilepsy, insanity, loss of memory, as diuretic and also in snake bite.
5.	*Boerhaavia diffusa* Linn. (Fam. Nyctaginaceae)	Root.	Punarnava, Rakta punarnava.	Diuretic, laxative, expectorant, in asthma, antidote to snake venom.
6.	*Centella asiatica* (Linn.) Urban (Fam. Apiaceae)	Whole plant Leaves.	Mandukaparni, Brahmi.	Skin disease, leprosy, nervous disorder and as blood purifier. Leaves - improving memory, skin disease, insomnia.
7. tonic,	*Centratherum anthelminticum* (Willd.) Kuntze (Fam. Asteraceae)	Seeds.	Somraj, Somraji, Aranya Jiraka.	as anthelmintic, diuretic, in skin diseases, in scorpion sting.
8.	*Elaeocarpus ganitrus* Roxb. (Fam. Elaeocarpaceae)	Fruit.	Rudraksha.	used in diseases of the head and epileptic fits and also in heart disease.
9.	*Gloriosa superba* Linn. (Fam. Liliaceae)	Root.	Langali, Kalihari.	as purgative, anthelmintic, used in leprosy, parasitical affections of skin,

Sl No.	Name of the plant	Part(s) used	Ayurvedic name	used in/as
				piles, colic. Starch from the root given internally in case of gonorrhoea.
10.	*Holarrhena antidysenterica* Wall. (Fam. Apocynaceae)	Bark & Seed.	Kutaja, Indrajaba (seed).	Bark in dysentery, dropsy, bleeding piles, seeds in diabetes, fever, diarrhoea, intestinal worms.

2.9 Summary

The earliest mention of medicinal plants is found in the Rigveda (4500-1600 BCE) in which uses of 67 medicinal plants have been recorded. In Atharva Veda (2000-1500 BCE) about 290 plants are included for curing of diseases. Charaka (1000 BCE) and Sushruta (800 BCE), the two eminent physicians mentioned about 700 plant species in their Samhitas. Other ancient medical practioners are Jivaka, Nagarjuna, Vagbhatta and Bhava Misra.

Ayurveda, Siddha and Unani systems of medicine are the three major indigenous medicinal sciences in India. Ayurveda is the science of life. It is prevalent in India since the Vedic period. The Charaka Samhita is scientific in contents and reason-based. It has eight sections. Sushruta Samhita, on the other hand, in mainly the science of surgery and contains two parts - the Purva-tantra and Uttara tantra. Ayurveda is based on Panchamahabhutas (i.e. Akasha, Vayu, Agni, Ap, Prithvi), Saptadhatus (Rasa, Rakta, Mamsa, Meda, Asthi, Majja, Sukra) and Tridosha (Pitta, Kapha and Vata). Rasayana is an important way of healing in Ayurveda. It means the science of mercury or cinnabar (red mercuric sulphide). Rasayana is divided into two types-Kamya and Naimittika. Some of the Rasayana formulations are Brahmi Rasayana, Laxmivilas Ras, Makaradhwaja Vati etc. Ayurvedic medicines may be monoherbal, polyherbal or herbo-mineral. Many plants are used in Ayurveda, viz. Vacha (*Acorus calamus*), Shatavari

(*Asparagus racemosus*), Punarnava (*Boerhaavia diffusa*), Brahmi (*Bacopa monnieri*), Mandukaparni (*Centella asiatica*), etc.

2.10 Questions

1) What is Ayurveda? Name two books on Ayurveda.
2) Write the scope of Ayurveda in India.
3) Give an outline of Charaka's contribution to the field of medicine.
4) Who was Sushruta? Discuss his legacy in the field of Indian medical science.
5) What do you mean by Panchamahabhutas?
6) What are Saptadhatus? How is it important for a healthy life?
7) What are the three forces of human body according to Ayurveda?
8) What is Rasayana? Cite examples of some Rasayana fomulations. Name some plants which are included in Rasayanas.
9) What do you mean by 'Rsasasatra and Rasausadhi'?
10) Name some plants with classical name which are used in Ayurveda in different diseases.

2.11 Answers

1) Unit 2.1; 2) 2.2; 3) 2.3; 4) 2.3; 5) 2.4; 6) 2.5; 7) 2.6; 8) 2.7; 9) 2.7; 10) 2.8

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Unit 3 ❑ Siddha: Origin of Siddha medicinal systems, Basis of siddha system, Plants used in siddha medicine.

❑ Unani: History, Concept - Umoor-e-tabiya, Tumor treatments / therapy, Polyherbal formulations.

Structure

3.0 Objective

- In this unit emphasis given on 'Siddha' another Indian traditional healing concept.
- From this unit you will be able to learn 'Unani' other traditional system of medicine originated in ancient Greece.
- You will be able to compare the role of traditional systems of different ancient traditional systems of medicines.

3.1 Origon of Siddha System of Medicine

The Siddha system of medicine is considered to be among the ancient systems of medicine with origins in what is today, Tamil Nadu, in India and Srilanka. Palm leaf manuscripts say that the Siddha system was first described by Lord Shiva to his wife Parvati. Parvati explained all this knowledge to her son Lord Muruga. He taught the knowledge to his disciple sage Agasthya. Agasthya taught it to 18 Siddhars viz.Nandisar, Tirumular, Bhogar, Punnakisar, Ramadevar and others. They spread this knowledge to human beings.

Siddha is said to have been inspired by two systems in its formative stages-the Yoga system of Patanjali having its association with Chakras, Kundalini and meditation and Chinese Taoism with its Yin (female) and Yan (male) principles and their association with mercury and sulphur. This system is as ancient as the Ayurveda. It is also popular in Sri Lanka, Mayanmar, Malaysia and other South East Asian countries. In Tamil, Siddha medicine is called "Citta maruttuvam".

3.1.1 Basis of Siddha system

The term 'Siddha' comes from the word 'siddhi' or supernatural power. In Indian Culture, there are eight supernatural power or 'Ashtamahasiddhi'. Those who attained or achieved these powers are known as siddhars. The eight supernatural powers are -

(i) 'Animan' - the power to reduce oneself to an atom.

(ii) 'Mahiman' - the power to grow oneself exponentially

(iii) 'Gariman' - the power to become heavy

(iv) 'Laghiman' - the power to become weightless

(v) 'Prapti' - the power to access everything

(vi) 'Prakamya' - the power to will anything

(vii) 'Isitva' - the power to have lordship over all

(viii) 'Vasitva' - the power to subjugate all

The siddhars are individuals who have aquired all the eight powers after having performed hard religious works.

In Siddha the human body is regarded as a microcosm of the universe. It comprises the five elements—the 'Panchabhuta', three humors - Vatham, Pittham and Kapham and seven tissues - plasma, blood, muscle, fatty tissue, bone, bone-marrow and semen. When the normal equilibrium of the three humors (i.e. vatham, pittham and Kapham) is disturbed, disease is caused. The factors assumed to affect this equilibrium are

environment, climatic conditions, diet, physical activities and stress. Under normal conditions the ratio between the three humors is believed to be 4:2:1.

According to this system of medicine diet and lifestyle play a major role in health and curing diseases. This concept of Siddha medicine is termed as Pathiyam and Apathiyam, which is essentially a rule based system with a list of do's and donots.

In diagnosis, examination of eight items (**enn vakaith thervu**) is required. These are—

(i) Na (tongue) : Black in Vatham, yellow or red in pittham, white in Kapham, ulcerated in anaemia.

(ii) Varnam (colour) : Dark in Vatham, yellow or red in pittham, pale in Kapham.

(iii) Kural (voice) : normal in vatham, light-pitched in pittham, low-pitched in Kapham, slurred in alcoholism.

(iv) Kan (eyes) : in Vatham muddy conjunctiva, yellowish or red in pittham, pale in kapham.

(v) Thodal (touch) : Dry in vatham, warm in pittham, chill in kapham.

(vi) Malam (Stool) : Black stool in Vatham, yellow in pittham, pale in kapham, dark red in ulcer and shiny in terminal illness.

(vii) Neer (urine) : Early morning urine is examined. Straw colour indicates indigestion, reddish-yellow colour in excessive heat, rose colour in blood pressure, saffron colour in jundice and looks like meat washed water in renal diseases.

(viii) Naadi (pulse) : The confirmatory method recorded on the radial artery.

The drugs used by the siddhars are classified into three groups - Thavaram (herbal products), Thadhu (inorganic substances) and Jangamam (animal products). The thadhu drugs are further classified as 'uppu' (water soluble inorganic substances or gives vapour when put into fire), 'Pashanam' (not dissolved in water but emit vapour when fired), 'uparasam' (similar to pashanam but differ in action), 'Loham' (not dissolved in water but melted when fired), 'Rasam' (soft) and 'Ghandhagam (insoluble in water, like sulphur).

The special chemical processes evolved in this system to convert the minerals and metals into potent therapeutic agents are unique in this pharmaceuticals. It is practically the key note of this system. The ancient uses of cinnabar or Hingula (red mercuric sulphide) and orpiment or Haritala (arsenic trisulphide) internally is unique to this system. There are about 1000 drugs in this system of which 600 are commonly used.

Out of which 500 drugs are of plant sources, 80 are of minerals and 20 are of animal origin. At present, siddha system of medicine is known as Tamil medicine. It has specific remedies for diseases like mycosis, veneral diseases, leucoderma (vitiligo), asthma, leprosy etc.

3.1.2 Plants used in Siddha medicine

Sl. No.	Name of the plant	Part(s) used	Siddha name	used in/as
1.	*Adhatoda vasica* Nees (Fam. Acanthaceae)	Leaves.	Adathodal.	In bronchial asthma, eosinophilia and cough. The plant has antiulcer, antiinflammatory, hepatoprotective and antitussive properties.
2.	*Boerhaavia diffusa* Linn. (Fam. Nyctaginaceae)	Roots.	Mukaratee.	In asthma, dropsy, ascities, heart diseases, kindney stone and colitis. It has immunosuppressive effect associated with asthma and COPD (chronic obstructive pulmonary disease), used also as anti-bacterial, antidiabetic and antifungal agents.
3.	*Caesalpinia bonduc* Linn (Fam. Caesalpiniaceae)	Seeds.	Kaliccikkai.	Used in the treatment of fevers, intermittent and chronic asthma, acute arthritis, palsy, painful and swollen testicles.
4.	*Ocimum sanctum* Linn. (Fam. Lamiaceae) (Fig. 1d)	Leaves and seeds.	Thulasi.	In asthma, bronchitis, eosinophilia, chronic cough.Volatile oil from fresh leaves and fixed

Sl. No.	Name of the plant	Part(s) used	Siddha name	used in/as
				oil from seeds showed antiinflammatory activity against serotonin and histamin-induced inflammation. The plant is widely used in fever, leucoderma, ophthalmia, ringworms and skin diseases.
5.	*Piper longum* Linn. (Fam. Piperaceae)	Fruits.	Thippili.	Used in cough and cold, asthma in hoarseness, hiccup,colic, flatulence, used as counter irritant, analgesic, etc.
6.	*Solanum nigrum* Linn. (Fam. Solanaceae)	Leaves and fruits.	Manathakkali	Used in bronchitis and asthma. Fresh extracts of leaves used for inhibiting swellings, enlargment of liver and spleen, in cirrhosis of liver. It has antipyretic, antitumor and antioxidative activities.
7.	*Strychnos potatorum* Linn. (Fam. Loganiaceae)	Fruits and seeds.	Tentakotal	Fruits and seeds are used in treating bronchitis and are also useful in chronic diarrhoea, diabetes gonorrhoea, boils and dysentery. It has also antiulcerogenic, hepato protective and diuretic properties.

Fig. 1a : BAHERA
(*Terminalia bellerica*)

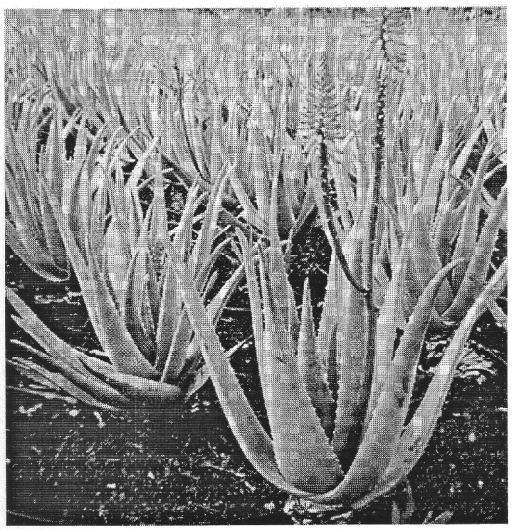

Fig. 1b : GHRITAKUMARI
(*Aloe sp.*)

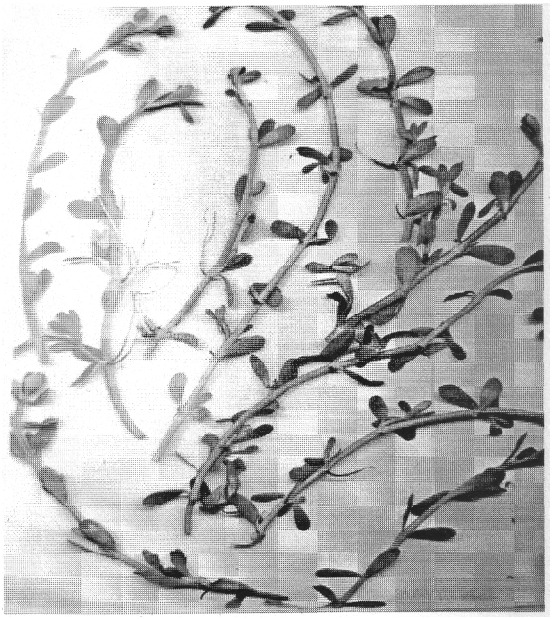

Fig. 1c : BRAHMI
(*Bacopa monnieri*)

Fig. 1d : TULASI
(*Ocimum sanctum*)

(Taken from 'Herbal power'— The Agri-horticultural Society of India, Alipore, 2004 and 'Database on Medicinal Plants', Vol. 2, CCRAS, New Delhi, 2001.)

Sl. No.	Name of the plant	Part(s) used	Siddha name	used in/as
8.	*Terminalia belerica* Roxb. (Fam. Combretaceae) (Fig. 1a)	Fruits.	Thandrikkal	Fruits are effective in cough, asthma, sore-throat, and also in dropsy, dysentery and diarrhoea. It has also antidiabetic, antidepressant and antispasmodic activities.
9.	*Tylophora indica* Merrill (Fam. Asclepiadaceae)	Roots and leaves.	Kurinjan.	Both root and leaf are used in asthma. These parts are also used in diarrhoea, dysentery and syphilitic rheumatism.

3.2 Unani Medicine

3.2.1 History

The 'Unani or Yunani' system of medicine originated in Yunan (Ionia), a populated coastal area of Anatolia in ancient Greece (Modern Turkey). The Greeks adopted the initial concepts of medicine (Tibb) from Egypt and Mesopotamia and systemized them. Thereafter, the Romans further advanced these concepts. In the medieval period, this medical system travelled to the Arab, Central Asian countries and parts of Europe, where it was developed to a great extent.

The basic knowledge of Unani medicine as a healing system was developed by the Muslim scholar Avicenna (Ibn-Sina) in his encyclopedic work 'al-Qanun fi al-Tibb' or the 'Canon of Medicine'.

The time of origin was thus dated 1025 CE, when Avicenna completed his 'Canon of Medicine' in Persia. He was primarily influenced by the Greek and Islamic medicines and also influenced by the Indian medicinal teachings of Charaka and Sushruta. In India, the Unani system of medicine came from Arabia and Iran during 13th century

with the establishment of Delhi Sultanate and it took its own course of development during the Mughal Empire. Alauddin Khalji (1316 CE) had several Eminent unani physicians (Hakims) at his royal courts. This royal patronage led to the development of Unani medicine in India and also the creation of Unani literature.

3.2.2 Concept of Unani system

Unani system is one of the oldest systems of medicine, based on the teachings of Hippocrates (Father of Medicine) in 460 BC, who freed medicine from the realm of superstition and magic, and gave it the status of science. It was further adopted by the Arabs and introduced to India. The Sultans of Delhi, the Khiljis, the Tughlaqs and the Mughal Emperors provided patronage to the scholars and physicians for its enormous development, improvement, and further refinement. Unani System of Medicine came to India in the eighth century and developed as a comprehensive medical system due to manifold contribution and new applications by scholars of successive generations. It has been practised, taught, and scientifically documented in different parts of India and flourished as a scientific medical system. The Government of India facilitated its growth, promotion and development by recognizing its utility and scope, and integrated into healthcare delivery system of India.

The fundamental framework of Unani system of Medicine is based on deep philosophical insights and scientific principles. In Unani medicine, **Al-Umoor Al-Tabiyah** is a set of seven basic physiological principles that are believed to maintain the health of the human body are Arkan, Mizaj, Akhlat, Aza, Arwah, Quwa and Al-Af 'al. These seven components interact with each other to maintain the balance of the human body's natural constitution. Each person's constitution has a self-regulating capacity, called '**tabiyat**', that keeps the seven components in balance. **Kulliyat Umoore Tabiya** is a fundamental subject that provides the basis for the study of Unani medicine.

In Unani medicine much emphasis is given on the prevention of disease and promotion of health than to cure. It also recognizes the influence of surrounding and ecological conditions on the state of health of human beings. For the maintenance of good health these essential factors should be balanced in terms of quality, quantity, and sequence in order to sustain good health. Balanced relationship between these factors keeps the humours and temperament on the right track.

Umoor-e-Tabiya is a term used in Unani medicine, a traditional system of healing and health maintenance. It refers to the "essential factors / principles of life' that govern the body's health and balance. In Unani medicine, health is considered to be the result of a harmonious balance of various elements in the body, and Umoor-e-Tabiya are the key factors that influence this balance.

Seven Umoor-e-Tabiya, which play a central role in maintaining health and preventing disease, include:

1. **Arkan (Elements)**: are the basic elements like earth, air, fire, and water that make up the body.
2. **Mizaj (temperament)**: characterizes the body due to balance of hot, cold, moist, and dry qualities associated with the body.
3. **Akhlat (humours)**: existed as liquids within the body. According to 'Humoral theory' / 'theory of akhlat', balancing of four humours - blood, phlegm, yellow bile, and black bile play a vital role in maintenance of health; imbalance of their proportion either qualitative or quantitative can cause disease.
4. **Aza (organs)**: Our physical body is made up of organs / tissues which may be of two types: Simple and Compound. Examples of simple organs are tissues like fat, bone etc. while compound organs are poly-tissue structures like heart, brain, liver. Proper functioning of different organs is responsible for normal physiological processes.
5. **Arwah / Pneuma (vital spirit)**: Life force or spirit provides life to the organism. It also acts as the seat and carrier of the physiological powers or faculties (Quwa) which are responsible for producing the corresponding physiological processes like nutrition and growth, sensation, and movement etc.
6. **Quwa (faculties or powers)**: refer to the physiological powers that give rise to corresponding physiological functions. Natural, vital, and psychic faculties in fact drive bodily functions.
7. **Al-Af 'al (functions or actions)**: are the physiological functions and processes undergoing in organs and tissues due to the operation of faculties or physiological powers.

Brief idea on the above mentioned seven factors considered in Umoor-e-Tabiya as fundamental natural principles governing human health is explained below.

The basic elements (Arkan) in Unani medicine are simple invisible matter which provide the primary components for the human body and others. Each element has two sets of basic qualities (Kayfiyat) : hot or cold and dry or wet. The four elements are Fire (Nar), Air (Hawa), Water (Ma) and Earth (Ard). The basic qualities are

Fire - hot and dry

Air - hot and wet

Water - cold and wet

Earth - cold and dry

All things including man and drug are made up of these four basic elements.

Temperament or Mizaj : Human being are classified into four types which indicates their body, mind and pneuma. Each type is associated with a dominant humour and named accordingly as :

Sanguine (Damawi) - hot and wet

Choleric (Safrawi) - hot and dry

Phlegmatic (Balghami) - cold and wet

Melancholic (Sawdawi) - cold and dry

The temperament can also be described in terms of basic qualities, as shown in the second column. The temperament of man, can be diagnosed by ten categories of bodily and mental parameters (Ajnas 'Ashara) e.g. complexion, texture, built, hair, dreams etc.

Humours (Akhlat) : The humours are fundamental liquid substance of living things these are four in number and characterized by the dominant basic qualities -

Blood (Dam) — hot and wet

Phlegm (Balgham) — cold and wet

Yellow bile (Safra) — hot and dry

Black bile (Sawda) — cold and dry

The humours are formed within various organs, primarily in liver and run together in the blood vessels. They have both subtle (Latif) and gross (Kathif) components.

Organs (A 'da') : The physical body is made up of organs/tissues (A 'da'). They are of two types - simple (Basit) and compound (Murakkab). the simple organs are tissues like fat, bone etc. while compound organs are poly-tissue structures like heart, brain, liver etc.

Pneumas (Arwah) : The Ruh (plural Arwah) is subtle, physical substance made of subtle components of the humours. It possesses vitality and provides life to the organism. It also acts as the seat and carrier of the physiological power of faculties (Quwa) which are responsible for producing the corresponding physiological processes, e.g. nutrition and growth, sensation and movements, etc.

Man possesses three pneumas, each generated in a vital organ :

Vital pneuma (Ruh Haywani) - Heart

Psychic pneuma (Ruh Nafsani) Brain

Natural pneuma (Ruh Tabi'i) - Liver

Mind corresponds to psychic faculty which subsists in psychic pneuma. Thus Unani system of medicine is very successful in curing psychiatric diseases by treating mind as a substance.

Faculties (Quwa) : These are physiological powers which give rise to the corresponding physiological functions. The faculties are non-substantial powers that can exist in the organism only by subsisting in the corresponding pneuma.

Functions (Af'al) : These are physiological functions and processes that the organs and tissues undergo due to operation of faculties or physiological powers. According to unani system health is divided into three states-stable optimum health, vulnerable optimum health and debility without disease. The first state is to be maintained by a healthy life style, a healthy environment and diet. The second and third stages require special diets, regimens (massage, exercise, etc.) and even drugs.

According to this system disease (Marad) is a pathological condition of the body provoked by a cause. These are of two types :

Single disease (Marad Mufrad)

Complex disease (Marad Murakkab)

Drugs are often used for preventive purposes. Roots of *Smilax china* Linn. (Chobchini) are used in healthy people when they enter the middle age (40-50 years). The use of honey and saffron (*Crocus sativus* Linn). is found to protect the body from ill-effects of cold climate. Some other drugs used prophylactically are *Glycyrrhiza glabra* Linn. (Rubb-us-soos) (Muleti), *Coriandrum sativum* Linn., (Kishneez sabz or Dhania) and *Berberis vulgaris* Linn. (Root bark of Kashmal).

Cause of disease (Sabab) corresponds with etiology. Causes are divided into two-external causes (Asbad Badiya) and internal causes (Asbad Batina). External causes affect the body from outside, viz. excessive hot or cold climate, polluted atmosphere, injury etc. Internal causes, on the other hand, affect the body internally, viz formation of stones inside the kidney or bladder.

3.3 Tumour treatment / therapy

Tumour or cancer is one of the major causes of death worldwide. It strikes more than one third of the worlds population. The knowledge of tumour both benign and malignant in the Unani system of medicine can be traced back to ancient times (131-200 CE).

According to Unani system, cancer or tumour is a disease of black bile, i.e. excessive production and collection of black bile (SAWDA). Malignant tumour mostly occurs in soft tissues like breast, uterus, stomach, intestine, pancreas, prostrate glands, oral cavity, lungs etc. The philosophy of Unani system describes cancer as the end stage of degeneration of the metabolic efficiency of the body for incorrect diet and other imbalances in various aspects of the patient's life, usually ocurring over a long period of time. Unani physicians or Hakims recognized the natural healing process as critical in achieving best possible health. They recommended following principle of treatment in given successive steps.

1. **Venesection (Fasd) :** it is surgical incision of a vein for blood letting used for relieving blood pressure preventing accumulation of waste matters in blood, reducing toxicity, stimulating metabolic processes and correcting heat in one's temperament.
2. **Evacuation of morbid material (Tanqiya) :** If the temperament is changed due to an increase in the quantity and volume of certain humours and morbid materials get accumulated, it should be evacuated with the help of some herbs.
3. **Diet :** diet should be easily digestable to reduce the excess production and accumulation of black bile and also to help in cooling and refreshing of the body.
4. **Control of pain :** Pain associated with tumour or cancer can be controlled or reduced with analgesic or sedative medicines.
5. **Local medication for cancer or tumour :** Routine allopathic chemotherapy for cancer treatment has several side and toxic effects. Since long time Unani medicine is being used to cure cancer. More than twenty Unani herbal drugs are being used for the prevention and treatment of different types of tumours and cancers. These unani herbal drugs may help to synergize the anicancer effects and reduce the side effects of conventional drugs. The most important pharmacological effects of these drugs are :
   (i) Cytotoxicity : This means quality of being toxic to cells.
   (ii) Apoptosis induction : Apoptosis is a form of programmed cell death that occurs in multicellular organisms.
   (iii) Antioxidation : This is inhibition of oxidation.
   (iv) Immunomodulation : It refers to any process in which an immune response is altered to a desired level.

The different plants used in the treatment of cancer or tumour in the unani system of medicine include the following :

Dillenia indica Linn.

Oroxylum indicum Vent.

Terminalia arjuna W. & A.

3.4 Polyherbal formulations in the unani system of Medicine

The Unani system of medicine includes a large number of traditional formulations used since a long time in India and abroad. This system consists of different types of formulations like Itrifal, Jawarish, Majun, Qurs and Habbs and has been ignored for scientific validation of these formulations as well as for the quality, control using modern techniques.

Some of the polyherbal formulations mentioned in the National formulary of unani medicines (NFUM), published by the Department of AYUSH, Govt. of India are stated below :

1. **Tiryaq wabai :** This is used as immunostimulator in elderly persons, useful for prophylaxis during epidemics of cholera, plague and other epidemic diseases. It consists of 3 ingredients :
   (i) Sibr (*Aloe barbadensis* Mill.) — dried juice of plant (Fig. 1b).
   (ii) Zaafran (*Crocus sativus* Linn) — dried style and stigma.
   (iii) Mur (*Commiphora myrrha* (Ness) Engl. — gum resin.
2. **Habb-e-Real :** used in diarrhoea and dysentery. It consists of two ingredients.
   (i) Gond Kikar (*Acacia arabica* Willd.) — gum.
   (ii) Raal Safed (*Vateria indica* Linn.) — fatty oil from fruit.
3. **Majoon-e-Jalali :** used in sexual debility, hydrospermia and general debility.
   This drug consists of 11 plant materials :
   (i) Habbul Neel (*Ipomoea nil* (Linn.) Roth — seeds.
   (ii) Ajwain Khurasani (*Hyoscyamus niger* Linn.) — seeds.
   (iii) Balcharr (*Nardostachys jatamansi* DC.) — root stalk and rhizome.
   (iv) Darchini (*Cinnamomum zeylanicum* Blume) — stem bark.
   (v) Taj Qalmi (*Cinnamomum cassia* Blume) —stem bark.
   (vi) Zaafran (*Crocus sativus* Linn.) - dried style and stigma

(vii) Indrajao Shirin (*Wrightia tinctoria* R. Br.) - stem bark and seed

(viii) Mastagi Roomi (*Pistacia lentiscus* Linn.) - Resin

(ix) Khusyatus Salab (*Orchis latifolia* Linn.) - tuber

(x) Ood Hindi (*Aquilaria agallocha* Roxb.) - heart wood and oil

(xi) Jaozbua (*Myristica fragrans* Houtt.) - seeds

4. **Anushdaru Lului :** used as tonic for normal functioning of brain, heart, nerves, liver and stomach, useful in heart palpitation, improves cardiac muscle, stops acid secretion in the stomach, used as protective medicine to gastritis, hyper acidity and dyspepsia. It is composed of 19 ingredients, in which 15 components are of herbal origin. The plant materials are :

(i) Muqashsher (*Emblica officinalis* Gaertn.) - Fruits

(ii) Gul-e-Surkh (*Rosa damascena* Mill.) - flower

(iii) Saad Kufi (*Cyperus scariosus* R. Br.) - root

(iv) Mastagi Roomi (*Pistacia lentiscus* Linn.) - gum resin

(v) Asaroon (Tagara) (*Valeriana wallichii* DC.) - root

(vi) Qaranfal-clove (*Syzygium aromaticum* (Linn.) - Merr & Perry - dried flower

(vii) Sumbuluttib (*Nardostachys jatamansi* DC.) - rhizome & root stalk

(viii) Bisbasa Jayitri (*Myristica fragrans* Houtt.) - fruit

(ix) Dana Heel Khurd-Elachi (*Elettaria cardamomum* Maton) - seeds

(x) Dana Heel Lalani - Bara elachi (*Amomum subulatum* Roxb.) - seeds

(xi) Jaozbua (*Myristica fragrans* Houtt.) - seeds

(xii) Khurfa - Luni (*Portulaca oleracea* Linn) - whole plant

(xiii) Zaafran (*Crocus sativus* Linn.) - dried style and stigma

(xiv) Zarnab (*Taxus baccata* Linn.) - fruit

(xv) Kehraba (*Vateria indica* Linn.) - fruit

Other ingredients are pearl, coral and ruby.

5. **Qurs-e-Hummaz :** used as anti-inflammatory drug in the unani system of medicine. It is composed of ingradients of herbal origin. These are :

(i) Beejband (*Rumex vesicarius* Linn.) - seed

(ii) Tabashir (*Bambusa bambos* Druce) - bamboo manna, the calcarius deposition inside the stem (Bansolochan)

(iii) Gul-e-Surkh (*Rosa damascena* Linn.) - flower

(iv) Rasaut (*Berberis aristata* DC.) - fruit

(v) Zarwand - i-Gird (*Aristolochia rotunda* Linn.) - root

(vi) Zaafran (*Crocus sativus* Linn.) - root

Another ingredient of this formulation is lac resin (*Coccus lacca*)

3.5 Summary

Siddha system of medicine is considered to be originated in Tamil Nadu. In this system the human body is regarded as a microcosm of the universe. It comprises the five elements or Panchabhuta, three humours, e.g. vatham, pittam and kapham and seven tisses, e.g. plasma, blood, muscle, fatty tissue, bone, bone-marrow and semen. The drugs used in this system are Thavaram (herbal products) Thadu (inorganic substances) and Janagamam (animal products). Many plants are used in Siddha system of medicine viz. Adathodal (*Adhatoda vasica*), Panaimaram (*Borassus flabellifer*), Kaliccikkai (*Caesalpinia bonduc*), Thipplil (*Piper longum*), etc.

The basic knowledge of Unani medicine was developed by Muslim scholar Avicenna in his work the Canon of Medicine (1025 CE). This system of medicine describes the man as being made up of seven natural factors or Umoor-e-tabiya. These are Elements, Humours, Temperament, Organs, Pneuma, Faculties and Functions. According to Unani system, cancer or tumour is a disease of black bile (Sawda). Polyherbal formulations of this system are mainly Tiryaq Wabai, Habb-e-Raal, Majoon-e-Jalai etc. Roots of Chobchini (*Smilax china*), Zaafran (style and stigma of *Crocus sativus*), etc. are used for preventive purposes in Unani system of medicine.

3.6 Questions

1. What are the basis of Siddha system of medicine?
2. Name three plants with siddha name used in respiratory diseases.
3. What is meant by Umoor-e-tabiya?
4. Describe different types of temerament (Mizaj) and humours (Akhlat) as stated in Unani system of medicine.
5. State the principle of treatment of tumour/cancer according to Unani system of medicine.

6. Name two polyherbal formulations of Unani system alogwith the ingrediants and uses.
7. What is the main cause of cancer or tumour according to unani system of medicine.
8. State whether the following sentences are true or false
   (i) Herbal products are called Thavaram in Siddha system.
   (ii) *Calotropis gigantea* is known as Arka in Siddha system.
   (iv) Avicenna wrote the book entitled 'Canon of Medicine'.
   (v) Complex disease is called 'Marad Mufrad' in unani system
   (vi) Blak bile is called 'Sawda' in Unani system.
   (vii) Indrajaba is the seed of barley.

3.7 Answers

(1) 3.1.1, (2) 3.1.2, (3) 3.2.2, (4) 3.2.2, (5) 1.6.3, (6) 1.6.4, (7) 1.6.3 (8) (i) true, (ii) false, (iii) true, (iv) false (v) true, (vi) false.

3.8 References and further readings

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Unit 4 ❑ Conservation of Endangered and Endemic Medicinal Plants

Structure

4.0 Objective

- From this unit you will be able to learn about the need of conservation for endangered and endemic medicinal plants.
- You will be able to know the importance of in-situ and ex-situ conservation.
- You will be able to discuss the role of Botanical gardens, ethnomedicinal plant gardens in conservation.

4.1 Introduction

Conservation is the protection, preservation, management or restoration of wildlife and natural resources, such as forests and water. India has a rich resource base of medicinal plants with about 8000 different species. According to the Government of India, traditional medicines are the sole means of health care for about 65 percent of the population. The medicinal plants are the basic raw material for the production of Ayurveda, Unani and Siddha medicines. The bulk of the raw material (about 80% of the demand) is derived from the forests only. Hence, the forest areas have been over exploited in the past to meet the requirement of the pharmaceutical and allied industries. Consequently, many of the important plant species have been threatened and some of them are on the verge of extinction due to unscientific collection by untrained persons. Recently, medicinal plants have also been gaining immense popularity not only in developing countries, but also in developed countries due to various reasons related to safety and efficacy. Therefore the demand for the basic raw materials has been further increased and forest areas are hardly able to meet this increasing demand for industries. In view of above circumstances, there is an urgent need to conserve and to propagate some important medicinal plant species so as to save these from extinction and also to ensure greater availability of raw materials.

4.2 Why conservation is needed?

Through the conservation, the survival of many species and habitats can be ensured. The most obvious reason of conservation is to decrease the rate of extinction of species. Extinction is a natural phenomenon and has been going since life began. Extinction (i.e., the complete disappearance of a species from earth) is an important part of the evolution of life on Earth. The current biodiversity of species is a product

of the processes of extinction and speciation throughout the previous 3.8 billion years history of life. There are three types of extinction processes :

1. **Natural extinction** : With the change in environmental conditions, some species disappear and others, which are more adapted to changed conditions, replace them.
2. **Mass extinction** : There have been several periods in the Earth's geological history when a large number of species became extinct because of catastrophe or sudden widespread disaster.
3. **Anthropogenic extinction** : This man-made extinction represents a very severe depletion of biodiversity, particularly because it is occurring within a short period of time.

We have no control in the above first two, but by conservation, we can control the third one. The rate of extinction can be increased several folds by Anthropogenic activities. The rate is at least 10,000 times greater than the natural rate of species extinction, as estimated using the fossil recods.

4.3 Endemic and Endangered medicinal plants

4.3.1 What is endemism?

Endemism is a phenomenon which indicates the situation of an element (either plant or animal) restricted to a region or area of distribution. The phytogeographer or associated taxonomists recognize two types of endemism.

1. One is whether the element is of a young species or genus which may not yet have attained its maximum area as determined by its dispersal barriers. This is termed, in the strict sense, an endemic, e.g. some species of *Aponogeton* (*A. undulatus, A. microphyllous, A. crispus,* etc.) endemic to India and Srilanka.
2. The second type is one in which the element is old or relic occupying now a contracting and much smaller area than before, an element that is surviving but contributing to plant evolution it is termed as an epibiotic, e.g. *Welwitschia mirabilis*, endemic to the south west African coast. Endemism is of significance to the taxonomist since it is vitally concerned with the history of the flora.

According to D. Chatterjee (1962) more than 50% of dicotyledonous species in India are endemic. He stated that these endemic forms are specially concentrated in the Himalayas (3169 dicotyledons and about 1000 monocotyledons) and South India

(2045 dicotyledons and 500 monocotyledons) The Indo-Gangetic plain is poor in comparison to the above two regions.

4.3.2 Endangered Medicinal Plants

Definition : The term 'endangered' is applied to species that possess a very high risk of extinction as a result of rapid population declines of 50 to more than 70 percent over the previous 10 years (or three generations), a current population size of fewer than 250 individuals, or other factors.

The species that possess an extremely high risk of extinction as a result of rapid population declines of 80 to more than 90 percent over the previous 10 years (or three generations), a current population size of fewer than 50 individuals, or other factors are called **critically endangered**.

In this connection IUCN's Red List of Threatened species is noteworthy.

What is the IUCN (International Union for Conservation of Nature and Natural Resources) Red List? Established - 1964, the IUCN's Red list of threatened species has evolved to become the world's most comprehensive information source on global conservation status of animals, fungi and plant species. The IUCN Red list, is a critical indicator of the health of the world's bidiversity. Far more than a list of species and their status, it is a powerful tool to inform and catalyze action for bidiversity conservation and policy change, critical to protection of the natural resources we need to survive.

It provides information about the range, population size, habitat and ecology, use and/or trade, threats and conservation actions that will help to inform necessary conservation decisions.

4.3.3 Red List Criteria

The IUCN system uses a set of five quantitative criteria to assess the extinction risk of a given species. In general these criteria consider :

1. The rate of population decline.
2. The geographic range.
3. Whether the species already possesses a small population size.
4. Whether the species is very small or lives in a restricted area.
5. Whether the results of a quantitative analysis indicate a high probability of extinction in the wild.

After a given species having been throughly evaluated, it is placed into one of several categories. In addition, three of the categories (CR-critically endangered,

EN-endangered and VU-vulnerable) are contained within the border notion of threatened. The IUCN Red List of threatened species recognizes several categories of species status. These are -

1. **Extinct (EX)** : A designation applied to species in which the last individual has died or where systematic and time-appropriate surveys have been unable to log even a single individual.
2. **Extinct in the wild (EW)** : A category containing those species whose members survive only in captivity or as artificially supported populations for outside their historic geographic range.
3. **Critically Endangered (CR)** : The specis which possess an extremely high risk of extinction, the rapid population declines of 80% to more than 90% over the previous 10 years (or three generations) and the current population size of fewer than 50 individuals, or other factors.
4. **Endangered (EN)** : The species that possess a very high risk of extinction as a request of rapid population declines of 50% to more than 70% over the previous 10 years (or three generations), a current population size of fewer than 250 individuals, or other factors.
5. **Vulnerable (VU)** : A category containing those species that possess a very high risk of extinction as a result of rapid population declines of 30% to more than 50% over the previous 10 years (or three generations), a current population size of fewer than 1000 individuals, or other factors.
6. **Near threatened (NT)** : A designation applied to species that are close to becoming threatened or may meet the criteria for threatened status in the near future.
7. **Lower Risk (LR)** : A category containing species that are pervasive or able to spread throughout and abundant after careful assessment.
8. **Data Deficient (DD)** : A condition applied to species in which the amount of available data related to its risk of extinction is lacking in some way. Consequently, a complete assessment cannot be performed. Thus, unlike the other categories in this list, this category is unable to describe the conservation status of a species.
9. **Not Evaluated (NE)** : A category used to include any of the nerly 1.9 million species described by the scientists but not assessed by the IUCN.

The Threatened Plants of India

IUCN's Red list species of flowering plants of India are represented in eFI (e-flora of India). IUCN data (IUCN Red List of Threatened species 2007-2017) indicates

that 1314 species were assessed for threat status in India. Six are extinct (EX), two extinct in wild (EW), 75 critically Endangered (CR), 161 Endangered (EN), 131 Vulnerable (VU), 41 Near Threatened (NT), 1 Lower Risk (LR), 64 Data Deficient (DD) and the rest are not evaluated (NE). The complete list of threatened flowering plants in India is available at www.iucnredlist.org

e flora of India (eFI) during its 10 year journey (June 2007 to June 2017) has showcased a large number of Red Listed species from different wild habitats of India and botanical gardens. A search of eFI database reveals the following number of red-listed species.

Categories	**Category Symbol**	**Total Number of species in India**	**Number of species represented in eFI**
Extinct	EX	6	1
Extinct in Wild	EW	2	1
Critically Endangered	CR	75	17
Endangered	EN	161	29
Vulnerable	VU	131	45
Near Threatened	NT	41	10
Lower Risk	LR	1	1
Data Deficient	DD	64	12
Not Evaluated	NE	833	-

Some examples under above categories include :

A. Extinct (EX) : *Madhuca insignis* (Sapotaceae)

B. Extinct in Wild (EW) : *Corypha taliera* (Arecaceae)

C. Critically Endangered (CR) :

Aconitum chasmanthum (Ranunculaceae)

Commiphora Wightii (Burseraceae)

Gentiana kurroo (Gentianaceae)

Nardostachys jatamansi (Valerianaceae)

Saussurea costus (Asteraceae)

D. Endangered (EN)

Aconitum heterophyllum (Ranunculaceae)

Curcuma caulina (Zingiberaceae)
Mangifera andamanica (Anacardiaceae)
Pterocarpus santalinus (Fabaceae)
Syzygium alternifolium (Myrtaceae)

E. Vulnerable (VU)

Aconitum violaceum (Ranunculaceae)
Aquilaria malaccensis (Thymelaeaceae)
Santalum album (Santabaceae)
Saraca asoca (Caesalpiniaceae)
Vanda spathulata (orchidaceae)

F. Near Threatened (NT) and Lower Risk (LR)

Aglaia edulis (Meliaceae)
Elaeocarpus munronii (Elaeocarpaceae)
Prunus jacquemontii (Rosaceae)
Vigna khandalensis (Fabaceae)

G. Data Deficient (DD)

Abrus fruticulosus (Fabaceae)
Corypha macropoda (Arecaceae)
Diospyros ebenum (Ebenaceae)
Magnolia pterocarpa (Magnoliaceae)
Magnolia doltsopa (Magnoliaceae)

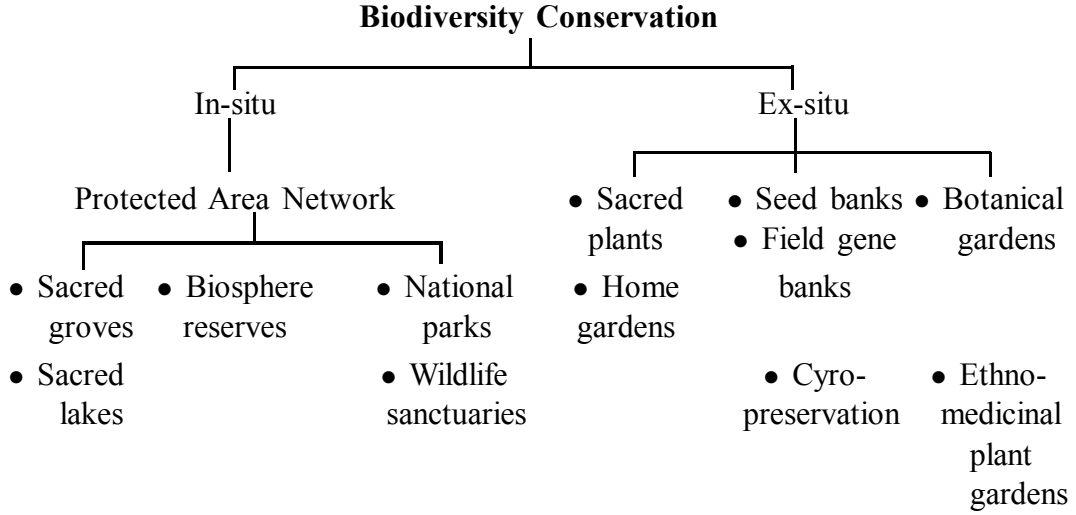
4.4 In-situ conservation

4.4.1 Definition and objectives

Two main strategies of **biodiversity conservation** are in situ (protection of species in their natural habitats) and ex-situ (protection of species outside their natural habitats). There is a need for coordinated conservation efforts based on these strategies. More information is required on medicinal plant production, utilization, trade, monitoring the stock of medicinal plants, development of sustainable harvesting practices, preservation of traditional knowledge and intellectual property rights. The World Conservation Union (formerly known as the International Union for conservation of

Nature and Natural Resources) categorized plants Red Data List categories based on the detailed knowledge of the population dynamics and genetics of the species. Conservationists focus their attention exclusively species extinction rather than genetic erosion within individual gene pools, and the latter may be of equal importance in terms of loss of biodiversity.

Hence, it is imperative that viable strategies to conserve the populations and genetic resources of medicinally important species are essential to avoid further loss. Ongoing efforts in India include both in-situ and ex-situ conservation measures viz., plant tissue culture, introduction of new crop genetic resources, research in habitat restoration, seed storage, tissue banking etc.



4.4.2 In-situ Conservation : Different Advantages

Most of the medicinal plants available in our country are endemic species and their medicinal properties are mainly because of the presence of secondary metabolites that respond to stimuli in natural environments and that may not be expressed under cultural or controlled conditions. In-situ conservation of whole communities allows us to protect indigenous plants and maintain natural communities. In-situ conservation also increases the amount of diversity that can be conserved and strengthens the link between resource conservation and sustainable use. In-situ conservation efforts have focused on establishing protected areas and taking an approach that is ecosystem-oriented, rather than species-oriented. Successful in-situ conservation depends on rules, regulations and potential compliance of medicinal plants within growth habitats.

(a) It is a cheap and convenient way of conserving biological diversity.

(b) It offers a way to preserve a large number of organisoms simultaneously, known or unknown to us.

(c) The existence in natural ecosystem provides opportunity to the living organisms to adjust to different environmental conditions and to evolve in to a better life form.

4.4.3 Different disadvantages of in-situ conservation :

Fig. 2a : Part of a Biodiversity Park.

Fig. 2b : Part of a Floral Plant Biodiversity.

The only **disadvantage** of in-situ conservation is that it requires large space of earth which is often difficult because of the growing demand for space. The protection and management of biodiversity through in-situ conservation involves certain specific areas known as protected areas which include Biosphere reserves, Sacred groves, National parks etc.

4.4.4 Biosphere reserves

Definition : Bisphere reserves or natural reserves are multipurpose protected areas with boundaries circumscribed by legislation. The main aim of the biosphere reserve is to preserve genetic diversity in representative ecosystems by protecting plants, traditional life style of inhabitant and domesticated plant genetic resources. These are scientifically managed allowing only the tourists to visit.

Importance of biosphere reserves :

(a) These help in the restoration of degraded ecosystem

(b) The main role of these reserves is to protect and preserve genetic resources, species, ecosystems and habitats without disturbing the habitats.

(c) These maintain cultural, social and ecologically sustainable economic developments.

(d) These support education and research in various ecological aspects.

Some important biosphere reserves in India are :

Simlipal (Odisha) ;

Sunderban (West Bengal) ;

Kanha (Madhya Pradesh) ;

Kaziranga (Assam) ;

Manas (Assam) ;

Nanda Devi (Uttarakhand) ;

Nokrek (Meghalaya).

4.4.5 Sacred groves

Definition : Portions of forests preserved on religions faiths are known as sacred Groves. Many ethnic communities of India, residing in and around forests, keep certain patches in surrounding forests as sacred. These are given different names in different regions, e.g. Devrai in the Western Ghat, Kavu in Kerala, Orans in Rajasthan and Law in Meghalaya. Hunting and logging are usually strictly prohibited within these patches. Other forms of forest usage like honey collection and deadwood

collection are sometimes allowed on a sustainable basis. Sacred groves did not enjoy protection via federal legislation in India. Some Non Government Organisations (NGO) work with local villagers to protect such groves. Traditionally, and in some cases even today, members of the community take turns to protect the grove. However, the introduction of the protected area category community reserves under the Wild Life (Protection) Amendment Act, 2002 has introduced legislation for providing government protection to the community held lands, which could include sacred groves.

Indian sacred groves are often associated with temples, monasteries, shrines or with burial grounds. Historically, sacred groves find their mentions in Hindu, Jain and Buddhist texts. Many plant species are being conserved in the sacred groves of different regions in India. For example, the plant species named *Kunstleria keralensis* is still present in the Kavus of Kerala and not found anywhere else. In Law Lygdoh, a sacred grove in Meghalaya, species of *Castanopis, Myrica, Quercus, Schima* and a few others form the dominant vegetation, but these are rarely seen in the provalent pine-forests of the area.

Similarly, the deo-rans or "goddess woods" in the Aravalli hills of Rajasthan are covered with prickly thorny trees typical of the region.

4.4.6 National Parks

These are the small reserves meant for the protection of life and their natural habitats. These are maintained by Government. The area of national parks ranges between 0.04 to 3162 Km. The boundaries are well demarcated and circumscribed. The activities like grazing forestry, cultivation and habitat manipulation are not permitted in these areas. There are about 89 national parks in India.

Important National Parks in India are :

(i) Corbett National Park, Nanital, Uttarakhand (First National Park);
(ii) Biological Park, Nandankanan, Odisha;
(iii) Kaziranga National Park, Jorhat, Assam;
(iv) Tudela National Park, Maharashtra;
(v) Hazaribagh National Park, Hazaribagh, Jharkhand;
(vi) Bandhavgarh National Park, Madhyapradesh;
(vii) Bandipur National Park, Karnataka;
(viii) Kanha National Park, Madhyapradesh;
(ix) Keibul Lamjao National Park, Manipur;
(x) Navegaon National Park, Maharashtra.

4.5 Ex-situ Conservation

4.5.1 Definition and objectives

Ex-situ convservation may be defined as conservation or protection of species outside their natural habitats. This type of conservation is not always separated from in situ-conservation. It is an effective complement to it, especially for those overexploited and endangered medicinal plants with slow growth, low abundance and high susceptibility to diseases due to replantation. Ex-situ conservation aims to cultivate and naturalize threatened species to ensure their continued survival and sometimes to produce large quantities of different plant parts used for the preparation of medicines. It is often an immediate action taken to sustain medicinal plant resources. India has the rich sources of raw materials like Amlaki (*Emblica officinalis*), Ashwagandha (*Withania somnifera*), Guduchi (*Tinospora cordifolia*), Vasaka (*Adhatoda vasica*), Haridra (*Curcuma longa*) Safed Musli (*Chlorophytum tuberosum*), Kali Musli (*Curculigo orchioides*), Swarnapatri (*Cassia angustifolia*), Brahmi (*Bacopa monnieri*), Langali (*Gloriosa superba*), Arjuna (*Terminalia arjuna*), etc. In spite of rich resources, we are failing to produce these valuable medicinal plants in large scale. So it is high time to educate the farmer and to create awareness regarding cultivation of medicinal plants in large scale which is an immediate need.

4.5.2 Different advantages of ex-situ conservation

(a) Different genetic techniques can be utilized in this process.

(b) Tissue culture techniques may be applied for propagation of different species through different organs.

(c) Germplasm can be stored in this process.

4.5.3 Some disadvantages of this type of conservation

(a) The favourable conditions may not be maintained always.

(b) New life forms cannot evolve.

(c) Amount of active principles (e.g. alkaloids, glycosides, essential oils etc.) sometimes may be decreased due to change of habitats.

Some of the modes of ex-situ conservations are stated as—

4.5.4 Botanical Gardens

Botanical gardens are the most conventional methods of ex-situ conservation. The facilities provided through this mode of protection are not only housing and nurturing of endangered species, but also spreading knowledge to the visitors for creating

awareness regarding the origin, utilisation and conservation of different plants. Botanical gardens are the most publicly visited ex-situ conservation sites.

Botanical gardens hold living collections. The botanical garden conservation could be considered as field gene bank or seed gene bank or both, depending on the conservation method being used. However, they tend to focus their conservation efforts on wild, ornamental, rare and endangered species (Figs. 2a & 2b). Most of the germplasm conserved in botanical gardens do not belong to the plant genetic resources for food and agriculture.

A botanic garden which wishes to start a small seed bank /gene bank would be advised to start with collection of germ plasm that is very well documented from their living plant collection. This would allow them to experiment with a wide range of species and find suitable facilities and techniques for their particular needs.

According to the database of World Information & Early Warning System (WIEWS) and the FAO, it is estimated that there are now more than 2000 botanic gardens around the world in over 150 countries. Together, they maintain more than 6 million accessions in their living collections and 142 million herbaria specimens in the botanic garden herbaria. 60% of the total number of accessions are known to be stored in medium-term or long-term facilities, 8% in short-term facilities and 10% in field gene banks, in vitro and under cryopreservation.

Some famous Botanical Gardens / Research Centres / Institutions

International

1. Royal Botanical Garden, Kew, England - It is the largest botanical garden in the World. Its herbarium is also largest in the World, having more than 6 million specimens.
2. ICRISAT - International Centre for Agriculture Research for Semi-Arid Tropics, Patancheru, Hyderabad, India.

National

1. Indian Botanical Garden, Sibpore, Howrah (near Calcutta). Largest botanical garden in India. Its herbarium is largest in India having more than 1 million specimens. It was first established as Royal Botanic Garden in 1787 by Colonel Robert Kyd. Initially the garden was set up for trading purposes of the East India Company. In 1950, 'Royal botanic Garden' Calcutta was renamed as the 'Indian Botanic Garden' and subsequently as 'Acharya Jagadish Chandra Bose Indian Botanic Garden in 2009. In 1957 the herbarium of the "Royal Botanic Garden", Calcutta, was transferred to the Botanical Survey of India and soon this herbarium

shot into fame as the 'Central National Herburium' which acts as a repository of all type specimens gathered from any area in India.

2. National Botanic Garden, Lucknow—This was the garden of the Nawabs of Oudh, later it was converted into a botanic garden. It occupies an area of about 70 acres. It has a good herbarium with a collection of about one lakh specimens of plants from India and adjacent countries. It is financed by the Council of Scientific and Industrial Research, New Delhi.

4.5.5 Ethnomedicinal Plant Gardens

The medicinal plants used by different ethnic groups in India are of prime importance for future drug development. So conservation of these plants are necessary. In places, where the medicinal plant diversity is high MPCAs (Medicinal Plant Conservation Areas) have been declared. In these areas commercial exploitation is completely closed. Conservation of MPCAs will help in conserving the gene pool of medicinal plants species. Four MPCAs have been established in South Bengal, viz. Garh Panchkot, Bonnie camp, Kankrajhore and Susunia. Under National Medicinal Plant Board (NMPB) project it has supplied quality planting materials to different divisions for rising plantation by involving local people. In these four in-situ conservation centres different medicinal plants of indigenous uses are being nurtured in in-situ conditions.

The mangrove species having several medicinal properties viz. *Avicennia alba* (Paira Baen), *Excoecaria agallocha* (Genwa), *Heritiera fomes* (Sundari), *Sonneratia apetala* (Keora), etc. are being maintained in Bonnie camp MPCA situated in Mathurapur II Block, South 24 Parganas.

In Kankrajhore MPCA in Jungal Mahal (near Jharkhand Border) the area is Sal dominated, other plants are *Emblica officinalis* (Amloki), *Terminalia tomentosa* (Asan), *Flacourtia indica* (Baichi), etc.

In the Garh Panchkot MPCA, in Purulia the priority species for conservation are *Mucuna pruriens* (Alkushi), *Morinda citrifolia* (Ach), *Aristolochia indica* (Ishwarmul) *Gloriosa superba* (Bisalanguli), *Gymnema sylvestris* (Gurmar), etc.

In the Susunia MPCA in Bankura the important species are *Boswellia serrata*, *Dalbergia latifolia* (Sitsal) *Garuga pinnata* (Ghogar, Jum), *Helicteres isora* (Atmora) *Mallotus philippensis* (Kamala, Kamila), *Acacia catechu* (Khadir), etc.

Amlachati Ex-situ conservation site

Amalachati is 5 km away from Lodhasuli National Highway and 20 Km from Jhargram town. The ethno-medicinal plant garden is established by Forest Department, Govt. of West Bengal in 2 hectare area in the year 2000 with aim of preserving germplasm

of medicinal plants. The medicinal plant garden has 2 lakh capacity of nursery for supply of seedlings under National Medicinal Plant Board (NMPB) scheme, this nursery has supplied quality planting materials for raising medicinal plantation in the South Bengal. Some important plants are listed below :

Abelmoschus moschatus (Latakasturi)
Chlorophytum borivillianum (Safed mushli)
Mesua ferrea (Nagkesar)
Thysanolaena maxima (Phooljharu)
Tylophora indica (Antamul)
Wedelia chinensis (Bhringaraj)
Zingiber cassumuner (Ban ada)

Digha Medicinal Plant Garden

It is situated in Digha town in the coastal area. It was established in 2002. It has collection of 146 species of medicinal plants. This medicinal plant garden has been created for generating awareness for the tourists visiting Digha.

In addition to these ethnomedicobotanical gardens there are some gardens established for supply of plant materials in small scale and also for generating awareness to the people. These are -

1. Medicinal plant garden in Narendrapur Ramakrishna Mission, Garia, Kolkata.
2. Jawaharlal Nehru Ayurvedic Medicinal Plant Garden and Herbarium (JNAMPGH)-CCRAS, Kothrud, Pune.
3. Medicinal and Aromatic Plant Garden at CIMAP (Lucknow).

4.6 Summary

Conservation may be defined as the protection, preservation, management or restoration of wildlife and natural resources. The main objective of conservation is to decrease the rate of extinction of species.

The term endemism indicates the situation of an element (plant or animal) restricted to a region or area of distribution. More than 50% of the dicotyledonous species in India are endemic. The term endangered is applied to species that possess a very high risk of extinction. The IUCN's Red list of threatened species recognises several categories of species status. These are - Extinct, Extinct in wild, Critically endangered, Endangered, Vulnerable, Near threatened, Lower risk, and Data deficient. IUCN's Red list species of flowering plants of India are represented in eFI (e-flora of India).

In-situ conservation is the protection of species in their natural habitats. Ex-situ conservation, on the other hand, is the protection of species outside their natural habitats. Sacred groves, Biosphere reserves National parks are the modes of in-situ conservation. Home gardens, seed banks, field gene bank, cryo-preservation botanical gardens etc. are the ways of ex-situ conservation.

Propagation of plants is a natural phenomenon-propagation can be made artificially through cuttings, layering, grafting or budding.

Nurseries of plants are of much importance for maintenance of seedlings and plantlets. There are various types of nurseries. Sowing of seeds and pricking out of seedlings are important in a nursery.

Greenhouse nursery is very important for maintenance of exotic plant species. They may enable certain plants to be grown throughout the year. The relalively closed environment of a greenhouse has its own unique management requirement, compared with outdoor production. In case of critically endangered or threatened species green house nursery is very much beneficial for proper growth and development of the plants.

4.7 Questions

1. What is conservation? Why conservation of plants is necessary?
2. What do you mean by Endemism? Cite examples of some endemic plants in India.
3. What is meant by endangered species?
4. What are the criteria of IUCN's Red list? Describe different categories of species status according to IUCN's Red list of threatened plants.
5. Name some critically endangered and vulnerable medicinal plants.
6. What is in-situ conservation?
7. Describe the advantages of in-situ conservation.
8. Explain biosphere reserves with suitable examples.
9. State the necessity of sacred groves in conservation of medicinal plants.
10. Give some examples of National Parks in India.
11. What is ex-situ conservation? Describe advantages and disadvantages of ex-situ conservation.
12. 'Botanical Gardens are the most conventional methods of ex-situ conservation of plants'—justify the statement.

13. Give some examples of ethnomedicinal plant garden.
14. Fill in the blanks with suitable words in the bracket.
    (i) Man-made extinction of plant species is known as _____ (Natural / Anthropogenic / Mass) extinction.
    (ii) According to _____ more than 50% of the dicotyledonous species in India are Indemic (IUCN / David Prain / D. Chatterjee)
    (iii) *Lilium polyphyllum* is a _____ plant (Vulnerable / Critically endangered / Endangered).
    (iv) Cryo-preservation is a type of _____ conservation (in-situ, ex-situ, protected area).
    (v) National Parks are the mode of _____ conservation (in-situ, ex-situ, natural)

4.8 Answers

(1) Article nos 4.1, (2) 4.3.1, (3) 4.3.2, (4) 4.3.3, (5) 4.3.3, (6) 4.4.1, (7) 4.4.2, (8) 4.4.4, (9) 4.4.5, (10) 4.4.6, (11) 4.5.1, 4.5.2, (12) 4.5.3, (13) 4.5.4, (14) (i) Anthropogenic, (ii) D Chatterjee, (iii) Critically endangered, (iv) ex-situ (v) in-situ

4.9 References and further readings

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Unit 5 ❑ Propagation of Medicinal Plants

Structure

5.0 Objective

- From this unit you will be able to learn about the need of conservation for endangered and endemic medicinal plants.
- You will be able to know the importance of in-situ and ex-situ conservation.
- You will be able to discuss the role of Botanical gardens, ethnomedicinal plant gardens in conservation.

5.1 Introduction

Propagation is a natural phenomenon in all plants. It may be defined as the process of multiplication of a plant by sexual or asexual means to ensure the continuation of its progeny. It is achieved artificially on the field by adopting techniques suitable to the specific plant and its growth cycle.

It ensures the continuation of the progeny of a species. In nature it allows a plant species to enter into different growth stages and cope up with the climatic changes. Propagation allows a species to flourish and develop into a population by making use of the available resources in a given region.

5.1.1 Basic Methods of plant propagation

Plants perpetuate in nature through seeds or through vegetative parts or special and modified organs. Based on the mode of propagation, two types of propogation are usually recognised among plants (i) Sexual and (ii) Asexual propagation.

(i) Sexual method of propagation

In this method propagation takes place through seeds, which is a reproductive part that is the result of union between male and female gametes of a plant. Seeds are fertilised ovules caused through pollination and are generally developed inside the fruits. On germination a seed gives rise to a young seedling. Since seeds are produced periodically or regularly in the reproductive phase of a plants life cycle, it is a rather convenient method of propagation of plants.

(ii) Asexual method of propagation

In this mode of propagation, a plant multiplies with the help of plant parts other than seeds. It is carried out either by using the vegetative parts, e.g. stem, leaf and root, or by using special and modified parts, e.g. tuber, rhizome, corm, bulb, sucker etc. Asexual propagation in nature is found in many plants.

5.1.2 Advantages and disadvantages of each method

Advantages of sexual method of propagation

- Sexual method of propagation is simple to follow and generally does not require any special care as the seeds germinate easily in most of the cases.
- Each plant will be able to produce a huge number of seedlings, since the number of seeds available from a single plant is generally high.
- As the seed production is a seasonal or an annual event in a plant's life cycle, this method can be followed regularly.

- As the seeds of many species are generally small in size with less moisture content, they facilitate cost effective storage in a smaller space for a longer period.

Disadvantages of sexual method of propagation

- As the seeds are the product of the union between two sexes of a plant, the seedlings obtained from such seeds will not resemble the mother plant completely. This is more expressed in the seedlings of those plant species which are cross-pollinated.
- Seeds of some species exhibit dormancy and propagation of such species using seeds is not easy.
- Seeds of certain species are known to exhibit poor viability and such species do not propagate easily.
- Special qualities or plus traits of a mother plant cannot be passed on in total to the young ones produced by using seeds.
- Plants raised by this method takes a long span to attain maturity.

Advantages of Asexual method of propagation :

- Since the propagating material used is a part derived from a mature plant, the young ones always resemble the mother plant in all respects and retain all the characters of the mother plant.
- This method is useful for propagating those plants which do not produce seeds, or set seeds irregularly, those produce seeds which are sterile or non-viable and those which are male by sex.
- This method helps in maintaining the progeny of those plants which exibit special characters.
- Since the parts used for propagation, would have attained physiological maturity at the time of planting, the young ones come to bear flowers and fruits at an early age.

Disadvantages or limitations of asexual method of propagation

- As the method involves separation and severing of the propagating organs from the mother plant, intensive collection of the planting materials may damage the mother plant.
- A single mother plant may not provide the required planting material in a large quality, since the parts used are of a specific type.

- Since the method involves a definite procedure, it demands proper skills and time to carry out the exercise.
- This method cannot be implemented all through the year, since the planting material is specific and available only during certain growth stages of a plant.
- The propagation material cannot be stored for longer periods of time under room conditions, since the parts used are quite often fleshy.
- Since the new plants raised from this method are not capable of developing a strong tap root system, they are more prone to wind damage.

5.2 Objectives of the Nursery

- A nursery may be defined as a place where the seedlings and young saplings of a plant are raised, nurtured and maintained with care and attention till they attain a specified stage of maturity and ready for transplanting into the field or for distribution. A nursery may also be defined as a pool house of seedlings and juveniles of various species of plants.
- Nursery serves as a means of ex-situ conservation. It plays an important role in ex-situ gene pool of different species. Nurseries provide a viable means for the collection and maintenance of seeds and seedlings of commercially important species.
- Nurseries are the reliable source of authentic planting material of medicinal plants for local healers and households.
- A nursery is an open-air classroom to study propagation and related subjects. A nursery often assumes the shape of a man-made forest and provides ample scope to study a plant from a close distance. It this way, it also serves as conservation education and learning centres.
- Since it serves the community at one hand, it can also become a common forum for local healers and medicinal plant growers to come together and share their experience.

5.3 Classification of nurseries

According to utilisation and economic purposes, nurseries may be classified as follows :

(i) Retail nurseries : Which sell seedlings or young plants to the general public.

(ii) **Wholesale nurseries :** Which sell only to business such as other nurseries and to commercial gardeners.

(iii) **Private nurseries :** Which supply the needs for institutions or private estates.

According to the environmental conditions followed for easy growing of the seedlings or saplings, nurseries may grow plants in open fields, on container fields, in tunnels or greenhouses. In open fields nurseries grow decorative trees, shrubs and herbaceous perennials.

On container field nurseries grow small trees shrubs and herbaceous plants, usually destined for sales in garden centres.

In the greenhouse or glasshouse grow plants requiring regulated climatic conditions.

5.4 Important components of a nursery

The essential components of a nursery are stated as :

(i) **Seedbed and Nursery bed :** For raising seedlings, some permanent or temporary structures for seedbed may be prepared. These beds will be minimum 0.5 to 0.75 m high from ground level. The beds may be 0.75m to 1.00 m in breadth and length may be as per availability of land. The nursery beds will be prepared for storing of perennial plants or the plants that are kept for sale.

(ii) **Collection and planting of mother plants :** The plantation of mother plant is an important work for developing a nursery. The mother plant must be true to the type and true to the variety. The plants should be properly lebelled. Collection of exotic type of mother plants is a continuous process or job.

(iii) **Storage of dried, cleaned soil and compost manure :** For raising seedlings during rainy or winter season, the soil and compost manure would be stored during hot or summer season.

(iv) **Production of seeds :** Production of seeds is highly specialized job. The seeds should be produced carefully. If the quality of seed is good, the percentage of seed germination, seedling vigour, vegetative and reproductive growth of the crop will be good.

(v) **Storage of propagated plants in nursery bed :** The propagated plants are planted in nursery beds for better growth or hardening the plants.

(vi) **Manuring :** Manuring is an important component of a nursery. Vigorous growth of a plant is always attractive to buyer. In case of medicinal plants only organic manure should be applied. Heavy manuring is not beneficial.

(vii) **Watering :** Like manuring, watering is also important. Watering will be done according to need of the plant. Showering is needed in the seed bed. The nursery should have a water source of its own, long pipes are needed for watering. For this, digging a well (12 m deep x3 m diameter) and installing of a 2.0 HP pumpset with accessories are considered.

(viii) **Drainage :** For sufficient vegetative and reproductive growth of plants, good drainage system must be developed in between beds and around the nursery. Adequately gentle slope in the pot bed surface is also desirable. It is extremely important to ensure that water logging does not occur in and around the pots and beds.

(ix) **Plant protection :** Keen observation on attack of different pests and diseases (viral, fungal or bacterial) is required. Necessary control measures should be taken immediately on observation.

(x) **Maintenance of an experimental laboratory :** An experimental laboratory (regarding tissue culture, testing of viability of seeds, formation and growth of roots in case of cutting and grafting, detection of fungal and other diseases, need of micronutrients) should be established in an ideal nursery. Different chemicals e.g. tetrazolium chloride (for viability test of seeds), Indole butyric acid (for rooting), dilute hydrochloric acid (for softening the hard seed coat), dilute solution of mercuric chloride (for surface sterilization of seeds), different plant hormones (Indole acetic acid, Gibberellic acid, etc.) should be kept in the laboratory of the nursery.

(xi) **Harvesting and storage :** The seeds, bulbs, tubers, corms etc. should be harvested in the proper stage. Bulbs, corms and tubers are stored in single layer over dry sand, flat wooden trays or racks in a well-aerated store room with low temperature and low humidity. Living plants should be kept in shade. Seeds are stored in a cool and dry place or kept in desiccator.

For all the above-mentioned components, a nursery covering a total area of 0.5 acre is considered. To maintain a greenhouse and tissue culture room additional spaces are required.

5.4.1 Sowing and Pricking

Sowing : Sowing is the process of casting handfuls of seeds over a prepared ground or broadcasting the seeds over the land. Usually hand sowing is done. Practice is required to sow evenly and at the desired rate. A hand seeder can be used for sowing. Generally, a drag or harrow is employed to incorporate the seed into the soil.

In agriculture, most of the seeds are now sown using a seed drill, which offers greater precision. In this way the seeds are sown evenly maintaining the desired rate. The drill also places the seeds at a measured distance below the soil, so that less seed is required.

A seed rate of about 100 kg of seed per hectare of land is typical, though rates vary considerably depending on crop species, soil conditions and farmer's preference. Excessive seed rate may cause the crop to lodge, while too thin a rate will result in poor utilisation of the land, competition with weeds and a reduction in the yield.

Pre-treatment of seed before sowing - Before sowing, certain seeds first require a treatment prior to the sowing process. There is a proverb - 'As you sow, so you reap'. It is absolutely true. The treatment of seeds may be seed scarification, stratification, seed soaking or seed clearing, surface sterilization of seeds with dilute mercuric chloride etc. Seed soaking is generally done by placing seed in water for at least 24-48 hours.

Pricking out seedlings : Pricking out is a process of putting single seedling into a cell or a pot for further growth and development in a wide space.

When seeds germinate the first two cotyledonary leaves arise, which are usually a pair of oval, flesly leaves that bear no resemblance to the mature leaves of the plant. The conventional advice is that seedlings should not be pricked out or transplanted until the first true leaves appear, but the gardener must exercise common sense and move the seedlings when they are large enough to handle. Seedlings should be removed from the seed bed taking care and not damaging the delicate roots.

It is good planning to prepare the planting holes in the trays or pot or in the prepared land of well-moisted compost manure before lifting out the seedling from the sowing container.

Proprietary compost manures contain enough plant food to give the pricked out seedlings a good start in life.

5.5 Use of Greenhouse for nursery production

5.5.1 Concept of greenhouse

A greenhouse (also called a glasshouse) is a structure with walls and roof made chiefly of transparent material, such as glass, in which plants requiring regulated climatic conditions are grown. These structures range in size from small sheds to industrial-sized buildings. A miniature greenhouse is known as a cold frame. The

Fig. 3a : Part of a Nursery.

Fig. 3b : Part of a Green House Nursery.

interior of a greenhouse exposed to sunlight becomes significantly warmer than the external ambient temperature, protecting its contents in cold weather. (Fig. 3)

Many commercial glass greenhouses or hothouses are high-tech production facilities for vegetables or flowers. The glass greenhouses are filled with equipments including screening installations, heating, cooling, lighting, and may be controlled by a computer to optimize conditions for plant growth. Different techniques are then used to evaluate optimality-degrees and comfort ratio of greenhouse micro-climate (i.e., air trremperature, relative humidity and vapour pressure deficit) in order to reduce production risk prior to cultivation of a specific crop.

The warmer temperature in a greenhouse occurs because incident solar radiation passes through the transparent roof and walls and is absorbed by the floor, earth and contents, which become warmer. As the structure is not open to the atmosphere, the warmed air cannot escape via convection, so the temperature inside the greenhouse rises. This is so-called the **Greenhouse effect**.

5.5.2 Greenhouse for nursery

Greenhouses allow for greater control over the growing environment of plants. They may enable certain plants to be grown throughout the year. Greenhouses are of prime importance in the growth of seedlings and young plants under controlled atmospheric conditions. It is also useful for transplants. Many plants of medicinal importance viz. *Acorus calamus, Alpinia galanga, Mentha arvensis, Chlorophytum arundinaceum,* etc. if maintained in greenhouses grow with sufficient active principles. The relatively closed environment of a greenhouse has its own unique management requirement, compared with outdoor production. Pests and diseases are also controlled in greenhouse.

In case of endangered and threatened species greenhouse nursery is very much beneficial.

5.6 Propagation through cuttings

Propagation through cuttings is an easy and less expensive method of vegetative propagation. A cutting is usually a division of the stem or root or leaf of a plant. Cutting is extracted from a plant part and planted in the soil. The extracted cuttings are trimmed and planted in the soil horizontally or vertically depending on the need. Among all types of cuttings, stem cuttings are most widely used. Different types of cuttings are stated below :

1. **Hardwood cuttings :** Cuttings taken from the branches of the current years growth of a plant are usually considered to be hardwood cuttings. These

usually measure 25-30 cm with 4-5 nodes. Cuttings of pencil thickness with uniform internodal growth are preferred. Some of the medicinal plants that are usually propagated by hardwood stem cuttings are *Hibiscus rosa-sinenis* (Jaba), *Punica granatum* (Dalim), *Lawsonia alba* (Mehendi), etc.

2. **Semi hardwood cuttings :** These cuttings are prepared from tender shoots and branches of the current year's growth that are not too hard but show brown blotches on the green stem. They usually measure about 20 cm with a pair of leaves retained at the tip. Some examples of semi hardwood cutting propagation are - *Adhatoda vasica* (Basak) *Tinospora cordifolia* (Gulancha), *Gymnema sylvestre* (Gurmar), etc.
3. **Softwood stem cuttings :** These type of cutting are prepared from the soft tender shoots remaining green in colour. These cuttings usually measure 8-10 cm with a growing tip and leaves are usually retained at the tip. Some of the medicinal plants that are usually propagated by softwood stem cuttings are *Bacopa monnieri* (Brahmi), *Gymnema sylvestre* (Gurmar), etc.

5.7 Propagation through layering

In this technique a vegetative branch is made to root while it is still attached to the mother plant. The rooted branch will be later excised and planted as a new seedling. There are different type of layerings. (Fig. 4)

1. **Air layering** : Air layering may be carried out as follows - pencil size shoot of the current year's growth is to be selected. Preferably on the based portion of the selected shoot, a ring of bark is removed and exposed wood is scraped.

   The exposed portion is further wrapped with moist inert rooting medium like sphagnum moss, moist coir etc. and covered with polyethene sheet making air tight.

   This branch is left undisturbed on the mother plant for about 2-8 weeks depending on the species. During the course several adventitions roots emerge from the base of the exposed bark which is covered. The rooted branch will be later cut below the covered portion and planted as a separate seedling. This type of air layering is frequently followed in *Emblica officinalis* (Amlaki), *Tamarindus indica* (Tentul), etc.
2. **Mound layering :** It is another technique of layering and carried out as follows-

   A long and supple or flexible branch is selected. Ring of bark is removed at the base and buried the soil.

In due course, roots emerge from the buried portion. After sufficient emergence of the roots the branch will be separated from the mother plant and planted as an independent plant. Examples of this type of layering are : *Merremia tridentata* (Daru jamjuri), *paederia scandens* (Gandha prasarani), etc.

3. **Serpentine layering :** A series of above mentioned layering done on a single long branch that is buried and exposed alternately makes serpentine layering. Serpentine layering can be tried for species which have drooping long and supple branches. In case of medicinal plants, serpentine layering is found in a very few species, e.g. *Tinospora cordifolia* (Gulancha), *Celastrus paniculatus* (Jyotismoti).

5.8 Propagation through grafting

Grafting is a propagation technique usually employed to improve the quality of the nursery stock or to produce seedlings that carry special qualities or plus traits of a mother plant. It is carried out by bringing together two vegetative parts from two different plants of the same species and joining them together to grow as a single plant. Usually the stem branches are used for the purpose of grafting. The plant part which receives another plant part is called the stock, while the plant part that serves as the graft is called the scion. When these two i.e. stock and scion are joined together, graft union takes place. The scion always carries the positive qualities of the mother plant, while the stock serves as the root system for the young plant. After the completion of graft union, scion becomes the upper part and the stock acts as the basal part of the new plant. The stock plant is usually a plant that is already established and growing. The stock and scion are tied together with the help of tape to ensure the union. The graft is maintained in that condition for a specied time period. After the graft union is ensured, the remaining portion of the stock plant above the graft union is removed and the scion is encouraged to grow. After this, the graft is ready for planting. (Fig. 4)

Different types of grafting

(i) Approach grafting : This method involves causing the graft union between the two selected branches of stock and scion while the branches are still growing on the parent plants.

(ii) Wedge grafting : This method involves causing the graft union by inserting the scion, which is in the form of a wedge, on to an incision on the stock plant. The scion as usually a branch excised from the mother plant.

(iii) Epicotyl grafting : Grafting is done on the tender shoot of about 5-7 days old of a germinated seed with its epicotyl still intact.

(iv) Sofwood grafting : Grafting is done on the soft shoot of the stock plant which is a seedling of about 6 months.

In the case of medicinal plants grafting is found only with selected species of the genera *Artocarpus, Syzygium, Myristica, Garcinia,* etc.

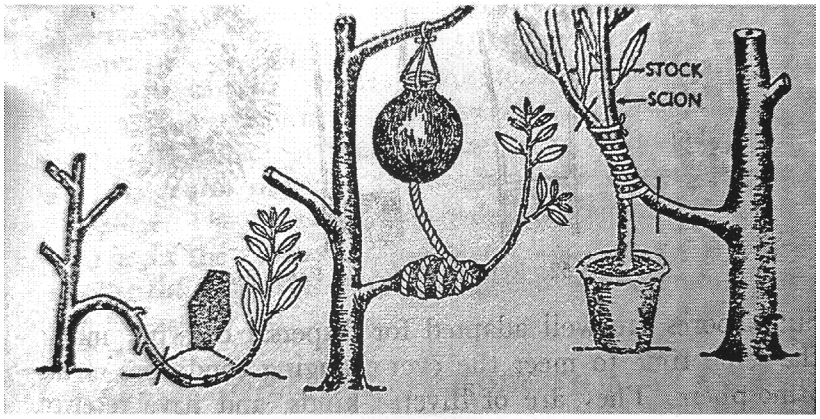

Fig. 4 : Layering and Grafting (After A.C. Dutta, 1980)

5.9 Propagation through Budding

- It is another technique of propagation where a vegetative bud is excised from a mother plant and used as scion material. The technique involves,
- The removal of selected vegetative bud alongwith a patch of bark from the scion plant and inserting it to the stock plant.
- The graft is further tied to keep the bud in place and maintained till the union takes place.
- After the union is ensured, the portion of the stock above the bud union is removed and the sprout from the scion bud is encouraged to grow further.

Different budding techniques viz. Shield budding, Patch budding, Ring budding are found in use, in which the scion material (in the shape of a shield, a small rectangular patch, a ring respectively) is inserted on to the stock plant. Howerver, in the case of medicinal plants, budding is very rarely practised.

5.10 Summary

Propagation of plants is a natural phenomenon-propagation can be made artificially through cuttings, layering, grafting or budding.

Nurseries of plants are of much importance for maintenance of seedlings and plantlets. There are various types of nurseries. Sowing of seeds and pricking out of seedlings are important in a nursery.

Greenhouse nursery is very important for maintenance of exotic plant species. They may enable certain plants to be grown throughout the year. The relalively closed environment of a greenhouse has its own unique management requirement, compared with outdoor production. In case of critically endangered or threatened species green house nursery is very much beneficial for proper growth and development of the plants.

5.11 Questions

1. Describe the objectives and different types of nursery.
2. What are the important components of a nursery?
3. What is meant by Greenhouse nursery? How it is maintained?
4. State different types of cuttings.
5. What is layering? State different types of layering.
6. Why grafting is necessary for propagation?
7. State different types of grafting and budding.
8. Fill in the blanks with suitable words in the bracket.
   (i) Nurseries are the reliable source of _____ planting material (authentic, cheap, valuable)
   (ii) Pretreatment of _____ is necessary before sowing (plantlets, seeds, seedlings)
   (iii) Pricking out is a process of putting a single _____ into a cell or a pot for further growth. (tree, plant, seedling)
   (iv) A miniature greenhouse is known as a _____ (glasshouse, cold frame, framehouse)
   (v) *Punica granatum* is propagated through — cutting. (hardwood, softwood, semi-hardwood)

(vi) In *Amlaki plant* usually _____ layering is followed for propagation (Mound, Air, Serpentine).

(vii) *Madhuca insignis* is an _____ species (extinct, endangered, vulnerable)

5.12 Answers

(1) 5.7.2, 5.7.3, (2) 5.7.4, (3) 5.8.1, (4) 5.9, (5) 5.10, (6) 5.11, (7) 5.11, 5.12, (8) (i) authentic, (ii) seeds, (iii) seedling, (iv) cold frame, (v) Hardwood, (vi) Air, (vii) extinct.

5.13 References and further readings

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Unit 6 ❑ Ethnobotany and Folk Medicines

Structure

6.0 Objective

- In this unit you will get an overview of Ethnobotany and Folk medicine.
- You will become acquainted with ethnobotany in India.
- You will also learn about palaeoethnobotany.

6.1 Introduction

The term 'Ethnobotany' is derived from two Greek words *ethnikos* or *ethnos* meaning nation, and *botanikos* or *botane* meaning plant. So etymologically the word 'Ethnobotany' means study of the plants related to nation(s). The term was first applied to modern studies by Harshberger in 1896 to the study of plants used by primitive and aboriginal people. Subsequertly Jones (1941, 1962), Bank II (1957) and Schultes (1960, 1962, 1963) have independently interpreted ethnobotany as 'total relationship between primitive people and their plant surroundings in the widest sense'.

According to Jain and De (1966), "the relationship between the indigenous people and their plant surroundings forms the subject of ethnobotany." And they suggest that ethnobotany includes studies of the plants used by the indigenous people or aboriginals for their food, clothing and medicine and the impact of such usage on the survival of the plant growth. Ford (1978) suggested to include the modern economic uses of plants within the purview of ethnobotany.

It may be mentioned that the Man-plant relation cannot be restricted to the limits of Economic Botany and Environmental Studies only. Man-plant relation is multidimensional. All these relations can broadly be grouped into two classes : (i) utilitarian and (ii) aesthetic.

The utilitarian group includes those relationships which are directly or indirectly associated with the support or subsistence of man, e.g. (a) food, (b) shelter, (c) garments, (d) medicine, (e) implements, (f) weapons etc. While the aesthetic group includes the impact of plants on the psyche of man as evidenced through man's attempt in beautification, decoration, welcoming guests with flower-bouquets, offering flowers and foliages at the feet of perceptor or deity as mark of submission and in literature (coining similies from plants, part(s) of the plant) In view of these Manilal (1988) states that the term ethnobotany denotes the entire realm of useful relationship between plant and man.

6.2 Ethnobotany in India

It has been over 100 years since John Harshberger (1896) first defined Ethnobotany and described a research agenda. Since then Ethnobotany has had a wonderful history in U.S.A. While Harvard University has become a leading centre, the University of Michigan has established an Ethnobotanical laboratory and many other Universities of USA have included ethnobotany as a subject of study and research. Canada has established 'Canadian Ethnobiology Service". It has become a major subject in Maxico, Brazil and other countries of South America. The subject has become a major one in South Africa, West Indies, Uganda, Kenya, Indonesia, Australia, New Zealand. It has become a thrust area of research in Bangladesh and Nepal. The subject is receiving increasing attention in European countries like UK, France, Denmark, Portugal and others.

In India, while ancient and medieval literature in Sanskrit, Pali, Tamil, Persian and the regional languages include huge wealth of ethnobotanical information, seeds of

modern investigation in ethnobotany were perhaps sown by Rev. P.O. Bodding (1925-40) through his publication on "Studies in Santal Medicine and connected folklore" The next important contribution was made by Late Professor G. P. Majumdar (1938) in the form of a book entitled 'Some Aspects of Indian Culture-from plant perspective'. Bodding collected his data from a living traditional community, viz the Santal. Majumdar collected information from Sanskrit and Pali sources. Sm Janaki Ammal emphasized on Ethnobotany in her duties of Economic botanist in Botanical Survey of India during 1958-59. Since 1960 methodical studies of different traditional societies were started under the execution of Dr. S. K. Jain. Previously Kirtikar and Basu (1935) in their 'Indian Medicinal Plants' mentioned a few plants used by the tribal people. B. D. Basu, the second author of this book has made substantial contributions on phytomedicine of Gond of Madhya Pradesh. The Department of Science and Technology, Govt. of India, in 1981, decided to set up in All India Co-ordinated Research Project on Ethnobiology (AICRPE) under the head of 'Man and Biosphere' programme. Since July, 1982, the project is going on Eighteen units eg National Botanical Research Institute, Central Drug Research Institute, Birbal Sahni Institute of Palaeobotany, Ethnobotany and Plant Systematics Laboratory - Garhwal University, Nagpur University, Regional Research Laboratory, Jammu, Botanical Survey of India, Osmania University, Central Research Institutes of Ayurveda (CCRAS) and others are participating in the different phases of the programme. The project has covered now about 80% of the tribal area.

Ethnobotany has been incorporated in the curriculum of Botany in many Indian Universities, e.g. Manipur, Guwahati, Srinagar-Garhwal, Jodhpur, Calicut and Sagar. In West Bengal, University of Calcutta, Vidyasagar University, Vishwa Bharati, Netaji Subhas Open University, and some others have included this subject in their syllabi.

The Botanical Survey of India has created a section of Ethnobotany. Foundation of societies of Economic Botany, Ethnobotany and Ethnobiology and publication of their journals have elevated the status further. International society of Ethnobiology are sponsoring International Congress of Ethnobiology at regular intervals.

Many books and articles on Ethnobotany have been published by the Indian authors. Dr S. K. Jain has published and edited about 25 books and 250 articles. Some

of his books are Glimpses of Indian Ethnobotany, A manual of Ethnobotany, Dictionary of Indian Folk Medicine and Ethnobotany. Pal and Jain (1998) published a book on 'Tribal Medicine' which is a remarkable work on Medico-ethnobotany. Dr. Jain also founded the society of Ethnobotanists and later the International Commission on Ethnobotany.

6.2.1 Application of Ethnobotany

According to Pal and Jain (1998) out of 3200 taxa so far known as medicinal plants in India a total number of 343 species under 298 genera and 98 families are known to be used as medicine by four major groups namely Santal, Munda, Oraon and Lodha. But Ethnobotany has been constructed not be limited only to vascular plants but also to include studies on algae, fungi, lichens and bryophytes. It is strongly linked with taxonomy, pharmacognosy, phytochemistry, pharmacology, ecology and conservation biology. Ethnobotany with no doubt remains the main revenue contributing to both orthodox and traditional medicine. A number of useful drugs have been developed based on ethnobotanical approaches. Ethnobotany is a multi-disciplinary subject. the growing interest in ethnobotany can be observed through the increased number of journals and periodicals on this subject. The selection of plants based on ethnobotanical studies has gained in popularity as a means to identify which plants contain relevant compounds for exploitation. This economic focus of biological prospecting, including the use of patents and other intellectual property mechanisms has highlighted important issues concerning indigenous rights, cultural knowledge and traditional resources.

This situation led to the emerge of what the so-called Socio-ethnobotany, a new sub-discipline of ethnobotany that deals with the question of how indigenous people can be compensated for sharing their ethnobotanical knowledge.

It has been stated earlier that Ethnobotany plays an important role in the development of new drugs. Many plants produce economically important organic compounds e.g. oils, resins, gums, tannins, waxes, dyes, flavours and fragrances, pesticides and pharmaceuticals. Many of the medicines used and/or currently in use viz. Aspirin, codeine, Ipecac, Pilocarpine, Pseudoephedrine, Quinine, Reserpine, Scopolamine, Theophylline, Vinblastine etc. have been derived from medicinal plants based on ethnobotanical research programmes. Recently, many of the reputed pharmaceutical companies have produced a number of herbal preparations based

on ethnobotanical leads for different purposes. Few examples of these products and their botanical sources are given in the table below :

Botanical Name	**Family**	**Ethnobotanical leads**	**Verified biological activities**	**Commercial product**
Acacia nilotica (L.) Del. ssp. *indica* (Benth.) Bren.	Mimosaceae	*Acacia* gum has been used for healing wounds.	Antihypertensive, anti-spasmodic, anti-inflammatory.	Acacia liquid extract, Acacia gum capsules.
Camellia sinensis (L.) Kuntze.	Theaceae	Stimulant, treats conjuctivities, diuretic, relieves inflammation, allergies.	Anti-hypercholes-terolemic, antioxidant antimicrobial.	Sbelttix peso exacto, etc.
Capparis decidua (Forsk.) Edgew.	Capparid-aceae	Jaundice, rheumatic arthritis and to treat swells.	Strong anti-inflammatory anti-microbial properties.	Rista-*Capparis decidua* in brine.
Balanites aegyptiaca (L.) Del.	Simarou-baceae	Veneral diseases, rheumatism, digestion problem, dysentery, etc.	Anti-mycobacterial.	Balanites oil, Balanites fruit pulp.
Aloe barbadensis Mill.	Liliaceae	Boils, softening of skin, jaundice liver complaints, skin disease, to wash hair, etc.	Scientific evidence for the cosmetic or therapeutic efficacy of *Aloe* is limited and frequently contradictory.	*Aloe vera*

6.3 Palaeo-ethnobotany

6.3.1 Definition

Palaeoethnobotany is the study of the remains of plants cultivated or utilized by man in ancient times, collected from different archaeological sites. It is based on the recovery and identification of plant remains and the ecological and cultural information available for modern plants. The major themes of research are the uses of different wild plants, the origin and domestication through agriculture and the co-evolution of human-plant interactions. It is more or less closer to Archaeobotany which have survived in archaeological context and different from Palaeobotany, which deals with any fossilised plant material, whether directly related or not with man in the geological past.

6.3.2 Preservation of the plant remains

Plant microfossils are preserved through four main modes of preservation at archaeological sites.

(i) Firstly, plant remains usually cereal grains, chaff, seeds and charcoal are largely reduced to elemental carbon (charred) when they are heated in a reducing atmosphere; these are referred to as 'charred' or 'carbonised' plant remains.

(ii) Secondly, plant remains deposited in permanently waterlogged anoxic conditions are preserved as the absence of oxygen generally prohibits microbial activity. This mode of preservation usually occurs in deep archaeological features such as wells, in urban settlements where organic refuse in rapidly deposited and at settlement adjacent to lakes and rivers. In this case the preserved plant remains include seeds, fruit stones, nutshells, leaves, straw and other vegetal materials.

(iii) Thirdly, calcium phosphate mineralization of plant remains occur usually in toilet or latrine pits and in middens or refuse-heaps as the plant remains are completely replaced by calcium phosphate. In latrine pits, plant remains consumed by humans are the most common items, e.g. seeds of flavouring agents or spices, seeds and stones of fruits.

(iv) Finally, plant remains may be preserved by desiccation or drying in arid environments, where the absence of water limits decomposition. Delicate plant remains are also preserved, e.g. onion skin or scale leaves, bracts of artichoke (*Helianthus tuberosus*) alongside fruit stones, cereal chaff and seeds of wild plants.

6.3.3 Methods of recovery of the plant remains

A variety of methods to recover and identify the plant remains may be used by the palaeoethnobotanists. Charred remains are usually recovered by flotation. The matrix (the soil from a suspected archaeological feature) is slowly added to agitated water. The heavy material including soil, sand etc known as heavy fraction sink to the bottom. Less dense organic material, e.g. charred seeds, grains and charcoal tend to float to the surface. The material that floats to the top, called light fraction, is poured into a sieve (usually 250-500 um), the light fraction is then dried and examined later under a low power microscope. Samples of the heavy fraction are also collected for later analysis.

Waterlogged plant remains are separated from the matrix by a combination of wet-sieving and /or small-scale flotation in a laboratory. Desiccated or dried plant remains are usually recovered by dry-sieving using a stack of different sieves to separate larger items such as cereal straw and fruit stones from smaller items such as weed seeds.

6.3.4 Identification and Quantification of the samples

Indentification of micro-remains is usually carried out under a stereomicroscope, using morphological characters, e.g., shape and surface in case of seeds, or micro-anatomy in case of wood or charcoal. Identification may be done by comparing the samples with modern plant materials. Depending on the type of material and its condition, other methods, e.g. thin sections or scanning Electron Microscope (SEM) technique may be applied.

Palaeoethnobotanists may also recover and analyze microremains, e.g. phytoliths and pollen, human and animal excrements (palaeofeces, sometimes called coprolites) or plant impressions in ceramic potsherd or broken piece of earthenware and clay.

The work done in palaeoethnobotany can be divided into field work, collections management, systematic description of species, and theories into the origins of human and plant interaction.

6.4 Summary

There are over 8% (of total population) ethnic communities or indigenous tribes in India. This sub-continent is home to about 645 tribes, most of whom have been living here since times immemorial. The major tribes are Abor, Asur, Bhil, Birhor, Chakma, Kuki, Lodha, Mikir, Santal, Toto etc. They use many plants in different ailments.

The active principles or the chemical compounds produced by a living organism found in nature are called natural products, e.g.Reserpine from Sarpagandha, Withanolide

from Aswagandha, Andrographolide from Kalmegh. The natural products are of immense value in drug development. Many natural products are used as remedy in different diseases, viz. sphaeranthine (from *Sphaeranthus indicus*) is useful in jaundice, Reserpine (from roots of *Rauwolfia serpentina*) is useful in high blood pressure, Jambosine (from seeds of *Syzygium cumini*) is useful in diabetes, etc.

6.5 Questions

1. What is Ethnobotany? Who first applied the term to modern studies?
2. When the methodical studies on Ethnobotany were started and by whom?
3. Write a brief note on contributions of different Indian Scientists for betterment of Ethnobotany.
4. How Ethnobotany plays role in new drug development?
5. How Ethnobotany plays role in new drug Development.
6. What is meant by Palaeo-ethnobotany?
7. How plant remains or microfossils are preserved?
8. How the plant remains are recovered?
9. Write the methods used for identification and quantification of the samples.
10. Write the Scientific name, family used and the commercial products of the followings.

    a) Aloe, b) Acacia gum, c) Tea

6.6 Answers

(1) See 6.1, (2) 6.2, (3) 6.2, (4) 6.2, (5) 6.2.1, (6) 6.3, (7) 6.3.2, (8) 6.3.3, (9) 6.3.4, (10) 6.2.1 table.

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Unit 7 ❑ Ethnobotany and Ethnic Communities

Structure

7.0 Objective

- From this unit you will get general idea of methods of studying ethnobotany and Folk medicine.
- You will become acquainted with ethnobotany in India.
- You will also learn about palaeoethnobotany.

7.1 Ethnobotanical Investigations

The ethnobotanical data are the outcome of intensive studies conducted in the tribal pockets of different regions of a country. The cordial relationship with tribals should be created in the primary phase. Then the informations on tribal customs, culture, beliefs etc. should be gathered accordingly.

The tribals or aboriginals consider urban visitors, superior to them. They feel shy and hesitate in speaking to them about their knowledge. This situation can be changed by creating a healthy relationship by accepting the drinks and eatables offered by them, participating in their religious customs and festivals, advising them for their progress and upliftment in the community, conducting education programmes for them etc. An atmosphere of trust and confidence should be established among them so as to open up the secrets of traditional plant lore, even though the traditional notion that 'any

secret is revealed, the curative property of the plant will vanish' prevails among them.

More reliable informants are to be selected with the help of local officials and the persons of forest department. The number of informants may be 8-10, they should have rich experience and practical knowledge of plants used in the traditional system of medicine. These informants may be regarded as collaborators in ethnobotanical research.

Three methods of collecting ethnobotanical information are as follows :

1. First method is 'Cat and Mouse' technique as termed by Prof. R. E. Schultes (1962) of the Harvard University, USA. In this process, all the useful specimens are collected by the investigator and shown to the informants one by one giving the known uses. The informant will interrogate the investigator out of curiosity to confirm whether their knowledge coincides with that of the investigator's thus revealing their secrets on medicinal plants.
2. In the second method, the knowledgeable informants are taken directly to the field and information was collected through in-depth interviews. Informal discussions are carried out with the informants having high degree of herbal knowledge.
3. In the third method the informants are employed on daily wages. They are allowed to take the role of a demonstrator or instructor to the investigator, thus helping in collecting the specimens from the field.

   Proforma for Ethnobotanical Investigation -

   (i) State / District / Village - i.e. the place of investigation
   (ii) Boundary - surrounding area, the geographical boundary
   (iii) Topography - detailed description on map, natural or artificial features of the place
   (iv) Altitude
   (v) Area of the village
   (vi) Population
   (vii) Ethnic group
   (viii) Religious customs / beliefs
   (ix) Literacy
   (x) Language spoken
   (xi) Occupation

(xii) Food habits
(xiii) Economic status
(xiv) Farming and agriculture
(xv) River / Water supply
(xvi) Geological studies rock, soil etc.
(xvii) Climate-rainfall, temperature, humidity etc.
(xviii) Area under forest and nature of the forest.

Regarding information collected in the field the proforma may be followed as :

1. Collection No.
2. Date of collection
3. Place of Collection
4. Name of the informant
5. The collected specimen is wild or cultivated
6. Local name of the plant and family with scientific name
7. Plant part(s) used -whether fresh, dried, powdered or mixture of other ingredients / herbs, if any.
8. Nature of use of plant / plant part (s) in detail
   (a) Medicinal
      - Name of the disease
      - Symptoms of the disease
      - Method of preparation (decoction / juice/paste)
      - Mode of administration (oral/external/infusion)
      - Dosage (before/after food)
      - Duration (hours/days)
      - Case of study observed, if any

   (b) Edible
      - Way in which it is consumed
      - Cereals / pulses
      - Vegetables / fruits
      - Oils / fats
      - Condiments / Spices / Sweets

   (c) Insecticide, Pesticide and fish stupifiers

(d) Magical and religios beliefs, taboos

(e) Miscellaneous uses of plants as

- Fodder / fibre
- Dye
- Gum and resin
- House building
- Art and culture

The information may be collected from both men and women folk. The knowledge of uses of medicinal plants related to gynaecological diseases / disorders may be gathered from the women folk who play a significant role in the discussions since they possess more knowledge about the utility of local herbal medicine. The recipes on the method of preparation of ethno-herbal products alongwith dosage, application and duration are also to be collected.

As in many other communities, the 'Mukhya' is the hereditary head among the tribal communities. He is regarded as informant. The knowledge about the uses of plants, particularly about the medicinal uses of plants in the treatment of different diseases among the tribal groups are often specialised and limited to a few number of people in the community who are recognised as medicine men or 'Vaidya'. Those persons are generally considered as respectable and indispensable members in the tribal society. Thus the informations may be gathered from two broad categories :

(i) From the recognized medicinemen of the localities

(ii) From other individuals possessing knowledge due to their personal efforts and interest.

Another important point is the authenticity of information. Once the information on a particular plant has been taken as reliable after repeated verification, its local name and uses should be recorded. Details about the part utilised in the preparation of the medicine, the ailments, the mode of preparation and prescription are also to be recorded.

Herbarium specimens and field notes on herbarium sheets are the good source of information. In many cases, the observation on plant lore made by previous botanical explorers may be noted on herbarium labels.

Efforts may also be made to search out each and every herbarium sheets deposited in Botanical Garden, Calcutta and in the industrial section of Indian Museum. Some data which are not directly related to the tribal people may also be considered because of the fact that the plants and their uses are related to the other adjacent ethnic

communities. So there is every possibilities that the uses are also known to tribal people. The photographs of the medicinal plants alongwith the tribal people may also be taken for authentication and documentation.

After identification of the plant species collected from various regions conventional characterizations of the plants should be done. These include Botanical origin, regional and classical name, part(s) used, macoscopic and microscopic charaters including organoleptic studies, cell contents, extractive values in water and different polar and nonpolar solvents, total ash and acid-insoluble ash, preliminary phytochemical studies etc. All these data would help in the pharmacognostic evaluation of the plants.

7.2 Ethnobotany and National Interest

Challenges and future perspectives of Ethnobotany and herbal medicine are the major criteria of national interaction. The increasing interest on plants and their ethnobotanical bioperspecting were in general based on the perception that herbal remedies or drugs are always safe. This is infact a false assumption. Herbs or herbal preparations sometimes may create a wide range of undesirable or adverse reactions, causing serious damages, life-threatening conditions and even death. In many regions, herbal medicines and related products are introduced in the market without any mandatory safety or toxicological evaluation. So efficacy and safety measures should be followed for the preparations of such medicines.

Another thing is Intellectual property rights and biopiracy. Information about the uses of specific plant species in a community is generally obtained via interviews of invididuals or groups of people and the scope of this information may vary based on the methods used.

The economic focus of biological prospecting based on these indigenous knowledge including the use of patents and other intellectual property mechanisms has highlighted important issues concerning indigenous rights, cultural knowledge and traditional resources.

Establishment of a guideline for protection of cultural knowledge of different ethnic communities and intellectual property rights could provide a significant control of ethical utilization and dissemination of cultural knowledge for both academic reserchers and industrial applications. These are the important criteria of national interacts.

7.3 Ethnic Communities of India

India is a vast and diverse multiethnic country, that is a home to thousands of small ethnic and tribal groups. The Indus civilization, a society of the Indus river valley is

thought to have been Dravidian-speaking, thrived from roughly 2500 to 1700 BCE. An early Aryan civilization-dominated by peoples with linguistic affinities to people in Iran and Europe-came to occupy northwestern and then north-central India over the period from 2000-1500 BCE and subsequently spread southwest ward and eastward at the expense of other indigenous groups. Despite of caste restrictions, that process was attended by intermarriage between groups which probably has continued to the present day. The complexity has been developed from a lengthy and involved process of migration also.

According to the current tribal demography of India, our sub-continent is home to about 645 tribes, most of whom have been living here since times immemorial. Indigenous tribes or ethnic communities comprise over 8% of the total population (2011 census Data).

7.3.1 A brief account of some ethnic groups in India :

1. **ABOR (ADI)** : A tribe in northeastern India, linguistically of Arunachal Pradesh, branch of Tibeto-Chinese family.
2. **ADIYAN** : About 8000 persons in South India, mainly in Kerala.
3. **ANDAMANESE** : A very small tribe of Negrito race of a few dozen persons inhabiting the Strait Island, off the east coast of Middle Andaman Islands in Bay of Bengal
4. **ANDH** : A large tribe of about 0.23 million in penisular India, mainly Maharashtra and Andhra Pradesh.
5. **ASUR** : A tribe of about 12,000 persons mainly in Bihar, Jharkhand and West Bengal.
6. **BHIL** : A large tribe of about 7.4 million people, mainly in Rajasthan, Gujarat, Madhya Pradesh and Maharashtra, linguistically Indo-European family.
7. **BHOTIA** : There are two tribal groups by this name, one in the high valleys of Himalaya, mainly in U.P. and Uttarakhand and the other in Sikkim and North Bengal. (i) Bhotia of UP and Uttarakhand - they inhabit high mountain regions at around 3500 m attitude. According to their habitat, they have different sections like Johari, Darmi, Byanshi and Chaudansi. They are about 32,000 (total) in number. (ii) Bhotia (Bhutia) of Sikkim region - they inhabit Sikkim, Bhutan and Darjeeling region. In Sikkim, they are about 50,000 in number and called as Drukpa. In North Bengal, they are about 40,000 in number and include Toto, Dukpa, Yolmo and Sherpa. They are linguistically of Tibeto Himalayan branch of Tibeto-Chinese family.

A Lodha couple in West Bengal

A Garo tribal with leaf of *Licuala peltata*
(From Dictionary of Indian Folk Medicine and Ethnobotany—S.K. Jain, 1991.)

8. **BHUMIJ** - A tribe of about 75,000 persons in Odisha and Madhya Pradesh, also called DESUA.
9. **BIRHOR** - A tribe of about 4000 people in Bihar (including Jharkhand), 700 in West Bengal, 500 in Madhya Pradesh and 150 in Odisha. They are nomadic or seminomadic.
10. **BODO** - A tribe mainly in Brahmputra and Barak Valleys in Assam. They are linguistically a group under Assam-Burmese Branch of Tibeto - Chinese family.
11. **CHAKMA** - A tribe of about 0.1 million persons in northeast India mainly Tripura, Mizoram and Assam.
12. **GADDI (GADI)** - A tribe of shepherds inhabiting Himachal Pradesh and some adjoining areas, population about 80,000.
13. **GARO** - A branch of BODO race, of about 0.45 million in northeastern India, mainly in Meghalaya, Assam and Tripura. Linguistically they belong to BODO group in Assam-Burmese branch of Tibeto-Chinese family.
14. **GOND** - A large tribal group 7.4 million, mainly in Madhya Pradesh, Odisha, Bihar, Jharkhand, Maharashtra, Andhra Pradesh, Telangana and Gujarat. They have several sub-divisions e.g. Raj-Gond, Durve-Gond, Muria Gond, Koda-Muria and Muria. They are linguistically of Munda branch of Austro-Asiatic family.
15. **JARAWA (JORAWA)** - A small tribe of about 250 persons inhabiting South and Middle Andaman Islands in Bay of Bengal. They live mostly by hunting and collecting. They are of Negrito race.
16. **KOL (or COL)** - About 0.13 million, mainly in the plateau region in Madhya Pradesh, Maharashtra, Bihar and Odisha. This term is also applied to some sections of Munda or Oraon origin in old Chota Nagpur region.
17. **KUKI** - about 1,30,000 persons in northeast India, mainly in Lushai hills, Mizoram, also in Tripura, Assam and Nagaland. There are several sub-troups or tibes under the name Kuki.
18. **LEPCHA** - This tribe of about 50,000 people has two main sections - Rong and Khamba. They inhabit a long stretch south of the Himalaya in Sikkim, North Bengal and Bihar in eastern India. Linguistically they are of Himalayan Group of Tibeto-Chinese family.
19. **LODHA -** A tribe of about 60,000 people, mainly in West Bengal (Fig. 5a) and Odisha.

20. **MIKIR -** About 0.2 million, mainly in Karbi-Anglong district of Assam, some are also inhabitant of Meghalaya, Mizoram and Nagaland.
21. **MUNDA** - Considered a sect of Kols. About 1.4 million in Bihar (including Jharkhand), Odisha, West Bengal, Tripura and Madhya Pradesh.
22. **ORAON** - A tribe of about 1.8 millions people, mainly in Bihar, Jharkhand, Odisha, West Bengal, Madhya Pradesh and Maharashtra, also called DHANGAR or DHANKA in M.P and KURUKH in Maharashtra. Linguistically they are of Dravidian Group in Dravidian family.
23. **PARHAIYA -** About 30,000 in Bihar (including Jharkhand) and West Bengal, also called BAIGA, but different from BAIGA of Madhya Pradesh.
24. **RABHA** - A branch of BODO race of about 0.14 million persons in Assam and West Bengal (north and northeast India)
25. **SANTAL (SANTHAL) -** A large tribe of about 4.3 million in Bihar, Jharkhand, West Bengal, Odisha usually in the region of south of the Ganges. They are linguistically of Munda branch of Austro-Asiatic family.
26. **SAVAR** - A tribe of about 0.5 million people mainly of Odisha, Andhra Pradesh and Madhya Pradesh.
27. **TODA** - A tribe of about 1000 persons in Nilgiri Hills in Tamil Nadu and adjoining areas. They are considered as one of the most Primitive surviving tribal groups. They are totally vegetarian, foods are mainly milk, butter, ghee and few cereals.
28. **TOTO** - A group of about 150 households in northern part of West Bengal. They are linguistically of Himalayan group of Tribeto-Chinese family.

7.4 Summary

Modern investigation in ethnobotany was made by Rev. P.O. Bodding (1925-40). Prof. R. E. Schultes (1962) developed the methods of collecting ethnotanical informations. Many medicines used currently have been derived from medicinal plants based on ethnobotanical research programmes. These are Aspirin, Codeine, Ipecac, Pilocarpine, Quinine, etc.

There are over 8% (of total population) ethnic communities or indigenous tribes in India. This sub-continent is home to about 645 tribes, most of whom have been living here since times immemorial. The major tribes are Abor, Asur, Bhil, Birhor, Chakma, Kuki, Lodha, Mikir, Santal, Toto etc. They use many plants in different ailments.

7.5 Questions

1. Describe different methods for collecting ethnobotarical informations.
2. Write a note on the methods of cothections of ethnobotarical informations.
3. Why 'Mukhya' and 'Vaidya' are considered key persons in the tribal society.
4. What are the criteria used to characterized plants after collection for tribal area?
5. Why efficacy and safety measures are mandatory in case of herbal medicine?
6. How many tribes or ethnic groups are living in India?
7. Name the state or union territory of India where the tribal population is (i) over 80% and (ii) very low percentage or negligible.
8. Name some important ethnic groups or tribes living in Kerala, Bihar, Assam, Andaman & Nicober islands.
9. State a brief account on the following tribes - Kuki, Lodha, Mikir, Munda, Jarwa, Santal and Toto.
10. Prepare a list of tribes or ethric groups living in West Bengal.

7.6 Answers

(1) See 7.1, (2) 7.1, (3) 7.1, (4) 7.1 last para, (5) 7.2, (6) 7.3, (7) 7.3, (8) 7.3.1, (9) 7.3.1, (10) 7.3.1.

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Unit 8 ❑ Folk Medicines, Ethnoecology

Structure

8.0 Objective

- This unit will provide an idea of Folk medicines, Ethnomedicines and Ethnoecology.
- You will get an overview of traditional knowledge of ecology; religion interactions etc.

3.7 Folk Medicines

Folk medicine is also known as traditional or indigenous medicine. It comprises medical aspects of traditional knowledge that developed over generations within various ethnic societies before the onset of modern medicine. Folk medicine has a long history. According to the World Health Organization (WHO), "Traditional or Folk medicine is the sum total of the knowledge, skills and practices based on the theories,

beliefs and experiences indigenous to different cultures, whether explicable or not, used in the maintenance of health as well as in the prevention, diagnosis, improvement or treatment of physical and mental illness."

WHO also stated that inappropriate use of traditional medicines or practices may have negative or dangerous effects and that further research is needed to ascetain the efficacy and safety of several of the practices and medicinal plants used by traditional medicine system.

8.1.1 History

'Necessity is the mother of invention'—this dictum fully applies to different rural or primitive societies which have to discover solutions to almost all their needs and problems from natural resources arround them.

In the written record, the study of herbs dates back 5000 years to the ancient Sumerians, who described well-established medicinal uses of plants. In ancient Egyptian medicine, the Ebers papyrus from c. 1552 BC records a list of folk remedies and magical practices.

Traditional medicine may sometimes be considered as distinct from folk medicine and considered to include formalized aspect of folk medicine. Under this definition folk medicines are long standing remedies passed on and practised by lay people. Folk medicine consists of the healing practices and ideas of body physiology and health preservation known to some in a culture, transmitted informally as general knowledge and practiced or applied by anyone in the culture having experience.

8.1.2 Folk medicines in different countries

Many countries have practices of folk medicine. This system of health care may coexist with science-based and institutionalized systems of medical practice represented by conventional medicine. Examples of folk medicine traditions are traditional chinese medicine, traditional korean medicine, Arabic Indigenous medicine, Japanese Kampo medicine, traditional Aboriginal Bush medicine, Georgian folk medicine, among others. Bush medicines are generally used by aboriginal and Torres strait Islander people in Australia. These are made from plant materials, e.g. bark, leaves and seeds, although animal products may be used as well.

In India folk medicines are used in different areas. Some of these are mentioned below:

Sl. No.	Name of the Plant	Local name	Part(s) used	Area in which used	Used in/ as
1.	*Alstonia scholaris* (L.) Br. (Apocynaceae)	Buchong, Chhatim, Ealilam.	latex.	Assam region, Arunachal.	in child birth and tuberculosis.
2.	*Costus speciosus* (Koen.) Sm. (Costaceae)	Keokand, Besemati.	rhizome & stem.	Tamil Nadu, Meghalaya.	in Burns in Jaundice.
3.	*Gloriosa superba* Linn. (Liliaceae)	Karihari.	rhizome.	Rajasthan, Uttar Pradesh.	in leprosy in piles.
4.	*Justicia gendarussa* Burm. (Acanthaceae)	Trachamai, Amar, Jagatmadan.	leaf.	Meghalaya.	in bone dislocation and fracture.
5.	*Sida acuta* Burm. f. (Malvaceae)	Bala, Braphum, Holap.	leaf.	Meghalaya, and Assam.	to stop bleeding.
6.	*Vitex negundo* Linn. (Verbenaceae)	Nirgundi, Bagna, Ichur.	leaf.	Uttarakhand.	in boils and blisters.

8.2 Ethnomedicine

Ethnomedicine is certain type of medicine developed and originated from indigenous beliefs, concepts, knowledge and practices among an ethnic group, folk, people or race for preventing, lessening or curing disease and pain. Ethnomedicine is totally different from indigenous systems of medicine which have recognized levels of degree of learning, and organisation for registration of its practitioners, has also recognised institutions for teaching and text books.

Several interdisciplinary aspects of ethnomedicine are now in vogue, e.g., Ethnoepidemiology, Ethno-gynaecology, Ethno-ophthalmology, Ethno-orthopaedics and Ethno-pediatrics.

Scientific ethnomedical studies consititute either anthropological research or drug discovery research. The anthropological studies include the cultural perception and context of a traditional medicine. The purpose of drug discovery research is to identify and develop a marketable pharmaceutical product.

The pharmacological aspects of ethnomedicine is called Ethnopharmacology which is occasionally called ethnopharmacy. It is related study of ethnic groups and their use of drugs. It is the interdisciplinary science that investigates the perception and use of pharmaceuticals within a given human society. It involves studies of the following :

- Identification and ethnotaxonomy (cognitive characterization) of the natural material from which the remedy will be produced (Medico-ethnobotany)
- Traditional preparation of the pharmaceutical forms (Ethnopharmaceutics)
- Bio-evaluation of the pharmacological action of such preparations (Ethnopharmacology)
- Their clinical effectiveness (Clinical Ethnopharmacy)
- Socio-medical aspects implied in the uses of these pharmaceuticals (Medical Anthropology / Ethnomedicine)
- Public health and pharmacy practice-related issues concerning the public use and / or the re-evaluation of these drugs.

Ethnopharmacology is strongly linked to food science, since dietary modifications are traditionally used as a tool to modify health and disease conditions, and many plant species are traditionally used both as food and for medicinal purposes.

During investigation of a herbal product used by an ethnic group as a medicine, it is important that the methods of collection, extraction and preparation are the same or similar to those used by the ethnic group. This is to ensure consitency and legitimacy of the experimentation.

8.2.1 Form of Ethnomedicine

The preparation of drug and medicine among the ethnic or tribal communities is very methodical. Most of the medicines are prepared either from single plant or plant parts. The combination with other plant, animal organ, rock, mineral, salts etc. in ethnomedicine is not uncommon. Different preparations are in the forms of -

(i) Infusion, (ii) Decoction, (iii) Mixture, (iv) Syrup, (v) Paste, (vi) Pills and small cakes, (vii) Powder, (viii) Extract-both in water and in alcohol, (ix) Fomentation, (x) Medicated oil-both from plant parts and from animal fats, (xi) Drops, (xii) Massage balm, (xiii) Fumes, (xiv) Burning ash, (xv) Plaster, (xvi) Fresh juice, (xvii) Alkali, etc.

8.3 Ethnoecology

Ethnoecology is the scientific study of how different groups of people living in different regions understand the ecosystems around them, and their relationships with surrounding environments. The prefix 'ethno' in ethnoecology indicates a localized study of a people in conjunction with ecology, signifies peoples' understanding and experience of environments around them. Ecology is the study of interactions between living organisms and their environment. The development of this field lies in applying indigenous knowledge of Botany and placing it in a global context.

8.3.1 History

The term 'ethnoecology' was first coined in 1954 by Dr. Harold Conklin, a cognitive anthropologist who did extensive linguistic and ethnoecological research in Southeast Asia. Ethnoecology began with some of the early works of Dr. Hugh Popenoe, an agronomist and tropical soil scientist who also worked with Dr. Conklin. Ethnoecology is a major part of an anthropologist's toolkit. It helps researchers to understand how the society conceptualizes their surrounding environment. This information can ultimately be useful for other approaches used in envitonmental anthropology. Modern anthropologists emphasize the interpretation of cultures as systems and its conjunction with ecosystems.

8.3.2 Traditional ecological knowledge

Traditional Ecological knowledge (TEK) also known as 'Indigenous knowledge' refers to the evolving knowledge acquired by indigenous and local peoples over hundreds or thousands of years through direct contact with the environment. It involves the accumulated knowledge, beliefs and practices widely held by a specific community through their relationship with the environment.

TEK has traditionally focused on Western Science. As a result the modern science may learn from these communities the cultural knowledge in the scientific stuctures.

Within the discipline of Ethnoecology, there is a clear emphasis on those societies that are deemed indigenous or traditional, a common trend in anthropological studies. Traditional societies often treat medical issues through the utilization of their local environment. According to World Health Organization (WHO) almost 80% of the World's population utilizes ethnobotanical methods as a main source of treatment for illness.

8.4 Importance of interactions between the regions of the Nation

We all humans consider ourselves to be unique individuals with our own set of personal opinions, habits, preferences, and peculiarities. In spite of that, we mostly share our feeling that may be wrong or right. We share many such feelings, beliefs, and habits with most of the people living in our society of both rural and / or urban areas knowing fully well that other people have different feelings, beliefs, and habits from ours.

In the earlier units, we have seen that traditional healing practices play a crucial role in healthcare systems across the globe. Traditional and complementary medicine holds significant importance in healthcare and is prevalent in nearly every country. Proven quality, safety, and efficacy of traditional medicine contribute to the comprehensive goal of ensuring universal access to healthcare, which is only possible through the interactions between the religions of a nation. Established fact is that the roots of traditional healing practices run deep in the cultural heritage of India over and above other countries, constituting an integral part of the people's culture. Various forms of traditional healing methods have served as fundamental approaches to treating diseases and addressing diverse health issues since remote pasts. Researchers have highlighted the presence of two primary types of traditional healing systems in rural areas: a) *Religious healing* and b) *Non-religious healing*. The practices of former system involve the verses from religion texts, while the latter system embraces the uses of local medicinal plants and substances.

In India, traditional healers of *North-East* (Mishings, Bodos etc.) collect plants locally or cultivate them in their own herbal gardens for addressing prevalent ailments like jaundice, malaria, menstrual disorders, joint pains, and skin diseases. They use a total of 55 different herbs and their components for healing purposes. On the other hand, in *Western India* three major tribes (Bhil, Meena and Garasia) have well-established system for the application of traditional herbal medicines and curing practices. Common health issues addressed in western India through traditional medicine mainly encompass multiple fractures, pain, fever, blood pressure, snake bites, toothaches, asthma, and eczema etc. using about 25,000 plant-based formulations.

Traditional healing practices deployed by people of Southern India follow the Siddha System which is rooted in Dravidian culture, and flourished during the Indus Valley civilization. It is arguably the most ancient medical system globally, with its origins

tracing back to approximately 10,000 BC to 4,000 BC. Siddha medicine is distinguished from others by its utilization of metals like gold, silver, iron, lead, and mercury, along with extracts from corals and pearls. The unique aspect of Siddha medicine lies in its claim that these metals can be detoxified, rendering them suitable for the treatment of persistent diseases. Furthermore, traditional healers of other countries, for instance, *Voodoo* doctors of Latin America (from Central America and the Caribbean), *Houngans* (Haiti), *Hakims* (Pakistan), *Shamans* (India) and so forth, all practicing their distinct forms of healing, health promotion, and education adhering their tradition and belief.

Traditional medicine systems in India predominantly encompass regulated medicinal practices like Ayurveda, Yoga, Unani, Siddha, Homeopathy, and Tibetan medicine, collectively now called AYUSH. In addition to these, there are many unregulated traditional systems grouped under 'local health traditions' (LHTs). These LHTs typically possess a defined theoretical framework, a recorded 'materia medica" and the clinical traditions incorporating various preventive and therapeutic approaches.

From the foregoing paragraphs one can realise that many tribal communities have rich knowledge of medicinal plants, healing rituals, and natural therapies in essence over generations. Engaging such tribal communities in discussions exploring traditional medicine practices can indeed lead to many valuable outcomes. However, improving such interactions and optimizing traditional medicine practices require a sensitive, inclusive approach that respect cultural heritage while integrating scientific method. In that event some strategic interactions viz. collaborative research, educational workshops and training, due regard for intellectual property right (while commercializing traditional medicines), conservation of medicinal heritage, integrating traditional practices into public health, encouraging documentation, knowledge preservation may be taken into consideration along with similar others.

Through respectful collaborative interactions between different tribal communities and / or regions of the nation, traditional medicine practices can be preserved, enriched, and upgraded for the broader medical future.

8.5 Summary

Traditional or folk medicine is the sum total of knowledge, skills and practices based on theories, beliefs and experiences indigenous to different cultures. Ethnomedicines or tribal medicines are developed and originated from indigenous beliefs, concepts, knowledge and practices among an ethnic group. There are many interdisciplinary

aspects of ethnomedicine, e.g. Ethnoepidemiology, Ethno-ophthalmology, Ethno-gynaecology etc.

Ethnoecology is the scientific study of how different ethnic groups of people living in different regions understand the ecosystems around them and their relationships with surrounding environments. This term was first coined in 1954 by Harold Conklin.

Since, tribal communities have rich knowledge of medicinal plants, healing rituals and natural therapies, they must be engaged in community discussions further exploration of traditional medicinal practices to have many more valuable outcomes. In that event collaborative research, workshop and training are considered worthwhile

8.6 Questions

1. What is folk medicine?
2. What do you mean by traditional medicine? How it differs from talk medicines used in indigenous systems?
3. What is Ethnoecology? Who first coined the term?
4. Name some plants used in folk medicines of India.
5. Define 'ethnomedicine' and 'ethnophormancelogy'.
6. What are the different preparations used in folk medicines?
7. State the importance of studying ethnoecology.
8. Write the primary healing systems operated in rural areas.
9. Write a note on traditional healing practices of Southern India.
10. State of your opinion about upgradation of folk medicine in India.

8.7 Answers

(1) See 8.1, (2) 8.1.1, (3) 8.3, (4) 8.1.2, (5) 8.2, (6) 8.2.1, (7) 8.3.2, (8) 8.4, (9) 8.4, (10) 8.4

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Unit 9 ❑ Application of Natural Products in Treatment of Certain Diseases – Jaundice, Cardiac Problems, Infertility

Structure

9.0 Objectives

- From this unit you will learn about the role of natural products in treatment of jaundice, cardiac problems, and infertility.
- After studying this unit, you will be able to learn about the parts used and phytochemical constitutions of herbs used for treatment of the said problems.

9.1 What is natural product?

9.2 General Introduction

In the earlier units, we have seen the operation of indigenous systems of medicines for traditional healing purpose. Greek physician Dioscorides P. (100 A.D.), wrote the "*De Materia Medica*", which is still considered as a precious European document on the use of herbs in medicine. Collection of Ayurvedic tributes in India from 1000 B.C. describes the uses of over 1000 different herbs for treatment of different ailments. Large numbers of medicinal plants are now recognized, and a number of active constituents are being isolated and characterized from plants. Numerous pathophysiological conditions, such as cardiac problems, cancer, viral infection, immunological disorders, infertility, and metabolic diseases have been treated with concentrated extracts of natural products. Natural products, which are compounds or substances derived from living organisms, could provide answers to these problems because they contain various components that can exhibit unexpected biological properties. In this resume, therapeutic effects of natural products on certain human diseases will be taken up for your conceptualization.

9.3 Jaundice

It is a condition / symptom produced when excess amount of bilirubin (*a yellow waste product formed when haemoglobin of RBC breaks down*) circulating in the blood stream dissolve in the subcutaneous fat, causing a yellowish appearance of the skin, eyes, and mucous membranes. Other symptoms include dark colour urine, pale colour stools, discomfort in upper right abdomen mainly. This disease is also known as 'hyperbilirubinemia'.

Pathophysiology of jaundice indicates that it is mainly caused due to increased level of bilirubin and its overproduction in the liver, which may occur due to various reasons. Jaundice can occur at any age. It is very common in newborns which usually goes away on its own. However, in adults, jaundice can be a sign of a number of health problems including liver diseases (hepatitis or cirrhosis), obstruction of bile ducts, Gilbert's syndrome, infections like hepatitis A, B, or C, or Epstein-Barr virus infection, due to side effects of certain medicines, autoimmune diseases and so on. Anyway, jaundice is usually temporary and not harmful condition. Prompt treatment can prevent further complications including death.

9.3.1 Ethnomedicinal plants for curing jaundice

A large number of plants and herbal formulations have been claimed to have hepatoprotective activity. More than 160 phytoconstituents from more than 101 plants have been claimed to possess liver protecting activity. Literature on the ethnomedicinal plants revealed that for the cure of jaundice in India, various ethnic communities utilize various natural products comprising herbs.

- **Herbs:** *Aloe vera, Cyperus rotundus, Bauhinia variegata, Berberis integrrima, Emblica officinalis, Terminalia chebula and Carica papaya* are examples of some herbs that have been used to treat jaundice.
- **Medicinal plants:** *Boerhavia diffusa, Tinospora cordifolia, Saccharum officinarum, Cichorium intybus, Phyllanthus amarus, Ricinus communis, Andrographis paniculata, Oroxylum indicum, Eclipta prostrata* etc. have been used to cure jaundice in different parts of India.
- **Herbal decoctions:** i) 'Yin Zhi Huang' is an herbal decoction containing extracts from four different plants; ii) crushed root of *Ardisia paniculata* along with *Smilax ovalifolia* and *Bridelia tomentosa*; iii) concentrated, dried decoction of *Berberis asiatica* is taken orally with local sweet "khujja mishri" in different parts of India to treat neonatal jaundice.

Following is a small list showing ethnopharmacology of plants used to treat jaundice–

Name of Plant with family	Parts used	Active Principles
Aloe vera(Liliaceae)	Leaves	Fatty acids (n-hexadecanoic acid, oleic acid, tetradecanoic acid, 1,2-benzenedicarboxylic acid, diisooctyl ester, squalene, butyl-octyl ester)
Bauhinia variegata (Caesalpiniaceae)	Roots	Terpenoids, flavonoids, tannins, saponins, steroids, and cardiac glycosides
Boerhavia diffusa (Nyctaginaceae)	Root, stem, leaves	Rotenoids, quercetin, kaempferol, borhaavone, lignans, steroids, phenolic glycosides, phenolic compounds (trans-caftaric acid, xanthones)
Carica papaya(Caricaceae)	Leaves	Flavonoids, saponins, tannins,

	glycosides, and steroids
Centaurea behen(Asteraceae) Guaranolides, Behenin (lactone)	Root
Curcuma zedoaria(Zingiberaceae) Curcuminoids, Curcumol, Curdione	Rhizome
Picrorhiza kurroa(Scrophulariaceae) Picroside-II, Kutkoside (Iridoid glycoside)	Root

Hundreds of medicinal plant species are used to treat jaundice throughout the rural and tribal areas of India, and are now considered an important therapeutic resource to minimize this disease. However, there is a need for more research to fully understand the safety and efficacy of these alternative treatments. Healthcare professionals should play a key role in guiding patients to make informed decisions about alternative treatments.

9.4 Cardiac Problems

Also known as cardiovascular disease (CVD) or heart disease, is a general term for any disease that affects the heart or blood vessels. It may be Coronary artery disease (occurs when the coronary arteries narrowed or become blocked), Congenital heart disease (a birth defect), Rheumatic heart disease (damage of heart muscle and valves due to rheumatic fever), Deep vein thrombosis and pulmonary embolism (due to blood clots moving to the heart and lungs). The CVD is a leading cause of morbidity and mortality worldwide, but it can be prevented by changing lifestyle.

According to the WHO, cardiovascular diseases (CVDs) are found to be responsible for the highest number of deaths in 2019, and thought to increase up to 22.2 million CVD-related deaths by 2030. Researches have indicated that increasing levels of oxidative stress day by day contribute to the atherosclerotic plaque formation (buildup of fats, cholesterol and other substances in and on the artery walls) while lack of endogenous antioxidants is another important cause of coronary heart disease.

9.4.1 Ethnomedicinal plants for curing cardiac problems

Currently, there is an unprecedented drive for use of herbal preparations in modern medicinal systems because of their cost-effective therapeutic promise compared to standard modern therapies and the general belief that they are safe. Data on the ethnopharmacological therapeutic potentials and medicinal properties against CVDs

indicates that four plants viz. *Ginseng*, *Ginkgo biloba*, *Gynostemma pentaphyllum*, and *Ganoderma lucidum* (a fungus), are used widely. Besides the aforesaid four medicinal plants, *Salix alba, Digitalis purpureus, Ephedra sinica, Taxus brevifolia, Rauvolfia serpentina* and several others are used to cure / minimize adverse effects of atherosclerosis, hypertension, hyperlipidemia, hypercholesterolemia, thrombotic complications, and several others.

Following is a small list of ethnopharmacology of plants used to treat CVD –

Name of Plant	**Parts used**	**Active Principles**	**Nature of CVD**
Allium sativum (Amaryllidaceae)	Bulb	Allicin, Alliin, E-Ajoene, Diallyl sulfide, Allyl methyl sulfide	Atherosclerosis & Hyperlipidemia, Myocardial infarction
Coptis chinensis (Ranunculaceae)	Whole plant	Berberine, Palmatine, Coptisine, Epiberberine,	-do-
Crataegus oxyacantha (Rosaceae)	Flower, Ripe fruit	Vitexin, Hyperoside, Rutin, Catechin/ epicatechin, Crataegolic acids	Angina pectoris
Cymbopogon citratus (Poaceae)	Leaf	Caffeoylquinic acid, Flavonoids, Quinic acids, Swertiajaponin, isoorientin	-do-
Digitalis purpurea (Scrophulariaceae)	Leaf	Digitoxin, Gitoxin, Gitaloxin	Congestive heart failure
Ganoderma lucidum Basidiomycotina (Fungus)	Fruit body	Ganoderic acids A, B, C; small peptides like QLVP (Gln-Leu-Val-Pro), QDVL (Gln-Asp-Val-Leu), and QLDL (Gln-Leu-Asp-Leu) which are converting angiotensin enzyme (ACE) inhibitors	Anti-hypertensive, Hypo-cholesterolemic
Ginkgo biloba (Ginkgoaceae)	Leaf	Ginkgolides, Bilobalides, Kaempferol, Quercetin, Isorhamnetin	Cerebral insufficiency, vasodilatory and antihypertensive
Panax ginseng, P. notoginseng (Araliaceae)	Root	Ginsenoside, Ginsenosides protopanaxadiol, Ginsenoside protopanaxatriol	-do-
Rauwolfia serpentina (Apocynaceae)	Root	Reserpine,	Systolic hypertension

One of the recent studies (Hamer M., 2019) has shown that herbal treatments have been used in arrhythmia, congestive heart failure, cerebral and venous insufficiency, atherosclerosis, angina pectoris, and systolic hypertension are found to be very satisfactory. Besides medicinal plants, physical activity is thought to be the best cardioprotective.

9.5 Infertility

According to WHO, infertility is a disease of both male or female reproductive system defined by the failure to achieve a pregnancy even after 12 months or more of regular unprotected sexual intercourse. Infertility may occur due to male, female or unexplained factors. There are two types of infertility: i) *Primary infertility* denotes those couples who have never conceived even once, while ii) *Secondary infertility* indicates previous pregnancy but failure to conceive subsequently. Now a days, infertility is an issue affecting more than 80 million people globally. However, the rates of infertility differ from one country to another, with a minimum of about 5% to maximum 30%. In India, about 8% of currently married women are suffering from primary and secondary infertility, of which about 5.8% are the cases of secondary infertility. Furthermore, with increasing stress and changing lifestyles, both men and women are facing more and more problems.

It has been roughly estimated that 20-30 % of infertility cases are due to male infertility, while 20-35% are due to female infertility; but 25-40% are due to combined problems in both partners. Most common cause of female infertility is ovulatory problems which generally manifest themselves by sparse or absent menstrual periods, structural problems in fallopian tube or uterus, or problems in releasing egg and so on.

On the other hand, main causes of male infertility are low semen quality (caused due to endocrine problems, drugs, radiation, or infection), and sperm count (testicular malformation, hormonal imbalance, blockage of the duct system, side effect of some drugs, pesticides, industrial chemicals and others). Reports are available on infertile men, women, and couples with unknown (idiopathic / unexplained) cause of infertility. In these cases, abnormalities are likely to be present but not detected by current available methods.

9.5.1 Ethnomedicinal plants for curing infertility problems

Medicinal plants have tremendous potential in treating infertility and associated reproductive health issues. Medicinal plants as reported in literature can be used as such or formulations such as extract, decoction, paste, along with food supplements etc. / along with conventional therapies for managing reproductive health of women. Examples of some medicinal plants used to treat infertility / reproductive health **in women** are -

Name of Plant	**Parts used**	**Active Principles**
Abroma augusta (Malvaceae)	Root, Stem	Taraxerol, Friedelin, β-Sitosterol, α-Amyrin, Lupeol, Octacosanol, Abromine
Achyranthes aspera (Amaranthaceae)	Root, Stem	β-sitosterol, Ecdysterone, Quercetin etc. Anti-fertility effect through their action on hypothlamo-pituitary-gonadal axis
Acrostichum aureum (Pteridaceae)	Frond	Kaempferol, di-(2-methylheptyl) phthalate, β-sitosterol, Pterosin, Lupeol, á-Amyrin
Aegle marmelos (Rutaceae)	Fruit	Marmin, Fagarine, Alloimperatorin, Rutaretin, Scopoletin, Aegelin
Alstonia scholaris (Apocynaceae)	Bark, Latex	Scholaricine, 19-epischolaricine, Vallesamine, Picrinine
Argemone maxicana (Papaveraceae)	Root, Leaves	Mexitin, Isorhamnetin, Argemexicaine
Asperagus racemosus (Liliaceae)	Root	Steroidal saponins, Asparagamine, Racemosol and kaempferol
Bryonia laciniosa (Cucurbitaceae)	Seed	Punicic acid, Goniothalamin, Glucomannan
Butea monosperma (Fabaceae)	Flower, Bark	Kaurenoic acid, phenyl propanoid glucosides, Steroidal saponins, Heterocyclic aldehydes
Caesalpinia bonduc (Caesalpiniaceae)	Seed	α-, β- Caesalpin, Bonducin, Sitosterol, Heptocosane

Name of Plant	Parts used	Active Principles
Equisetum ramosissimum (Equisetaceae)	Frond	Loliolide, Genkwanin, Friedelinol, β- Daucosterol
Ferula foetida (Apiaceae)	Gum resin	Ferulic acid, Ferulenol, Umbelliprenin, coumarin esters (ferulone A, B), sesquiterpenes like guaianes, farnesiferol A, B, and sinkiangenorin C, E
Prunus cerasoides (Rosaceae)	Stem, Bark, Seed	Glucogenkwanin, Naringenin, Puddumin-A, B; Ursolic acid, Prunasetin
Prunus cerasoides (Rosaceae)	Stem, Bark, Seed	Glucogenkwanin, Naringenin, Puddumin-A, B; Ursolic acid, Prunasetin
Saraca indica (S. asoca) (Caesalpiniaceae)	Stem bark	Procyanidin, Leucopelargonidin, Sapogenin, Ketosterol, Gallic acid

Fertility herbal remedies are made out of special plants and plant extracts believed to have a positive effect on the reproductive organs, hormonal system, and sex drive in men who wish to overcome the fertility difficulties.

Name of Plant	Parts used	Active Principles
Argyreia nervosa (Convolvulaceae)	Root, Leaf	Ergine, Ergometrine, Lysergic acid, and Lysergol, Tricontanol, Epifriedelinol
Curculigo orchidoides (Amaryllidaceae)	Rhizome	Curculigoside, Yuccagenin, Lycorine, Norlignans, Curculigines,
Eurycoma longifolia (Simaroubaceae)	Root	Dimethoxycanthin, *β*-carboline-1-propionic acid, Infractine, Eurylene, Eurycomanone
Mucuna pruriens (Fabaceae)	Seed	Mucunine, Mucunadine, nonprotein amino acid Dihydroxyl phenyl-L-alanine (L-DOPA), Dimethyltryptamine
Panax ginseng (Araliaceae)	Root	Ginsenoside, Notoginsenoside R_1, Ginsenoside- R_e, Falcarinol, Arginine, Aspartic acid

Name of Plant	Parts used	Active Principles
Piper longum (Piperaceae)	Fruit	Piperine, Methyl piperine, Iperonaline, Piperettine, Asarinine, Refractomide A
Tribulus terrestris (Zygophyllaceae)	Aerial parts	Protodioscin, Neoprotodioscin, Prototribestin, Terestrinin A, B, D etc., Tribufuroside
Withania somnifera (Solanaceae)	Root	Withanoside-V, Withanoside-X, Withaferin-A, Withanolide- D,

Herbal drugs are primary source of naturally occurring fertility regulating agents. Some of the plants that have been reported to have antifertility activity are listed above. According to American Pregnancy Association, a number of herbal supplements are found to be helpful in supporting fertility for both women and men.

9.6 Summary

Natural products (mol. wt. < 2000 amu), that are produced by living organisms are well known for unique chemical diversity and medicinal properties. Such natural products are effective in maintaining good health and well-being, as well as preventing various diseases, for example, preventing jaundice, cardiac problems, infertility like burning complications.

Traditional or folk-based plant medicines have shown great potential to form the basis of curing jaundice. Most commonly used plants for the treatment of jaundice include *Emblica officinalis*, *Saccharum officinarum*, *Terminalia chebula*, *Berberis sp.*, *Cuscuta reflexa,* and *Tinospora cordifolia* etc. Plants that are mostly utilized for the treatment of jaundice need to be scientifically validated and should be used for the preparation of new drugs, which may prove far more beneficial than the existing modern drugs.

Use of traditional medicinal plants has rapidly expanded in recent years. Finding safe and effective drugs derived from natural products is a hot topic in the CVD field. Medicinal plants have great advantages for the treatment of cardiovascular disease primarily due to their safety profiles, easy availability and cheaper than modern allopathic medicines. Favourable effects of medicinal plants have been described for diseases such as hypertension, hyperlipidaemia, atherosclerosis, and chronic heart failure, as well as for the overall reduction of cardiovascular risk etc. Plants including fungi (*Ganoderma lucidum*), pteridophytes (*Ephedra sinica*), gymnosperms (*Ginkgo*

biloba, *Taxus brevifolia*), angiosperms such as Ginseng, *Gynostemma pentaphyllum*, *Salix alba, Digitalis purpureus, Rauwolfia serpentina* and several others are used widely to control CVDs.

Infertility is considered as one of the unsolved global health problems till now. It remains a social burden to women, even though male infertility contributes to more than half of global infertility. Following recent interest in the use of medicinal plants, scientists have sought to clarify their effects on both female and male fertility. There are many benefits of using herbal treatment (*Abroma augusta, Achyranthes aspera, Crocus sativus, Curcuma longa, Ferula foetida, Saraca indica* and several others) for solving infertility in women. Similarly, different medicinal plants like *Panax ginseng*, *Nigella sativa*, *Piper longum*, *Mucuna pruriens*, etc. exert positive effects on male fertility. All the studies have confirmed the beneficial effects of medicinal plants on the improvement of sperm and other reproductive parameters affecting male infertility. Positive therapeutic efficacy of medicinal herbs are attributed to the presence of diverse phytochemicals like alkaloids, flavonoids, and volatile oils.

9.7 Questions

1. What do you mean by the natural products? Cite some examples of natural products with sources.
2. What causes jaundice or hyperbilirubinemia?
3. Name some medicinal plants along with the parts used and primary phytochemicals.
4. What are CVDs? Mention its causes.
5. Name some plants of lower group used as ethnomedicine for CVDs.
6. Write the active principles of *Ganoderma* sp., ginseng, and *Ginkgo biloba* responsible for curing cardiac problems.
7. Mention the name of plants used to treat hypertension, myocardial infraction, and congestive heart failure.
8. Do you think infertility a female problem only?
9. What are the most common causes of infertility?
10. Name a few herbal plants used to prevent infertility in women along with the active ingredients.
11. Write a brief account on the use of plants for treatment of infertility in men.

12. Name the source plant of the following natural products:
    a) Borhaavone, b) Berberine, c) Mexitine, d) Mucunine, e) Withanolide

9.8 Answers

1) Consult 9.1; 2) 9.3; 3) 9.3.1 list; 4) 9.4; 5) 9.4.1; 6) 9.4.1; 7)9.4.1; 8) 9.5; 9) 9.5; 10) 9.5.1; 11) 9.5.1; 12) 9.0.

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Unit 10 ❑ Application of natural products in controlling diabetes, hypertension, and skin diseases

Structure

10.0 Objectives

- From this unit you will learn about the diseases like diabetes, hypertension, skin diseases and their herbal remedies.
- After studying this unit, you will be able to learn about the parts used for medicinal purposes, phytochemical constitutions.
- You will acquire knowledge on different uses of medicinal plants for curing common but very harmful ailments.

10.1 Diabetes

10.1.1 Introduction

It is a chronic disease that occurs when our body cannot regulate blood sugar levels,

either due to insufficient production of insulin, or when the body cannot effectively use the produced insulin. *Hyperglycaemia* (raised blood sugar level) is a common effect of uncontrolled diabetes which over time leads to serious damage to many of the body's systems, especially the kidneys, eyes, nerves, and blood vessels. On the other hand, *hypoglycaemia* is a condition in which blood sugar (glucose) level is lower than the normal range. It is most commonly occurring in people with diabetes, and having issues with medicine, food, exercise etc. But sometimes people who do not have diabetes, can also get low blood sugar (termed nondiabetic hypoglycemia).

Diabetes may be of two basic types, **Type 1 diabetes** (*known as insulin-dependent or juvenile diabetes, occur due to deficient insulin production*) and **Type 2 diabetes** (*known as non-insulin dependent or adult-onset diabetes, occur due to deficient insulin production*), of which former type requires daily administration of insulin while the latter type (developed when body does not use insulin properly due to several reasons) can be managed by life style modification and / or with taking medicines.

10.1.2 Herbal remedy

Utilization of medicinal plants in the treatment of diabetes holds significant promise due to their diverse bioactive compounds and as such long been used in traditional systems of medicine to control diabetes. Some plants have been historically acknowledged for their potential in managing diabetes and associated complications. They often contain secondary metabolites with inherent hypoglycemic properties, aiding in regulating blood glucose levels. Several plants and secondary metabolites have shown effectiveness in improving insulin sensitivity, enhancing glucose uptake, and mitigating the adverse effects associated with diabetes.

Anti-diabetic actions of medicinal plant and herb extracts are presently used. Several studies have revealed that medicinal plant extracts have anti-diabetic effects and can restore pancreatic-cell function. A list of common medicinal herbs is given below –

Name of Plant	**Parts used**	**Active Principles**
Allium sativum (Liliaceae)	Bulb	Allicin, Allin, Diallyl disulfide, Ajoenes, Vinyldithiins, Selenium
Aloe barbadensis (Liliaceae)	Leaf pulp, Latex (aloe juice)	Glucomannan, High fiber content, Barbaloin (aloin A), Anthraquinones, Chromones, Tetrahydroanthracenones,

Name of Plant	Parts used	Active Principles
Azadirachta indica (Meliaceae)	Leaf, Fruit	Azadirachtin, Nimbolinin, Nimbin, Nimbidin, Nimbidol, Sodium nimbinate, Gedunin
Bauhinia forficata (Caesalpiniaceae)	Leaf, Stem bark	Kaempferol, Quercetin, Tocopherols, Terpenoids, Saponins, Flavonoids
Coccinia indica (Cucurbitaceae)	Leaf, Fruit, Stem, Root	Coccinioside, Lupeol, β-amyrin, β-sitosterol, Taraxerone, Taraxerol, Cephalandrol
Eugenia jambolana (Myrtaceae)	Fruit, Seed	Jamboline, Ellagic acid, Gallic acid, Betulinic acid, Epi-friedelanol, Friedelin, Eugenin, Dihydromyricetin
Gymnema sylvestre (Apocynaceae)	Leaf	Gymnemic acids, Gymnema-saponins, Gurmarin, Hentriacontane, Pentatriacontane
Momordica charantia (Cucurbitaceae)	Fruit, Seed	Momordicoside-S, T, Karaviloside-XI, Saponins, Triterpenes, Charantin, Vicine
Opuntia streptacantha (Cactaceae)	Flower, Stem, Fruit, Seed	High Fiber and pectin,
Pterocarpus marsupium (Fabaceae)	Stem bark	Marsupin, Pterosupin, Epicatechin, Retusin glucoside, Pterocarpol
Silybum marianum (Asteraceae)	Fruit, Seed, Leaves	Silymarin, Silybin, Silychristine, Silidianin
Tinospora cardifolia (Menispermaceae)	Whole plant	Palmatine, Barberine, Tinosporin, Magnoflorine, Choline, Jatrorrhizine, Tinosporides, Ttinosporon, β-Ecdysone
Trigonella foenum-graecum (Fabaceae)	Seed	Trigocoumarin, Scopoletin, Saponins, Glycosides, Gitogenin, Apigenin, Tricin

Diabetes is a growing public health concern in both developed and developing countries. According to a report of WHO (April, 2023), more than 422 million people have

diabetes worldwide. By 2030, the number of adults with diabetes is projected to increase to 643 million and 783 million by 2045. It is also estimated that 3.4 million patients died from diabetes-related complications in 2004, which is likely to be double by 2030, if no urgent action is taken. In this scenario, herbal medicines will probably through light in managing diabetes in developing as well as developed countries. Taken together, it seems that *Gymnema sylvestre*, *Momordica charantia*, *Silybum marianum* and *Trigonella foenum-graecum* etc. have acquired enough reputation for their hypoglycaemic action and physicians can advise them for patients to improve management of diabetes.

10.2 Hypertension

10.2.1 Introduction

This is commonly known as 'high blood pressure', is a serious medical condition which occurs when blood moving through the arteries places too much force against the artery walls. It is said to have high blood pressure, if their blood pressure readings are repeatedly above normal (120-129/80 mm Hg) for a long time. Two types of hypertension can be diagnosed i) primary / essential hypertension and ii) secondary hypertension. In the 90 - 95% of cases where no identiûable cause of elevated blood pressure can be observed, the condition is called "primary / essential hypertension". In contrast, "secondary hypertension" results from an identiûable cause, like presence of kidney disease, coarctation (narrowing) of aorta, metabolic disorders, speciûc enzyme deûciencies etc. Hypertension is one of the most important 'causes of premature death' worldwide and the problem is growing very fast; an estimated 1.56 billion adults will be living with hypertension in 2025.

In India, it is a major modifiable risk factor for cardiovascular and renal disease. Improved detection and treatment of hypertension in India would reduce a preventable burden of cardiac (congestive heart failure, coronary artery disease), cerebrovascular (ischemic and haemorrhagic stroke) and renal (chronic kidney disease) disease related to hypertension successfully. For the prevention of hypertension one can go initially for promotion of weight loss (in case of obese), reduced intake of salt, increasing exercise levels (in the sedentary), cessation of tobacco use, reduce alcohol consumption etc.

10.2.2 Herbal remedy

As in other chronic diseases, the management of hypertension in India is confronted with many difficulties, including the high cost of anti-hypertensive drugs, absence of

lifestyle (including stress management) and dietary measures, inadequate medical care infrastructure (especially in rural areas). Furthermore, side-effects from anti-hypertensive drugs have motivated researchers to find new medicines in metabolites or extracts of medicinal plants to control hypertension that have fewer side effects. Recently, several ethnobotanical studies performed in different parts of the world showed that hundreds of plants are traditionally accustomed for empirical hypertension treatment throughout the globe. Some examples of medicinal plant species used to manage hypertension worldwide are –

Name of Plant	**Parts used**	**Active Principles**
Allium sativum (Liliaceae)	Bulb	Organo-sulfur compounds like Alliin, Ajoene, Diallyl sulfide, Sallylcysteine
Berberis vulgaris (Berberidaceae)	Fruit	Berberine, Berbamine, Berberamine, Isocorydine, Lupeol
Carthamus tinctorius (Asteraceae)	Flower	Chalcone flavonoid, Carthamin, Carthamidin, Safflamin C, Luteolin
Cichorium intybus (Asteraceae)	Leaves	Lactucin, Lactucopicrin, Coumarins, Lignans, Caffeoylquinic acids, Cichoric acid
Curcuma longa (Zingiberaceae)	Rhizome	Curcumin, Desmethoxycurcumin, Curcumol, Borneol, Cyclocurcumin, Gallic acid, Zingiberene
Gnetum africanum (Gnetaceae)	Root	Diallyl disulphide, Azacyclopropidene, Epihedrine, Naringenin, Cyanogenic glycosides
Helminthostachys zeylanica (Ophioglossaceae)	Leaf, Rhizome	Ugonins A, J, M, U, Quercetin
Mitragyna rotundifolia (Rubiaceae)	Leaf, Bark	Rhyncophylline, Ajmalicine, Corynantheidine, Mitraphylline, Paynantheine, Mitragynine
Nigella sativa (Ranunculaceae)	Seed	Dithymoquinone, Thymoquinone, Thymol, Caracole, Thymohyd-roquinone, Tanethole, Nigellicine, Nigellimine, Avenasterol, Patuletin

Name of Plant	Parts used	Active Principles
Rauwolfia serpentina (Apocynaceae)	Root	Rescinnamine, Serpentinine, Deserpidine, Sarpagine, Ajmaline, Chandran, Reserpine, Ajmaline, Rescinnamidine, Phlobatannins
Santalum album (Santalaceae)	Wood	Santalol, Santalbic acid, Vitexin, Isovitexin, Orientin, Saponins
Thymus serrulatus (Lamiaceae)	Leaves	α-Pinene, α-Terpinene, γ-Terpinene, p-Cymene, Carvacrol, Thymol, Linalool
Tribulus terrestris (Zygophyllaceae)	Leaves	Saponins (Furostanol, Spirostanol, Tigogenin, Diosgenin), Kaempferol, Tribuloside
Withania Somnifera (Solanaceae)	Root	Withanine, Withananine, Withananinine, Pseudowithanine, Somnine, Somniferinine, and Somniferine
Zingiber officinale (Zingiberaceae)	Rhizome	Bisaboline, Zingiberene, Zingiberol, Gingerol, Shogaol, Zingerone, High potassium

As mentioned earlier, hypertension is a chronic but often asymptomatic medical condition in which arterial blood pressure is elevated beyond normal. If it remains unattended, it may lead to cardiovascular dysfunction and cause congestive heart failure, myocardial infarction, pulmonary embolism, cerebral aneurysm, kidney failure like conditions. Both the developed and developing countries have shown their interest for herbal drugs due to public dissatisfaction with cost of allopathic medicines, and interest in returning in to traditional and natural remedies. Here, we have seen the most commonly used plants and their phytochemicals for the management of hypertension.

10.3 Skin disease

10.3.1 Introduction

Skin disease is a broad term encompassing a wide range of conditions affecting the skin, hair, nails, and associated glands. Such conditions can vary significantly in terms

of their severity, underlying causes, and clinical manifestations. From minor irritations to chronic and weary disorders, skin diseases can affect individuals of all ages and backgrounds. Most common skin diseases include acne, wart, eczema, ringworm, psoriasis, rosacea, vitiligo, scleroderma, scabies, cellulitis, alopecia areata and so on. Skin diseases may be contagious (when caused by pathogens and spread through contact with infected person), e.g. ringworm, warts, …) and non-contagious (not caused by pathogens e.g. acne, eczema, bacterial cellulitis ….) depending on the cause and nature of spreads. Conventional treatment of skin diseases includes topical or oral / systemic medication, surgery, immunotherapy, hormonal treatment, radiation therapy etc. depending on the specific diagnosis.

10.3.2 Herbal remedy

Maintaining healthy skin is important for a healthy body, and herbals are high in active components for treatment of unhealthy skin conditions. For such purpose and also for curing skin diseases / disorders natural drugs from the plants are gaining popularity often having lesser side-effects, better tolerance, relatively less expensive and acceptable due to a long history of traditional use. For these reasons several plants have been investigated for treatment of skin diseases ranging from itching to skin cancer. Preparations for application to the skin include creams, ointments, pastes, gels, collodions, paints, lotions etc. but the effectiveness of topical medicines depends on how they are prepared and on their ingredients.

Name of Plant	Parts used	Used in	Active Principles
Allium cepa (Liliaceae)	Bulb	Boils, wounds, scar	Diallyl disulfides, Diallyl trisulfides, S-allylcysteine, S-Methylcysteine, Alliin, Alliuocide G.
Allium sativum (Liliaceae)	Bulb	Boils, psoriasis, alopecia	Ajoene, Diallyl disulfide, inyldithiins, Vitamins A, B, C
Aloe vera (Liliaceae)	Leaf	Atopic eczema, acne, psoriasis, wounds	Aloesin, Lupeol, Salicylic acid, Urea nitrogen, Cinnamonic acid
Azadirachta indica (Meliaceae)	Seed oil, Leaf	Itching, eczemza	Nimbin, Nimbidin, Quercetin

Name of Plant	Parts used	Used in	Active Principles
Curcuma longa (Zingiberaceae)	Rhizome, Volatile oil	Eczema, warts, alopecia, lichen planus	Curcumin, Curcuminoids (Diarylheptanoids), Monoterpines, Sesquiterpenes and Diterpines of volatile oil
Hemidesmus indicus (Asclepiadaceae)	Root	Acne, wounds	Para-methoxy salicylic aldehyde, 2-hydroxy-4-methoxy-benzaldehyde
Hydnocarpus kurzii (Flacourtiaceae)	Seed oil	Dermatitis, psoriasis, leprosy,	Hydnocarpic acid, Chaulmoogric acid, Gorlic acid
Lavendula officinalis (Lamiaceae)	Essential oil, phenol,	Leaf	Acne, psoriasis, scar Total Flavones, Coumarin
Lawsonia intermis (Lythraceae)	Leaf, Stem bark	Hair loss, wounds	Quinone, Apigenin, Luteolin, Lawsone, Harmine, Harmaline
Matricaria chamomile (Asteraceae)	Leaf, Root	Eczema, acne, rosacea	Chamomile, Chamomillol, Farnesene, Berkheyaradulene
Rosmarinus officinalis (Lamiaceae)	Essential oil, Leaf	Hair loss, dermatitis, acne	Carnosic acid, Caffeic acid, Rosmarinic acid, Ursolic, Oleanolic, Micromeric acids
Saraca asoca (Caesalpiniaceae)	Leaf, Bark	Wounds, ulcers, dermatitis	Flavonoids, Steroidal glycosides, Gallic acid, Ellagic acid
Thymus vulgaris (Lamiaceae)	Leaf	Acne, alopecia, herpes	Camphor, Thymol, 1,8-cineole, Camphene, Carvarcrol

Skin disease is a common ailment which impact peoples of all ages causing harm in a number of ways. There are more than a thousand conditions that may affect our

skin, which can be eczema, rashes, pigmentation problems, tumour, warts and even cancer. Medicinal plants being rich source of active phytochemicals are considered as safer and cost-effective treatment for skin diseases ranging from rashes to dreadful skin cancer. The list above of plants provided evidence that herbal medicinal plants play an important role in the healthcare system even today.

10.4 Summary

Many clinical studies have been carried out in the recent past that revealed positive correlations between the usage of medicinal plants and improved blood glucose control, which has led to an increase in the use of more 'natural' ingredients to help manage their condition. However, according to the Expert Committee on Diabetes of the WHO, more clinical, pharmacological, toxicological assessment, biological standardization studies on traditional medicinal herbs is needed right now.

Traditional uses as well as modern study validated that herbal medicines could have great potentials to cure and maintain hypertension. Many secondary metabolites including flavonoids, alkaloids, carotenoids have found to exert antihypertensive effects *in vivo*. Use of plant-based natural compounds as protective and anti-hypersensitive agents is now becoming an exciting strategy for exploring more and more plant-based products.

Herbs have a lot of potential for treating a variety of skin conditions. In India, more than 80% of people rely on and employ a variety of plant-based medicines to treat skin disorders. Ethno-medicinal studies have also shown that herbal medicine is an alternative therapy for treatment and control of skin ailments. Pharmaceutical industries have developed huge diversity of medical agents using crude extract of plants as well as active principles for treatment of various skin diseases. Medicinal plants are considered as wealthy methods of traditional medicines and from such plants many of the new medicines will be coming out in the near future.

10.5 Questions

1. What causes diabetes in human being?
2. What herbs are used to treat diabetes?
3. Name any two common herbs used to treat diabetes along with their parts used and active ingredients.

4. Which plants are considered as 'herbs of choice' for management of diabetes?
5. Which chemical constituent of aloe are antidiabetic?
6. Mention the cause of secondary hypertension.
7. State the major adverse effects of high blood pressure?
8. Write the parts used and active principles of *Curcuma longa* and *Rauwolfia serpentina*.
9. Name the plants of which both barks and rhizomes are used for treatment of hypertension.
10. Write the scientific names of the herb where borneol, thymol, naringenin, serpentine is present as one of the active phytoconstituents.
11. What do you mean by skin diseases? Give examples of one infectious and one non-infectious skin disease.
12. Name are the herbs used to treat acne?
13. What is essential oil? State in brief about role of essential oil in curing skin diseases.
14. Mention the medicinal properties of *Santalum album*, *Tinospora cordifolia*, and *Allium sativum*. Which ailments are they suitable for?
15. Write the scope and uses of three common kitchen herbs for treatment of different skin problems.

10.6 Answer

1) See 10.1.1; **2)** 10.1.2 list; **3)** 10.1.2 list; **4)** Last para of 10.1.2; **5)** 10.1.2; **6)** 10.2.1; **7)** 10.2.1; **8)** 10.2.2; **9)** List of 10.2.2; **10)** 10.2.2; **11)** 10.3.1; **12)** 10.3.2; **13)** 10.3.2; **14)** 10.1.2 + 10.2.2 and 10.3.2; **15)** Unit 10.

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Unit 11 ❑ Some important medicinal plants of India with their geographical distribution and uses

Structure

11.0 Objectives

- From this unit you will information about some of the Indian medicinal plants and their distribution.
- After studying this unit, you will be able to learn about the parts used for medicinal purposes, phytochemical constitutions.
- You will acquire knowledge on different uses of medicinal plants for curing common ailments.

11.1 Introduction

Medicinal plants have been the keystone of health care since ancient times. Such plants have been used in India for centuries, and many common Indian plants are used in traditional medicine as well. Their uses have been documented and transformed through the generations for over 4000 years. However, from the early 19th century, with the beginning of scientific investigations, numerous plant-based drugs became available to cure a large number of diseases throughout the globe. The 21st century started with an exploration of these traditional remedies to meet patient needs. Now we are in an era where science and technologies side by side started to make clear the safety and efficacy of traditional medicines, though much more information on the uses of medicinal plants in various health practices remains unregistered. Since India has many medicinal plants that are used in herbal medicine, in this section an overall idea of some of the selected medicinal plants and their geographical distribution, uses / application will be provided.

11.2 *Acorus calamus* (Bach)

Family: Acoraceae

11.2.1 Distribution

Genus *Acorus* is native to most northern latitude countries around the world. *Acorus*

calamus is native to the southeastern USA, growing wild in wet areas in lake, ponds, river, swamps, marshes, ditches, and similar others environment. *A. calamus* is found wild throughout India, Nepal, different parts of Central Asia, Southern Russia, Siberia, Europe, North America, and Ceylon at an elevation up to a height of 6000 feet MSL (Mean Sea Level). Now a days, it is being cultivated as a promising medicinal crop, especially for marshy land.

In India, *A. calamus* is grown abundantly in the marshy tracts of Kashmir, in certain areas of Manipur, the Naga Hills and Sikkim up to an altitude of 5000–7500 feet.

11.2.2 Parts used & Uses

Parts used : Mainly Rhizome, but roots, leaves, flowers, and fruits are also used.

Uses : *Acorus calamus* has a long history of use in China, Nepal, and India as a traditional medicinal herb for a wide variety of ailments. It contains (Z)-methyl isoeugenol, Epi-shyobunone, Elemicin, Preisocalaminidiol, asarone, acoradin, galangin, and several other phytochemicals along with volatile essential oil.

a) This herb is used for increasing appetite, and also as an aid to the digestion.

b) Rhizome part is used to treat several diseases like asthma, bronchial catarrh, bronchitis, as well as a sedative. Powdered rhizome is also used for toothache and for congestion.

c) Bach is applied for treatment of epilepsy, mental ailments like memory disorders, on learning performance, intellectual health, dementia; chronic diarrhoea, dysentery, stomach cramps and cholic, strangury tumours.

d) Leaves, rhizomes, and its essential oil has also antifungal, antibacterial, antiviral, tranquilizing, carminative, anti-dyslipidaemia, neuroprotective, antioxidant, anti-cholinesterase, antispasmodic / spasmolytic, vascular modulator activities.

e) Various extract of *Acorus calamus* is traditionally used for the antidiabetes (insulin sensitizing), antiproliferative, immunosuppressive, hypolipidemic, mitogenic and anticarinogenic activity towards human lymphocytes.

f) Different extract forms possess the insecticidal properties, act as fish toxin also.

g) Commercially available as Krush capsules, Brainokan, Vach oil, Mahavishgarba Oil etc.

11.3 *Justicia adhatoda* (= *Adhatoda vasica,* Vasaka)

Family: Acanthaceae

11.3.1 Distribution

This plant is native to Indo-Himalayan belt, and widely distributed in India, Nepal, Bangladesh, Pakistan, Sri Lanka, Laos, Myanmar, Vietnam, Afghanistan, China mainly.

In India it is distributed in all most all the districts of West Bengal, Andhra Pradesh, Kerala, Odisha, Tamil Nadu, Manipur, and several others.

11.2.2 Parts used & Used

Parts used : Mainly leaves, but flower, bark, roots are also used in ayurvedic medicines.

Uses: This plant has been utilized in traditional Ayurvedic, Unani, and Siddha medicine systems for centuries and is also being used in European medicine. Its medicinal properties are due to presence of active principals like vasicine, vasicinone, adhatodine, adhatonine, adhavasinone, anisotine, peganine, vasicinol, astragalin, kaempferol, quercetin, vitexin, á-amyrin etc.

a) Leaves, roots, flowers, and bark of this plant have long been used in cough, colds, asthma, liquefying sputum, as bronchodilator, bronchial catarrh, bronchitis, and tuberculosis.

b) Leaves of the plant are commonly used for curing bleeding, haemorrhage, skin diseases, wounds, headache, and leprosy in Southeast Asia.

c) Usually, yellow leaves are exploited for cough, and smoke from leaves is used for treating asthma.

d) Leaves are used for stomach catarrh with constipation, gout, urinary stone, checking postpartum haemorrhage and urinary trouble.

e) Paste, powder and decoction of root is used for curing tuberculosis, diphtheria, malarial fever, leucorrhoea, and eye diseases.

f) Fresh flowers are used for ophthalmia and various preparations of flowers are used for treatment of cold, asthma, bronchitis, cough, antispasmodic, fever, and in gonorrhoea.

g) Fruits are used for curing cold, antispasmodic, bronchitis, jaundice, diarrhoea, dysentery, fever and as laxative.

11.4 *Aloe vera* (= *Aloe barbadensis,* Ghritakumari)

Family: Liliaceae

11.4.1 Distribution

Aloe vera plant is native to the Arabian Peninsula, Africa, and Madagascar, but abundant in the Hajar Mountains of the United Arab Emirates and Oman. However, it has been cultivated and naturalized in many other areas, including North Africa, Europe, Barbados, Texas, India.

In India it is found in Assam, Mizoram, Rajasthan, Andhra Pradesh, Gujarat, Maharashtra, Tamil Nadu, and West Bengal (South Bengal).

11.4.2 Parts used: Leaves, and fleshy parts

Uses: Chemical composition of *Aloe vera* can vary depending on the environmental conditions, cultivation methods, harvesting and processing, and storage conditions. Major chemical constituents include aloin, emodin like alkaloids, polysaccharides (glucomannans, acemannan), aloesin, aloeresin like glycosides, flavonoids, coumarins, sterols, vitamins (A, C, E, B12), minerals, etc. This plant produces at least 6 antiseptic agents such as salicylic acid, cinnamonic acid, lupeol, urea nitrogen, phenols, and sulphur. *Aloe vera* has been used for medicinal purposes since ancient times, and is known as the "healing plant" or "silent healer".

a) Mucilaginous gel is employed to soothe skin, to treat eczemza, burns, sunburns, irritation and wounds, other anti-inflammatory skin problems. It can also help to hydrate skin and calm inflammation caused by breakouts. Anti-inflammatory compounds 'anthraquinones' mainly help to reduce inflammation.

b) *Aloe vera* juice is an aid for digestion, and can relieve hyperacidity, ulcers, and gastroesophageal reflux disease (GERD).

c) It has laxative properties and can help to treat constipation, especially if it is related to Irritable Bowel Syndrome (IBS). Products containing aloin, aloe-emodin, and barbaloin are available as oral OTC laxatives.

d) Antioxidants present in 'aloe gel' (made from central part of leaf) and 'aloe juice' (a yellow, bitter liquid from the skin of leaf) can boost immune system and detoxify body.

e) *Aloe vera* has shown therapeutic properties including anti-cancer, anti-diabetic, anti-hyperlipidemic activities.

Plant extract helps to lower unhealthy LDL cholesterol and triglycerides while

boosting heart-friendly HDL cholesterol by reducing the absorption of cholesterol by the intestines.

f) Plant extracts found to support weight management through alteration of sugar and lipid-triglyceride regulation.

g) Exploited as a dietary supplement in pre- and post-operative patients, postmenopausal women and in cases of osteoporosis.

h) 'Aloe vera gel' is used as an ingredient in commercially available lotion, moisturizers, soaps, sunscreens, yogurt, beverages and some desserts as well.

11.5 *Atropa belladonna* (Belladona)

Family: Solanaceae

11.5.1 Distribution

Belladona is native to temperate Europe, North Africa, Turkey, Iran, and the Caucasus. In Britain it is native only on calcareous soils, on disturbed ground, field margins, hedgerows, and open woodland. It is naturalized in parts of North America, where it is often found in shady, moist locations with limestone-rich soils. It is now introduced outside its native range and cultivated successfully.

As mentioned earlier, it is not native to India, but growing commendably in Western Himalaya starting from Simla to Kashmir and adjoining Himachal Pradesh, Uttarakhand and several other states.

11.5.2 Parts used & Used

Parts used : Root of *Atropa belladonna* is used to make the drug 'belladonna', but the leaves and fruits also contain the alkaloid "atropine".

Uses : *Atropa belladonna* is an indispensable medicinal plant whose potential as a therapeutic plant is well documented. More than 20 alkaloids have been found in the roots, leave, and fruits of which most important are 'atropine, scopolamine (hyoscine) and hyoscyamine'. These alkaloids act as 'muscarinic antagonist'. Besides, it contains small amounts of volatile bases such as pyridine and N-methylpyrroline, along with scopoletin (â-methylaesculetin), calcium oxalate etc. Since belladonna is poisonous (neurotoxic), the varying doses used in herbal remedies can cause serious side effects including seizures, breathing problems, agitation etc. and hence, must be carefully monitored by a doctor.

a) Atropine, a tropane alkaloid extracted from belladonna, reported to have anticholinergic and spasmolytic properties, and used to dilate pupil in the treatment of eye related disorders.
b) Belladonna has been used to treat pain, including neuralgia, sciatica, joint pain, rheumatism, and gout.
c) It is used to treat inflammatory diseases such as otitis media, peritonitis.
d) Belladonna is in use to relax muscles and to treat muscle spasms in the stomach, intestine, and bile duct etc.
e) In ancient Europe, the fumes from burnt *Atropa belladonna* plants were inhaled to relieve bronchoconstriction.
f) It has been used to treat menstrual problems.
g) Preparation of *Atropa belladonna* is used to treat nervous diseases such as palsy, apoplexy, epilepsy, asthma, whooping cough, hydrophobia, melancholy, and mania.

11.6 *Cymbopogon citratus* (Dhanwantari)

Family: Poaceae

11.6.1 Distribution

Cymbopogon citratus is commonly known as 'Lemon grass' in India. It is a perennial fragrant (aromatic) grass native to Asia mainly Indochina, Indonesia, Malayasia, Thailand, Burma, Africa, America, and Sri Lanka. It is now widely grown throughout temperate, tropical, and subtropical regions of the world. However, the most suitable elevation for commercial cultivation is between sea level and 1000 feet.

In India lemon grass is cultivated in West Bengal, Assam, Odisha, Sikkim, Arunachal, Pradesh, Maharashtra, Kerala, Karnataka, Tamil Nadu, parts of Uttar Pradesh, Uttaranchal mainly.

11.6.2 Parts used & Used

Parts used : Mainly leaves, but leaf bases (stalks), young shoots are also applied for flavouring dishes.

Uses: Lemon grass essential oil contains neral, geranial, isoneral, isogeranial, geraniol, geranyl acetate, citronellal, citronellol, germacrene-D, and elemol making up about 60–80% of the essential oil. Minor components comprise of camphene, pinene, limonene, linalool, citronellyl acetate, elemene, and caryophyllene oxide. It has many

uses, including in traditional medicine, pharmaceuticals, aromatherapy, modern perfumery, flavouring agents for food, soap, cosmetics etc.

a) Essential oil and leaf extract have shown antimicrobial properties and thus, used as an antibacterial, antifungal, and antiviral agent on many occasions. Leaf extract can inhibit the growth of *Bacillus cereus*, *Escherichia coli*, *Klebsiella pneumoniae, Candida albicans, Aspergillus sp., Fusarium sp., Cochliobolus lunatus* like pathogenic microbes.

b) In traditional medicine, leaf and essential oil are preferred for treating cough, fever, vomiting, headache, and even insomnia and depression.

c) Tea prepared from the leaves of *C. citratus* is drunk for its antispasmodic, anti-inflammatory, and analgesic effects. Indians also give children lemongrass tea with slices of lemon to heal stomatitis.

d) Aqueous suspension (10%) of lemon grass essential oil has a total herbicidal effect on many weed species such as *Digitaria horizontalis*, *Sorghum halepense, Bidens pilosa, Euphorbia heterophylla* and *Raphanus raphanistrum* etc.

e) Volatile oil of *C. citratus* used to repulse insects like cockroach, housefly, and mosquito.

Besides, *in vitro* experiments have demonstrated its larvicidal activity [$(LC)_{50}$ value of 0.41 ìl/cm^2], and as such lemon grass oil is applied as a better ecofriendly alternative of chemical insecticides / insect repellents.

f) Macerated leaves reduce swelling, mosquito's bites, wounds, and eczema.

g) Aqueous leaf extract offers to control blood glucose level (in type 2 diabetes) and LDL level.

11.7 *Phyllanthus urinaria* (Hazarmani)

Family: Euphorbiaceae

11.7.1 Distribution

Recorded in Asia-Temperate (China, Tibet, Japan, Korea, Taiwan), Asia-Tropical (India, Pakistan, Bangladesh, Myanmar, Maldives, Vietnam, Philippines, Sri Lanka, Andaman-Nicobar Islands), Australia, South America. Species of the Asiatic section has been introduced and naturalized in tropical Africa, Northern America (Mexico, Kansas), Central America, South America etc.

In India it is known as 'bhumyamalaki' which occurs naturally in West Bengal, Assam, Odhisa, Kerala, Uttar Pradesh, Madhya Pradesh, Gujrat, and Rajasthan etc.

11.7.2 Parts used & Uses

Parts used: Root, stem, and leaf

Uses: Multiple functional compounds with medicinal effects, such as flavonoids, carboxylic acids, tannins, coumarins, and lignans, have been isolated from *P. urinaria*. Excoecarianin, Phyllanthusiin-C, Repandinin, Rhamnocitrin, Rutin, Quercetin, Naringin, Kaempferol, Phyllanthin, Nirtetralin, etc. are considered as the major bioactive compounds. Not only the *P. urinaria* but also many of the other species have been used in traditional medicine for a long time. This plant has been used to treat a wide range of ailments are given below.

a) Traditionally used to treat jaundice, ulcers, skin diseases, diabetes, chest pain, and urinary tract stone like urinary complications.

b) Bhumyamalaki is also employed in Asia to protect the liver and to treat hepatitis B. Liver damage caused by poor eating habits, heavy metal intoxication, alcohol intake or obstruction of biliary tract are treated with plant extract.

c) Plant extracts, and purified phytochemicals have significant growth inhibitory potential against various types of cancer cells including lung, breast, colon, liver, prostate, skin, and ovarian carcinomas.

d) Diabetes mellitus is caused by deficiency of insulin secretion and / or decreased response of organs to insulin can be cured by *P. urinaria*. It is established that hypoglycemic activity of *Phyllanthus urinaria* occurs via enhanced glucose metabolism and the suppression of glucose absorption in the gut.

e) Geraniin from *P. urinaria* displays anti-hypertensive effects, lowering systolic and diastolic blood pressures.

f) Treatment with *P. urinaria* extract markedly control peptic ulcers and some type of gastric cancer. It is to be noted that the *Helicobacter pylori*, a bacteria associated with the majority of peptic ulcers, shows antibiotic resistance worldwide. Extract of *P. urinaria* found to inhibit bacterial (*H. pylori*) adhesion and invasion to AGS cells *in vitro* successfully.

g) Infusion of *P. urinaria* is known for its several therapeutic potentials and thus employed as an antimutagenic, antioxidant agent. Antioxidant activity is attributed to its total phenolic and flavonoid content, while ellagitannins is responsible for its antimutagenic activities.

11.8 *Stephania japonica* (Akandi)

Family: Menispermaceae

11.8.1 Distribution

Globally it is distributed in Asia-Temperate (China, Japan, Korea) Asia-Tropical (India, Bangladesh, Nepal, Sri Lanka Andaman Nicobar Islands, Cambodia, Java, Sumatera, Taiwan), Australasia.

In India *Stephania japonica* plant is found in West Bengal, Assam, Arunachal Pradesh, Karnataka, Kerala, Maharashtra, Tamil Nadu.

11.8.2 Parts used & Uses

Parts used : Leaf, root, and whole plant.

Uses : Roots, tubers, and leaves of *S. japonica* contain alkaloids, steroids, and fats. Stems contain benzylisoquinoline alkaloids, stephasubine and dihydro-stephasubine, saponins, steroids and fats. Roots contain the alkaloids like fangchinoline, dltetrandrine, d-tetrandrine and disochondrodendrine. Aerial parts and roots of the plant contain aknadinine, epistephanine, hernandifoline, magnoflorine, aknadinine, aknadine and aknadicine. This plant is traditionally used to treat a variety of ailments.

a) Leaves and roots are bitter and astringent; used in fever, diarrhoea, urinary diseases, and dyspepsia.

b) According to Ayurveda and Sidha, a variety of ailments, including bowel disorders, dysentery, and heart troubles may be treated with this plant.

c) Leaves are mounted on the abscess and kept for bursting. Fresh leaves are also macerated in a glass of water and are taken after mixing with molasses to cure urethritis.

d) Plant extract is exploited as insecticide which acts against *Callosobruchus chinensis* (pulse beetle) and fruit flies very effectively.

e) Herb exhibit neuroprotective effect by reducing oxidative stress, neuroinflammation and inhibiting cholinesterase activity.

f) In Ayurveda and Sidha, *S. japonica* is put to use as hypotensive and spasmolytic.

g) Crushed leaves in water form a slightly gelatinous mass which is applied to cure breast infections.

11.9 *Withania Somnifera* (Aswagandha)

Family: Solanaceae

11.9.1 Distribution

This plant is native to India, Bangladesh, Sri Lanka, Pakistan, China, Palestine, Afghanistan, Iran, Saudi Arabia, Zambia, Zimbabwe like countries, but introduced later on in Mauritius, New South Wales, South Australia.

In India, it is widely distributed throughout the drier parts in subtropical regions and upper Gangetic Plains. It is easily available in West Bengal, Assam, Maharashtra, Karnataka, Kerala, Tamil Nadu, Punjab, Gujrat, Rajasthan, and other states.

11.9.2 Parts used:

Uses: *Withania somnifera*, also called 'ashwagandha' is a prominent medicine in India's Ayurvedic system. Various phytochemical investigations showed the presence of withanolides, withanine, withananine, hydroxywithanone, epoxywithanon, somniferiene, somniferinine, anaferine, anahygrine, steroidal lactones, saponin, flavonoids, tannin, phenolics, â-sitosterol, scopoletin, tropanol, and cysteine and several others. This plant is grown as a medicinal crop in India, mainly for its fleshy roots that contain bioactive compounds. India is the world's largest producer of Ashwagandha, exporting it to other countries.

a) Ashwagandha is used as an 'adaptogen' due to its rejuvenating activities. In Ayurvedic and Unani preparations, it is added as an ingredient to cope up stressful situations and to calm the nerves.
b) Ashwagandha is capitalized to stimulate growth in children.
c) This plant has anti-tumour, anti-inflammatory, anti-bacterial, fungicidal, anthelmintic, anti-convulsant, immunomodulatory and anti-pyretic properties.
d) With the fruits of ashwagandha skin ulcers, tumours, and carbuncles are treated successfully.
e) Paste prepared out of its leaves is exploited for curing inflammation of tubercular glands, while that of its roots for curing skin diseases, bronchitis, ulcer, dyspepsia, and also eye diseases.
f) Leaves are reported to contain anthelmintic and febrifuge properties, and hence taken by the tribals regularly.
g) An infusion of the bark is given for treatment of asthma.

11.10 Summary

According to WHO, traditional medicine is the knowledge, skills and practices based on the theories, beliefs, and experiences indigenous to different cultures, employed in the maintenance of health and in the prevention, diagnosis, improvement, or treatment of physical and mental illness. There are many different systems of traditional medicine, and the philosophy and application of each are influenced by the prevailing conditions, environment, and geographic area. But most of the systems rely on a common philosophy that is a 'holistic approach to life' and as such concentrate on human health rather than on disease.

Traditionally and also currently the herbal medicines are applied for treatment of chronic and acute conditions, and several ailments such as cardiovascular disease, hypertension, inflammation, urinary and prostate problems, mental illness and depression, cancer, microbial attacks, diabetes, liver, lung, eye diseases, weight management / obesity, oxidative stress, and also to boost our immune system and so on so forth.

In this resume, we have discussed the geographical distribution of several medicinal plants of traditional uses (like vasaka, belladonna, akandi, aswagandha etc.) to know their availability around the globe as well as in India, so that one can avail the resource for utilization. Furthermore, we have seen the secondary metabolites, aromatic substances important for pharmacological actions of the concerned herb. Despite of all, with the growing popularity of herbal medicine, the 'traditional' ways of identification and preparation of herbs, traditional application methods etc. need to be replaced with more accurate and reproducible scientific methods in order to ensure quality, safety, and consistency of the product.

11.11 Questions

1. Mention the family and distribution of *Acorus calamus*.
2. Name the plant parts of 'bach' used in traditional medicine.
3. Write the commercially available forms of *Acorus calamus*.
4. Name the active principles of *Justicia adhatoda*. Mention some common uses of it.
5. Why *Aloe vera* is known as "healing plant"?
6. What is atropine? Mention its uses in medicine.
7. Write the family and distribution of *Cymbopogon citratus*.

8. Give an outline idea of uses of lemon grass.
9. Name the bioactive components of 'bhumyamalaki'.
10. Write the scientific name of aswagandha. State its Indian distribution.
11. Which phytochemicals of *Withania somnifera* are responsible for its 'adaptogen' nature.
12. Mention the medical application of leaves of *Stephania japonica*.

11.12 Answers

1) Consult 11.2 and 11.2.1; 2) 11.2.2; 3) 11.2.2; 4) 11.3; 5) 11.4.2; 6) 11.5.2; 7) 11.6.1; 8) 11.6.2; 9) 11.7.2; 10) 11.9; 11) 11.9.2; 12) 11.8.2

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Unit 12 ❑ Medicinal Plants and Polyherbal Formulations – Brief introduction about Polyhedral Formulations with Examples

Structure

12.0 Objectives

- From studying this unit, you will be able to know about:
  - Polyherbal formulations and polyherbalism
  - advantages of polyherbal formulations over single herbal formulations
  - drawback of polyherbal formulations
  - examples and modern uses of polyherbal formulations

12.1 Introduction

Polyherbal formulation (PHF) is a method of herbal medicine preparation using more than one herb in a specific ratio. It is a traditional therapeutic strategy of *Ayurveda* and other traditional medicinal systems. This concept of polyherbalism is based on the notion that combining multiple herbs can achieve greater therapeutic efficacy than using individual / single herb at a time.

'Ayurveda' adopts a holistic approach to healthcare, and assume that living a long healthy life can be achieved by balancing "*Panchamahabhutas*" [the five elements - *Vayu* (air), *Teja* (fire), *Aap* (water), *Prithvi* (earth) and *Akasha* (aether)] or by preventing causes of imbalance of "*Tridosha*" [*Vata* (responsible for body movement), *Pitta* (responsible for bodily chemical reactions such as metabolism and temperature) and *Kapha* (responsible for growth, protection, lubrication, and sustenance)]. The idea is that well-being is achieved if balance exists between the three fundamental '*doshas*,' while imbalance causes disease. Based on these *Panchamahabhutas* and *Tridosha*, the *Prakriti* of an individual is determined and a unique treatment plan can be prescribed accordingly.

12.2 Herbal drugs of Ayurveda

We are familiar that 'herbal drugs' have existed world-wide with long recorded history of ancient Chinese, Greek, Egyptian and Indian medicine for various therapy purposes. Ayurvedic treatments regularly involve the use of natural remedies, including herbs, minerals, animals, and dietary guidelines. This approach aligns with the belief that nature provides the necessary elements for healing. Indian *Ayurvedic* system has included herbals as one of its most powerful healing ingredients, which are recorded in the literature such as Vedas and Samhitas. In India, more than 15,000 medicinal plants have been recorded, of which about 50% plants are used by the tribal communities for curing different diseases. It is acclaimed that in *Ayurveda* about 700 types of plant are listed in its medicinal systems.

With today's scientific progress, more and more pharmacologically active ingredients of the Ayurvedic medicines as well as their usefulness in drug therapy has become more comprehensive. Phytochemical constituents of the 'herbal drugs' which are responsible for desired healing effects are now known to some extent in several plants. A single herb usually contains more than one of the active principles / pharmacologically active constituents (alkaloids, flavonoids, terpenoids, sesquiterpenoids, tannins, saponins, phenolics etc.) which works synergistically with each other in producing desired pharmacological action. For example, saponin glycosides present in *Terminalia arjuna* enhance the function of heart muscle, while flavonoids of it provide antioxidant and vascular fortification effects.

12.3 Concept of Polyherbal Formulation

The historical Ayurvedic texts, dating back to 14th century, have pointed out the idea behind polyherbalism within our old healthcare system. Ayurvedic drug formulation normally stick to two fundamental principles: i) using a single medicinal substance, and ii) utilizing a combination of multiple drugs, of which latter referred to as Polyherbal Formulation (PHF). This traditional therapeutic strategy exploits the combining of several herbs to achieve extra therapeutic effectiveness, which is known as "polyherbalism."

Modern scientific studies have demonstrated that combining plants with varying potencies might perhaps yield superior results compared to their individual use or the sum of their effects. This positive interaction between herbs, known as "synergism", becomes evident when certain pharmacological actions are significant only in combinations, but not in isolation. It is now apparent that use of PHF enables better therapeutic effects with lower doses, reducing the risk of adverse side effects. Thus, PHF enhances comfort of a patient by eliminating the requirement of taking multiple single herbal formulations concurrently, alongside with improved compliance and therapeutic effectiveness. As a result, PHFs have gained popularity in the marketplace in contrast to their single herbal counterparts.

12.4 Advantages of using Polyherbal Formulations

As mentioned earlier, PHF is gaining popularity worldwide, due to some advantages which is not available in other versions of medicines.

1) **Safety and better therapeutic effect:** Active phytochemical constituents of individual plants may not be enough to achieve the desired therapeutic effect. Combining multiple herbs in a specific ratio can improve the therapeutic effects. From a statistical study conducted (2009) in UK, it was realized that the main reason underlying the use of medical herbalism is its effectiveness and favourable outcomes of the treatment.
2) **Therapeutic range**: Polyherbal formulations are effective against a wide range of diseases and safe for long term treatment. Most of them are effective even at a low dose and safe at high dose, thus they have superior risk to benefit ratio.
3) **Lower toxicity:** Combining multiple herbs can reduce toxicity and fewer side

effects as compared to allopathic drugs. NSAID (non-steroidal anti-inflammatory drugs) used for rheumatoid arthritis (RA) induces dyspepsia, gastric irritations, salt and fluid retention, hypertension like side effects. On the other hand, use of PHF available for treatment of RA created less or no side effects.

4) **Lower dose:** A lower dose of the herbal preparations may be needed to achieve the desired pharmacological action.
5) **Convenience:** Patients do not need to take more than one different single herbal formulation at a time.
6) **Cheaper**: Polyherbal formulations are comparatively cheaper than other allopathic medicines. Ingredients are readily available from nature.
7) **Eco-friendly**: Since, PHFs are the products of nature, these are always considered eco-friendly.

Of the aforesaid reasons, higher compliance and excellent therapeutic effect made PHF an ideal treatment of choice. Furthermore, polyherbal formulations have been used to treat a variety of ailments, including diabetes, wound care, hypertension, cardiovascular disorders, anxiety, neurological imbalances, disorders related to the gastrointestinal tract, respiratory tract, endocrine system, anti-bacterial, anti-fungal and several others. They are more affordable and accessible than costly modern treatments, and are culturally and socially acceptable. As a result, the PHFs are gaining importance throughout the globe.

12.5 Drawbacks of Polyherbal Formulations

Despite the beneficial aspects of PHF mentioned above, there are some unavoidable drawbacks, affecting their ability and efficacy in treatments. Such problems lie within the PHFs' sources and manufacturing process, patients, Ayurvedic practitioners, as well as the law and regulations.

Lack of standard preparations: Clinical reproducibility of PHFs is hard to achieve due to lack of standard preparation of PHFs. Selection of herbal material for PHFs, including habitat of the plant, season of growth, harvesting conditions, method of storage, pharmaceutical processing etc. exert profound effect on phytochemicals / active principles of the herbs; and thus, it is not easy to standardize the end product with reproducible quality.

Possible Drug-Herb Interactions: Simultaneous use of PHFs along with allopathic drugs is increasing day by day, as most of the patients do not inform their doctor

about concomitant treatments. Such uses lead to possible "drug-herb interactions" resulting into the adverse effects that deteriorate health. It is now known that many Ayurvedic herbs commonly used in formulation of PHFs are reported to contribute to drug-herb interactions. For example, *Hypericum perforatum* used in PHF for treatment of depression but induces hepatic microsomal enzyme cytochrome P-450, thus increasing the metabolism of certain drugs such as digoxin and theophylline, rendering them less effective.

Toxicity of PHF: It prevails but remained unsolved. In fact, heavy metals in Ayurvedic pharmaceuticals are not allowed, even in trace amount, to avoid toxicity. But in reality, heavy metals remain present in the formulations, which comes from either starting material (as the plants may grow in heavy metal infested soil) or some heavy metals are added intentionally for their therapeutic applications.

Lack of scientific validation: Many polyherbal products are not scientifically validated, which can lead to adverse effects in patients.

Adulteration: Herbal products are sometimes adulterated with wrong species or with other medicines, which can lead to adverse reactions.

Lack of strict vigilance: In India, regulation of Ayurvedic herbal manufacturing is not very strict even after enforcement of Drugs and Cosmetic Act. For example, undetected adulteration, substitution, contamination and short cuts during manufacturing are common.

12.6 Examples of some Polyherbal Formulations

Nature of Formulations	Name of Formulation	Ingredients	Pharmacological action
Tablet	Fast dissolving	Curcumin, Quercetin, Rutin SD complex, Crospovidone, Mannitol, Lactose, Magnesium stearate, Tale, Saccharine	Anti-inflammation, Anti-immunodeficiency, Anti-cancer, Anti-mutagenic
Tablet	Osteoporosis	*Nigella sativa*, *Zingiber officinalis*, *Curcuma longa*, *Terminalia chebula*, Kukkutandatvak bhasma, Calcium phosphate dibasic, Calcium carbonate, Starch, Magnesium stearate, Gum acacia	Cure bone fracture, osteoporosis, calcium deficiency

Nature of Formulations	Name of Formulation	Ingredients	Pharmacological action
Capsule	Hepatoprotective	*Andrographis paniculata, Emblica officinalis, Curcuma longa*, mannitol	Hepatoprotective activity
Capsule	Digestive	*Terminalia chebula, Terminalia belerica, Emblica officinalis*	Help in digestion, remove constipation
Syrup	Antacid	*Ficus glomerata, Rubia cordifolia, Hemidesmus indicus, Cuminum cyminum*	Quick relieves heartburn
Cream	Face cream	*Psidium guajava, Ocimum gratissium*, Steric acid, Liquid paraffin, Soft paraffin, Methyl paraben, Propyl paraben, Orange oil	Antioxidant, Antiseptic, Anti-inflammatory, Antimicrobial
Cream	Antiaging	*Punica* extract, Neem oil, Eucalyptus oil, Jamul powder, Glycerine, Propylene glycol, Methyl cellulose, Sodium alginate, Beeswax, Grape seed oil, Almond oil, Carrot powder, Lemon grass oil, Rose oil	Avoid aging of skin
Gel	Anti-inflammatory	*Berberis aristata, Boswellia serrata, Rubia cordifolia*	Anti-inflammatory, Anti-oxidant, Anti-cancerous
Suspension	IBS	Burma dhaniya (*Eryngium foetidum*), Sapota (*Manilkara zapota*), Curry leaves (*Murraya koenigii*)	Inflammatory bowel disease
Suspension	Antispasmodic	*Rubia cordifolia*, *Abies webbiana*, *Plumbago zeylanica*, Tween-80, Sodium CMC, Sucrose, Methyl paraben	Antispasmodic efficacy
Liquid handwash	Antimicrobial	*Tridax procumbens, Azadirachta indica, Glycyrrhiza glabra, Hibiscus rosa-sinensis,* Lemon Water, Sodium Lauryl Sulphate, Glycerin, Strawberry oil	Against various skin infections
Liquid Mouthwash	Antimicrobial	*Psidium guajava, Curcuma longa, Syzygium aromaticum,* Sucrose, Salt Solution, Sodium Benzoate	Reduce tooth decay, Plaque, Gingivitis, Cavities and bad breath

12.7 Summary

Use of Polyherbal Formulations has crossed the test of time. Using concept of Ayurveda for disease treatment, aligning with the principles of 'Panchamahabhutas and Tridoshas,' PHFs have provided treatment for diseases in a holistic way. Scientific advancements have redefined and improved formulation of PHFs, through the identification of phytochemicals, side by side with discovery of many useful herbal combinations which work synergistically to produce desirable benefits. PHFs have gained its popularity throughout the globe due to its comparable efficacy, fewer side effects and better acceptability over the allopathic medicines. Most of the time, PHFs produced satisfactory effect and a line of safety, making them one of the drugs of choice.

Inadequate knowledge of public due to misconception on the safety of PHFs sometimes resulted in opposite effect such as toxicity and undesired herb-drug interactions. Poor regulatory control and manufacturers' irresponsibility has also affected the quality of the PHFs manufactured, which can be dangerous for the consumers' health. This is why, preventive and corrective measures including strong regulatory frameworks, and comprehensive public education are necessary to reduce the hazardous risks of using PHFs. Only with correct and rational use, Polyherbal Formulations can exert the best effect on human health and well-being.

12.8 Questions

1. What do you understand by traditional holistic approach of healthcare?
2. Mention the fundamental 'dosha' and state how they are responsible for causing diseases.
3. What is the basis of 'Ayurvedic treatment' in India?
4. What do you mean by Polyherbal Formulations? How is it advantageous over single herb formulations?
5. State the disadvantages of using PHFs?
6. Why is it not advisable to take herbal and allopathic medicines side by side?
7. What causes toxicity of PHF?
8. How many types of form of PHF are available now a days?

9. Write the ingredients and mode of action of polyherbal handwash available in the market.

10) Give one example of hepatoprotective polyherbal formulation.

12.9 Answers

1) See 12.1; **2)** 12.1; **3)** 12.2; **4)** 12.3; **5)** 12.5 (1); **6)** 12.5; **7)** 12.5; **8)** 12.6; **9)** 12.6; **10)** 12.6

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Unit 13 ❑ MPCA and Medicinal Plants Conservation

Structure

13.0 Objectives

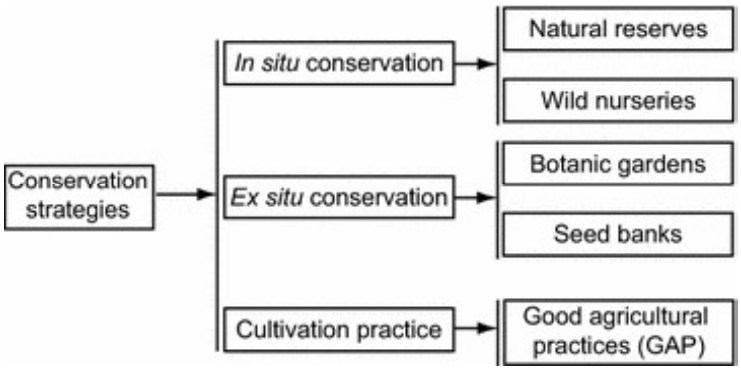
- In this unit emphasis will be on the necessity of conservation of medicinal plants, organizations involved in the process of conservation in India as well as international level.
- After studying this unit, you will be able to learn about medicinal plants conservation areas, MCPAs of West Bengal, how MPCAs are established and so on.
- You will acquire knowledge on role of medicinal plant conservation areas in conservation od locally threatened medicinal plants.

13.1 Introduction

Medicinal plants are used in both modern and traditional medicine. In traditional medicine, plants are the main resource for treatment, while in modern medicine about a quarter of drugs prescribed to the patients come from the medicinal plants. Medicinal plants harvested from the wild is of immense importance for millions of people around the world providing a source of income, besides rendering relief from illness.

According to the International Union for Conservation of Nature (IUCN) and the World Wildlife Fund (WWF), there are between 50,000 and 80,000 flowering plant species used for medicinal purposes throughout the globe, but distribution of such species is not uniform. For example, China and India have the most medicinal plants, with 11,146 and 7,500 species respectively, followed by Colombia, South Africa, the United States, and other 16 countries. About 90% of the Indian medicinal plant resources are found in the wild while rest 10% are found in land other than forest and community places.

A major issue in this sector is that there is no inventory of medicinal plants in most of the countries. Much of the knowledge on their use is held by traditional societies, whose very existence is now under threat. Little of this information has been recorded and stored systematically. Now a days, wild medicinal plant resources are collected in increasing volumes, because of its rising demand worldwide. It has been analysed that the surge for wild medicinal plants is increasing by 8–15 % per year in Europe, North America, and Asia in recent decades. As a result, medicinal plants are facing threats including resource destruction, overexploitation, habitat degradation, genetic erosion, pressure of invasive species and so on. Only wild nurseries are primarily helping to conserve endangered medicinal plants in their natural habitats. Once a species becomes extinct, the genetic resource of the species is lost forever, and therefore it becomes imperative to conserve these species in the forest area. Various recommendations relating to the conservation of medicinal plants have been proposed time to time from different sectors, includes *in-situ, ex-situ* conservations, cultivation strategies etc. In this context, establishment of Medicinal Plants Conservation Area (MPCAs) and presently Medicinal Plants Conservation Development Areas (MPCDAs) are the best ways for *in-situ* conservation and management of germplasm resource of native endangered, endemic medicinal plants species in India.



The concept of MPCA was ushered in 1993 when the first conservation step initiated by the UNDP in the Southern States of India in association with the 'Foundation for Revitalization of Local Health Traditions (FRLHT)' was triggered. In India, during 1992 to 2003, a total 108 MPCAs were developed in 13 states of the country to carry out the conservation works for Medicinal Plants. Later on, agencies like IUCN, WWF, WHO, all most all Botanical Gardens also came forward for conservation of medicinal plant.

The key institutions of India engaged actively in conservation of medicinal plants are the Ministry of AYUSH, National Medicinal Plants Board (NMPB), Central Drugs Standard Control Organization (CDSCO), Central Council for Research in Ayurvedic Sciences (CCRAS), National Bureau of Plant Genetic Resources (NBPGR) are praise worthy. The NMPB is entrusted to develop an appropriate mechanism for coordination between various ministries / departments / organizations in India, and to implement support policies / programs for overall growth of medicinal plants sectors (conservation, cultivation, trade, and export) both at the Central / State and International level. Under the NMPB scheme, there is one primary component for setting up the Medicinal Plants Conservation and Development Areas (MPCDAs) in forestland. As per the guidelines, State Forest departments, National and State Level Research Organizations / Institutions with expertise in the field are eligible to implement the projects on MPCDAs. Along with forestlands, smaller areas of important medicinal plant bio-diversities including sacred groves, endemic species, critically endangered medicinal plants etc. can also come into per view of MPCDAs. Presently (2024) more than 40 premier research institutions / councils / centers / units [e.g. CIMAP (Lucknow), IIIM (Jammu), IHBT (Palampur), National NBRI (Lucknow), NEIST (Jorhat) etc.] under the Ministry of AYUSH, Govt. of India, are working for conservation of medicinal plants across the states / union territories of India.

Besides different agencies and institutions, ethnic and tribal communities also play very pivotal role in conservation and management of medicinal plants. One of their efforts is the 'Sacred groves'. Tribal people in these grove areas depend on traditional medicine system for healthcare. Sacred groves have been considered as repositories of valuable ethno-medicinal plants and wild relatives of cultivated food plant species which have the potential to address country's need for food and medicine. Sacred groves are considered as a relic of once dominant flora and a part of the local ethnic identity. As per modern law, sacred groves are the protected areas of forest which are considered sacred by the local communities and are left untouched from human activities except worshipping (due to belief of deities in the forest). Hunting and logging are

prohibited (except ethnic rituals) in the sacred groves. However, other forms of forest usage, like honey and deadwood collection are allowed only on a sustainable basis. Sacred groves are thus the traditional way to conserve biodiversity and to protect their environment. Sacred groves are found all over India, especially in states like West Bengal [e.g. Purulia (Baghmundi, Pachapani), Bankura (Joypur), Jhargram (Chilkigarh), Hooghly, West Midnapore (Guptamoni)], Arunachal Pradesh, Manipur, Meghalaya, Assam, Bihar, Goa, Maharashtra, Karnataka, Kerala, and Tamil Nadu etc. Out of all, Himachal Pradesh has the largest number of sacred groves, with 5,000 species approx.

13.2 What are MPCAs?

MPCA stands for "Medicinal Plants Conservation Area" which is a strategy for *in-situ* conservation of genetic diversity of highly traded and threatened medicinal plants of India. It is a well-defined and demarcated area within a protected and conserved forest area, and known for harbouring medicinal plants especially the threatened and endangered plant species. This program has special focus on capturing the gene pools among the wild plant populations of endemic and threatened medicinal plants, ensuring their long-term survival. These gene pools will provide the source of propagules for selection, breeding, and *ex-situ* conservation in future.

After establishment in 2000, the National Medicinal Plants Board (NMPB), Government of India, continuously extending its supports for establishment of MPCAs across the country. State forest departments play a key role in establishing MPCAs, along with research institutions, but local people help to maintain the MPCAs.

13.3 MPCAs in West Bengal

Forest Department of West Bengal has also implemented the project to assess medicinal plant diversity by setting up altogether 14 MPCAs in two phases. According to Final Technical Report on assessment of medicinal plant diversity published by Research Circle, Directorate of Forests, Govt. of West Bengal (2023), that during 2008-09 a network of 7 MPCAs across the state were established, but considering its importance later on (2015 onward) another 7 new MPCAs were constituted which are given below.

i. **Darjeeling**: North Sevoke, Tonglu, Dhotrey, *Panchanai, Pahalut,* and *Rachila*
ii. **Jalpaiguri**: Sursuti

iii. **Alipurduar**: North Rajabhatkhawa

iv. **Nadia**: *Bichabhanga*

v. **West Midnapore**: *Kankrajhore*

vi. **Bankura**: *Susunia*

vii. **Purulia**: Garpanchakot

viii. **24-parganas (South)**: Bonnie Camp in Sundarbans

The State Forest Department jointly with ITSCEED (International Tagore Society for Cultural Educational and Environmental Development), Kolkata, conducted studies on the medicinal plant diversity in MPCAs of West Bengal at two levels involving: i) *Inventorisation* and ii) *Ecological assessment*. As per database developed by the FRLHT, wealth of medicinal plants of West Bengal consists of total 2800 taxa. Out of 2800 medicinal plant species recorded, a large portion of species (around 80-85%) are sourced from wild, that which around 46% of medicinal species are herbs, followed by trees (23%), shrubs (21%) and climbers (10%). MPCA-wise medicinal plant species recorded were 30, 154, 206, 249, 209, 216 and 254 respectively in Bonnie camp, Dhotrey, Garpanchkot, North Rajabhatkhawa, North Sevoke, Sursuti and Tonglu which were established in the first phase. It is to be noted that Forest Department has documented 581 species of medicinal plants in South Bengal and conserved them successfully *in situ*.

13.4 Steps to execute MPCA programme

Eight basic strategic steps are followed for execution of the MPCA program:

1. Create database on medicinal plants of India (from published literature including ethnobotany and ethnomedicine sources) with accurate correlation between vernacular, Sanskrit, and botanical names.
2. Generate sub-databases of medicinal plants of every State, District and Taluka in the country.
3. Generate geographical distribution data on medicinal plants of India (from floras, herbaria etc.) and place it on appropriate GIS platforms mainly for species of conservation concern.
4. Identify medicinal botanicals in all India trade with accurate correlation between trade and botanical names.
5. Apply IUCN criteria to identify threatened medicinal plants at State levels.

6. For high priority threatened species, undertake genetic sampling across their distribution range in order to identify hot-spots of intra-specific genetic variability of threatened species.
7. Identify ecologically suitable sites for creation of MPCAs for *in-situ* conservation of both species diversity and for species of conservation concern.
8. Review the gaps at State levels every 3 years in the national *in-situ* conservation MPCA program.

13.5 Criteria of selecting MPCA sites

While entrenching a particular MPCA, its natural diversity, visual richness of population and some other benchmarks are followed. Selection of forest areas is done on the basis of following important criteria –

a) Sites must be with a varied diversity of vegetation comprising some known medicinal plants species,
b) Forest area traditionally known for its rich diversity of medicinal plant species (preferably endemic species),
c) Area is selected as a compact block under Biodiversity Conservation Working Circle in territorial and wild life areas so that no felling operations are legal. In other words, undisturbed area by biotic factors as much as possible,
d) Area should be fairly larger (about 200-500 ha) for better management,
e) Area with reasonable accessibility.

Presence of viable population of conservation concern species is also taken into consideration when MPCAs are established for specific species (conservation concern / threatened medicinal plants). In that case, two approaches mostly followed for selection of MPCA sites are -

i) Capturing maximum diversity of medicinal plants,
ii) Capturing conservation concern medicinal plants.

In order to cover maximum medicinal plant diversity, MPCAs are established across different forest types and forest landscapes. Number of MPCAs needed to conserve gene pool of a particular species, however, depends on the extent of its distribution range. As for example, an endemic species may require only one MPCA to conserve its gene pool, while a widely distributed species may require several MPCAs to capture its diverse gene pool. It is to be mentioned here that the number of MPCAs

established currently is far less than the required number to capture the diversity of wild medicinal plants in the country.

13.6 Role of MPCAs in the conservation of locally threatened medicinal plants

The MPCAs are primarily concerned for generation of information and knowledge on the medicinal plant species diversity and their status, so that better resource management and strategies can be drawn up at the state level culminating into country level. Following are the roles of MPCAs:

- implementation of MPCAs / MPCDAs in the various Forest Zones of India is to preserve, protect and maintain the medicinal plants species so that they grow abundantly in natural way
- survey and demarcation of the proposed MPCA area with application of GIS & remote sensing
- assessment of biodiversity, estimation of carbon stock and carbon sequestration measurement of major species
- floristic inventorisation and documentation (collection & preparation of herbarium) of medicinal plants diversity
- conservation and management of medicinal plants through suitably designed area specific participatory models for threatened medicinal plants / flora
- to identify major threats and recommendation for management of selected species
- capturing gene pools of regenerating populations of high-traded endemics and threatened medicinal plants
- to provide potential study sites for threatened species recoveryre search programme
- raising and maintaining nursery of medicinal plants
- to supply authentic planting material for commercial cultivation
- organizing training of field staff and forest departmental staff
- promoting community awareness about local health traditions
- preparation of reports, management plans, leaflets etc.

In addition to aforesaid primary roles of MPCAs, it also plays a vital ecological role by helping in habitat protection, soil and moisture conservation, fire protection, alleviation of health and poverty issues.

13.7 Summary

Medicinal plants play a vital role in supporting healthcare systems like Ayurveda, Unani, Siddha, Homeopathy and even Allopathy system of medicines. India is one of the hot spots of world's biodiversity having huge wealth of medicinal plants. Forests are the main habitat of medicinal plants and a large number of species are also endemic that gives India a unique position in the world. However, due to various anthropogenic activities and unsustainable harvesting from wild, many medicinal plants species in India have become endangered and have been included in Red Data Book of threatened species. Thus, there is an urgent need to protect / conserve the natural habitats of these medicinal plants' wealth of the country. The National Medicinal Plants Board (NMPB), Govt. of India, in this regard has taken initiatives to support *in-situ* conservation of medicinal plants through establishment of MPCAs / MPCDAs throughout the country. India has a total 108 Medicinal Plant Conservation Areas (MPCAs) that work to conserve medicinal plants. These areas are spread across 12 states and cover a variety of forest types. For *in-situ* conservation, the State Forest Departments are playing a vital role in establishing the MPCAs / MPCDAs, ensuring conservation of the Red Listed medicinal plants species along with associated flora. There are fourteen MPCAs in West Bengal which are working to conserve medicinal plants present between the Himalayas in the north and the Bay of Bengal in the south.

13.8 Questions

1. What are the major threats of extinction of medicinal plants?
2. State the reasons for establishing MPCAs.
3. Write the different ways of conserving medicinal plants.
4. Write a note on the role of Govt. of India in conservation of threatened medicinal plants.
5. Mention the initiatives of state government in conservation of medicinal plants.
6. Specify the strategies involved in establishment of MPCA?
7. Write the approaches earmarked for conservation of specific species.

8. State any four strategic roles of MPCA in conservation of medicinal plants.
9. How many MPCAs are there in Darjeeling district? Write the names.
10. What are sacred groves? How they help in conservation of medicinal plants?

13.9Answers

1) See 13.1; 2) 13.1; 3) 13.1 flow chart; 4) 13.1 and 13.2; 5) 13.3; 6) 13.4; 7) 13.5; 8) 13.6; 9) 13.3; 10) Sacred groves are a traditional way to conserve biodiversity and protect the environment. They are also important sites for worship and community gatherings. By prohibiting hunting and gathering, logging etc. and through worshipping plants they help in conservation.

13.10 References and Further Readings

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Unit 14 ❑ Plant secondary metabolites of medicinal importance – alkaloids, flavonoids and terpenoids (brief account with examples)

Structure

14.0 Objectives

- From this unit you will be able to know about connection between primary and secondary metabolism.
- This unit will provide basic information on three classes of secondary metabolites, namely alkaloids, terpenoids, and flavonoids.
- You will acquire knowledge of structures, biosynthesis, and biological activities of alkaloids, terpenoids and flavonoids.

14.1 Introduction

Metabolites are the intermediates and products of metabolism which are usually restricted to small molecules. Primary metabolites are biomolecules that are essential for an organism's growth, development, reproduction; and present in every living cell capable of dividing. Examples of primary metabolites include carbohydrates, lipids, proteins, nucleic acids, vitamins, and amino acids etc. Alternatively, secondary metabolites are derived from primary metabolism, and do not make up basic molecular skeleton of the organism. Its absence does not immediately curtail the life of an organism, a feature contrary to primary metabolite, and hence, play no role in normal development.

Secondary metabolites also known as 'specialised metabolites' are small, biologically active metabolic intermediates or products produced by plants and other lifeforms. They are not essential for immediate survival of an organism, but provide a competitive advantage in defence, adaptation etc. Secondary metabolite is sometimes seen as a way to safely store or eliminate "waste" metabolites resulting from primary metabolism. In the usual course secondary metabolites are produced at their highest levels throughout a switchover from active growth to stationary phase. It is now established that secondary metabolites are essential components of cellular biology and metabolism; and depend on the primary metabolism for required enzymes, energy, substrates, and cellular machinery for production.

14.2 Some Basic Roles of secondary plant metabolites

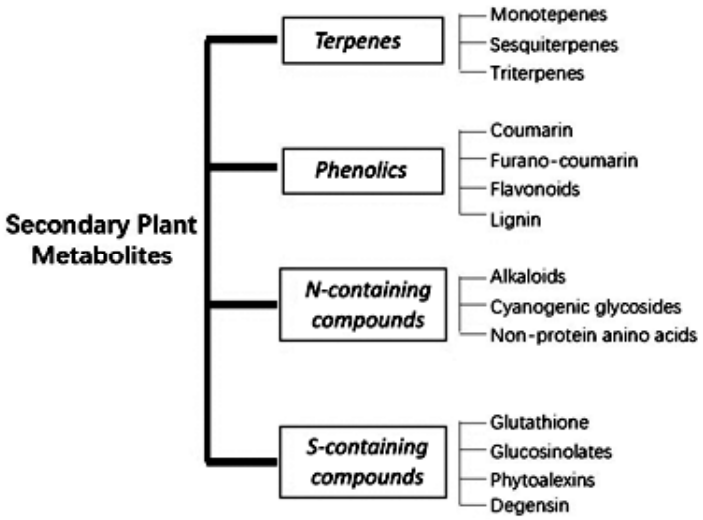
Secondary metabolites are molecules that play a variety of roles in producer plants, and above and beyond benefits human beings. The vast and versatile pharmacological

effects of medicinal plants are basically dependent on their phytochemical constituents. Several secondary plant metabolites played significant roles in alleviating several aliments in the traditional medicine and folk uses besides their roles for producer plants.

- **Plant defense**: Secondary metabolites help the producing plants to defend themselves from the attack of herbivores, fungi, bacteria, and other animals.
- **UV protection**: Secondary metabolites absorb UV rays and thus, protect leaves from damage.
- **Pigments and aroma**: Most of the plant pigments are secondary metabolites. They contribute to the fragrance of flowers, aroma of fruits etc. and there by play ecological role in several ways.
- **Health maintenance**: Numerous secondary metabolites used as herbal remedies for maintaining the vitality of cells and organ systems of our body.
- **Medicines**: Secondary metabolites are used in traditional and modern medicine to treat infections, diseases, and health disorders.
- **As flavourings agents**: Secondary metabolites contribute to the aroma and flavour of food.
- **Recreational drugs**: Majority of the recreational drugs (taken for enjoyment rather than for medical reasons) comes from secondary metabolites of plants. Alcohol, tobacco, caffeine etc. are examples of classical recreational drugs.

14.3 Classification of secondary metabolites

More than 21,40,000 secondary metabolites of plants are known today. They are usually classified on the basis their **chemical structure** (such as the occurrence of rings or sugars), **composition** (such as whether or not they contain nitrogen), **solubility** in organic solvents or water, and **biosynthetic pathways** / metabolic process. The biosynthetic route has been the most often utilised criterion for classifying the secondary metabolites in plants. *Terpenes*, *phenolics*, *N-containing* and *S-containing compounds* are the main categories into which the secondary metabolites of plants can be subdivided as shown in the flow chart.



14.4 Terpenes ((Terpenoids and Steroids)

Terpenes belong to the largest class of most abundant and important secondary metabolites. Over 35000 terpenes have been identified, all of which possess repeating five-carbon isoprene units (a five-carbon ring). In all cases isoprene units remain assembled and arranged in different ways generating innumerable patterns of structural motifs. Terpenoids (isoprenoids) are modified terpenes (through oxidation, hydrogenation, or dehydrogenation), so most have an unsaturated, non-polar hydrocarbon backbone with similar general formula $(C_5H_8)n$ as in terpenes (based on number of isoprene units). Steroids are also a subclass of terpenoids that are biosynthesized from terpene precursors. Plant steroids include steroidal alkaloids found in Solanaceae e.g. cardiac glycosides etc. Steroids are used as drugs to increase protein synthesis in animals besides their anti-inflammatory, anticancer and other properties, while terpenes and terpenoids are widely explored as biomaterials and biofuels. Terpenes were originally obtained from turpentine oil, produced from steam distillation of plants' oleoresins, primarily of conifers (pines) and hence, the name "terpenoids". It is to be noted that turpentine oil is a mixture of terpenes (α-pinene, β-pinene, limonene, camphene, etc).

Thus, terpenes, terpenoids and steroids are all derived from five-carbon isoprene units assembled and arranged variously. In this portion, we will take up the basic types of terpenoids, brief idea of biosynthetic pathways, general uses for better understanding of their functions and prospective applications.

14.4.1 Types of Terpenes

Number of isoprene units determines their subdivisions which are given below with few examples -

1. **Hemiterpenes** (single isoprene unit): Isovaleric acid (*Vaccinium myrtillus*), angelic acid (*Angelica archangelica*), eucalyptol (*Eucalyptus* sp.), citrinol (*Citronella* sp.).
2. **Monoterpenes** (two isoprene units): Geraniol (*Rosa* sp., *Geranium* sp.), cymene (*Cuminum cyminum*), menthol (*Mentha piperata*), camphor (*Cinnamomum camphora*).
3. **Sesquiterpenes** (three isoprene units): artemisinin (*Artemesia annua*), an antimalerial compound, pinenes (conifers) and cineol (*Eucalyptus globulus*).
4. **Diterpenes** (four isoprene units): Paclitaxel (*Taxus brevifolia*)
5. **Sesterterpenes** (five isoprene units): Carnosic acid, carnosol (*Rosmarinus officinalis*)
6. **Triterpenes** (six isoprene units): Cucurbitacines (Cucurbitaceae)
7. **Tetraterpenes** (eight isoprene units): Carotenoids, Xanthophyll pigments
8. **Polyterpenes** ('n' isoprene units): Natural rubber (made up of isoprene molecules twisted together in a twisted chain).

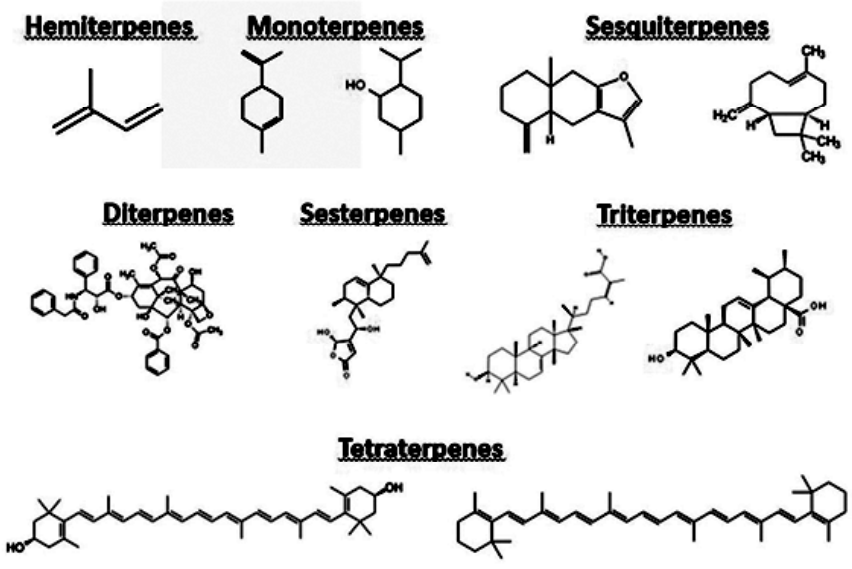


Fig. : Structural skeleton of different types of terpenes

14.4.2 Biosynthetic pathways of Terpenoids

Plants use two independent pathways to produce isopentenyl diphosphate (IPP) and its allylic isomer dimethylallyl diphosphate (DMAPP) using the primarily cytosolic mevalonic acid (MVA) pathway and plastidial methylerythritol phosphate (MEP) pathway. The MVA pathway provides the precursors for cytosolic biosynthesis of triterpenoids, sesquiterpenoids, phytosterols, and for other terpenoid biosynthesis in mitochondria. Conversely, the isoprene units derived from the MEP pathway are preferably used for biosynthesis of hemiterpenoids (e.g. isoprene), monoterpenoids, diterpenoids, carotenoids and their breakdown products, cytokinins, gibberellins, chlorophyll, tocopherols, and plastoquinones as shown below (Fig.).

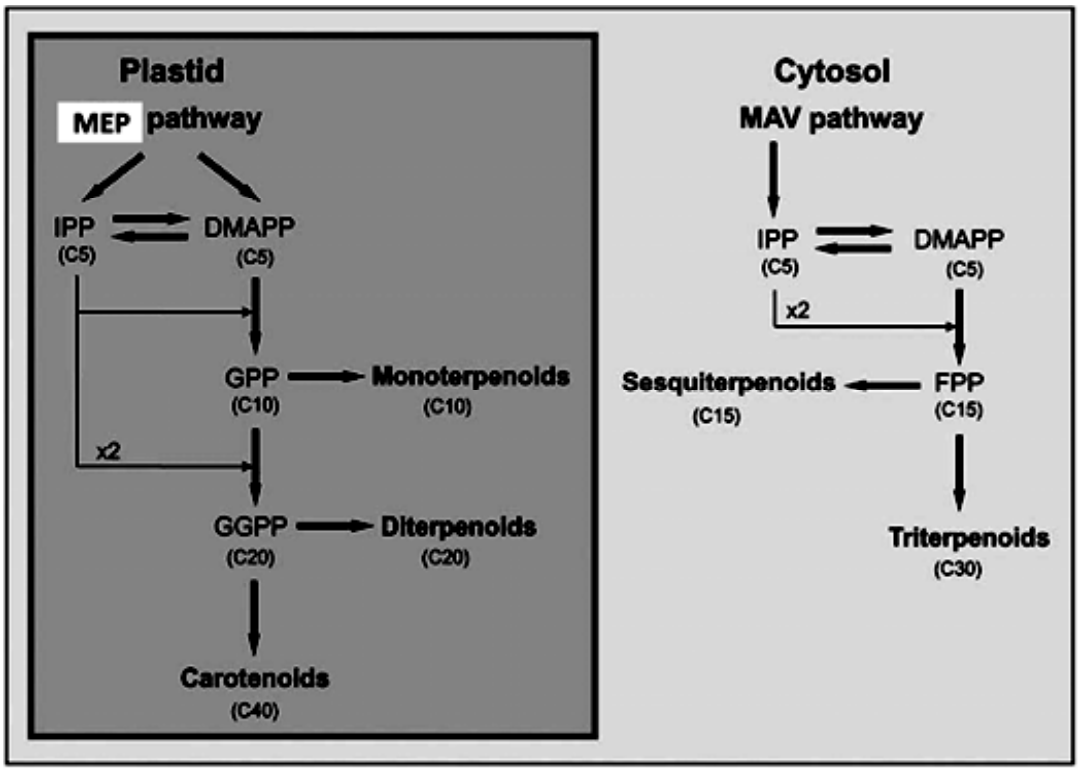


Fig : Outline of biosynthetic pathways of terpenes in plants

14.4.3 Biological activities of terpenes and terpenoids

As mentioned earlier, terpenes are a class of hydrocarbons that are found in many plants, including fruits, vegetables, and flowers. They have a wide range of biological

activities and are utilized in many pharmaceutical products. Some of the uses and health benefits of terpenes / terpenoids are given underneath:

- **Anti-cancer**: Terpenes can reduce tumour cell division, induce apoptosis, and inhibit tumour cell growth. e.g. Taxol from *Taxus baccata*, Andrographolide from *Andrographis paniculata*.
- **Anti-inflammatory**: Terpenes possess anti-inflammatory effects. e.g. Lycopene found in tomatoes and watermelons.
- **Anti-viral**: Monoterpenes are widely tested for their antiviral properties. Myrtucomvalones A, B, and C isolated from plants of Myrtaceae including *Myrtus communis* which can inhibit the respiratory syncytial virus (RSV).
- **Anti-malarial**: Terpenes have anti-plasmodial activity similar to the antimalarial drug chloroquine. e.g. Artemisinin isolated from *Artemisia annua*.
- **Anti-microbial**: Terpenes like Limonene showed antimicrobial properties, obtained from *Juniperus communis*. Natural constituents of the class are Geranylgeraniol, phytanol, escobarine A, escobarine B, furanoditerpenes, salasol A, germacrane, alantolactone etc. are found to be anti-tubercular in nature.
- **Anti-oxidant**: Many terpenes own antioxidant properties as in Phyllaembicilins from *Phyllanthus emblica*.
- **Neuroprotective**: Terpenes exhibit neuroprotective effects. e.g. Eugenol, β-elemene, β-caryophyllene and germacrene come from *Ocimum tenuiflorum*; Bilobalide and ginkgolides from *Ginkgo biloba*.
- **Digestive disorders**: can be handled comfortably with Zingiberene obtained from *Zingiber officinale*.
- **Anti-diabetes**: Type 2 diabetes mellitus often managed effectively using Stevioside a diterpene steviol glycoside which is extracted from leaves of *Stevia rebaudiana*, (possesses insulinotropic, glucagonostatic, and anti-hyperglycemic effects). Similarly, Andrographolide a diterpenoid lactone, obtained from *Andrographis paniculata*.
- **Sedative and analgesic**: Terpenes can have sedative and analgesic effects also.
- **Insect repellent**: Herbs and medicinal oils like terpenes and terpenoids exhibited a huge potential for bug control like carvacrol, linalool, cineole, eugenol etc.; especially against three insects namely lice, cockroaches, and Triatominae bugs.

- **Insect attractant**: Linalool, limonene and β-pinene from *Ficus hispida* can attract signal pollinators like wasp.

14.5 Alkaloids

Alkaloids are defined as basic (alkali like), nitrogen containing organic constituents. These are the only nitrogen-containing secondary metabolite found in plants, and contain one or more nitrogen atoms in heterocyclic ring (an amine functional group), produced by a range of organisms. Some groups of structurally related alkaloids found in plants ranges from few to more than 30. These alkaloids belong to the same class but have some differences in their structure, and one of them usually occurs as a major alkaloid. Some plant families are very rich in alkaloids.

Alkaloids were initially discovered and used as early as 4000 years ago and well recognized for their rich therapeutic potential. Precursors of alkaloids are usually amino acids, and exert certain biological function including a profound pharmacological activity. From structural view point, alkaloids can be classified, based on their precursor, structures, and origins or on the biological pathways used to obtain the molecule.

14.5.1 Classification of Alkaloids

Widespread distribution and wide array of structures makes the classification of alkaloids often difficult. However, for their study, alkaloids are classified depending on their chemical structure, biochemical origin, and /or natural origin. More than 40,000 compounds are known so far, and many of them are named according to their source of origin that is the plant and botanical family from which they are isolated. Moreover, alkaloids are also classified according to their biochemical origin or chemical structure, the latter being the most used (based on a CN skeleton) method.

14.5.1.1 Alkaloids based on their molecular precursor

1. **True alkaloids** obtained from amino acids and share a nitrogen-containing heterocyclic ring. Many of the alkaloids are crystalline, and form water-soluble salts with acid. Almost all the true alkaloids are bitter in taste and solid, (except nicotine). e.g. Ergot alkaloids synthesized from L-Threonine.
2. **Protoalkaloids** contains nitrogen atom of it is derived from an amino acid, but is not part of the heterocyclic ring system. e.g. Terpenoid indole alkaloids derived from L-Threonine, L-Proline, L-Tryptophan, L-Serine.
3. **Pseudoalkaloids** do not originate from amino acids (carry the basic carbon skeleton not directly derived from amino acids) as in previous cases. They are

derived from non-amino acid precursors like acetate or phenylalanine through amination or transamination reactions. Caffeine, ephedrine are very common examples of pseudoalkaloids.

14.5.1.2 Alkaloids based on basic heterocyclic nucleus in the structure

a) **Tropane alkaloids**: has tropane (C4N skeleton) nucleus. They are abundantly found in the family Solanaceae, derived from ornithine and acetoacetate. Cocaine, atropine are well known examples.

b) **Pyrrolizidine alkaloids**: occur in the plants as N-oxides. They occur in family Asteraceae and Fabaceae. Senecionine is the popular alkaloid of this type.

c) **Piperidine alkaloids**: contains basic ring system of piperidine (C5N) nucleus. Many of them are originated from plants. Although piperidine itself is a lysine-derived alkaloid, many of them are also derived from acetate, acetoacetate. Lobeline is one of the important alkaloids in this group.

d) **Quinoline alkaloid**: named so because of presence of quinolone-nucleus in alkaloid, isolated exclusively from the bark of Cinchona plant. Major alkaloid of this specific group is cinchonine, cinchonidine, quinine, and quinidine.

e) **Isoquinoline alkaloids**: presents an extremely large group of alkaloids mostly occurring in higher plants. Presence of Isoquinoline nucleus is the basic characteristic. Morphine and codeine are widely studied isoquinoline alkaloids, derived from tyrosine or phenylalanine.

f) **Indole alkaloids**: found to be the largest and most interesting alkaloid group derived from tryptophan. e.g. ergot alkaloids (ergotamine).

g) **Steroidal alkaloids**: carry 1,2-Cyclopentane phenanthrene ring system, characteristically from family Liliaceae, Solanaceae, Apocynaceae etc. For instance, rubijervine.

h) **Imidazole alkaloid**: provided with imidazole ring structure. e.g. Pilocarpine

i) **Purine alkaloids**: consist of purine ring. Typical examples are caffeine, theophylline, and theobromine.

j) **Pyrrolidine alkaloids**: accommodates basic nucleus with Pyrrolidine (C4N skeleton) motif. Members of the Asteraceae, Boraginaceae, Heliotropiaceae, and some genera of Orchidaceae etc. are the common producers. Rosmarinecine, heliotridine, scopolamine etc. are examples.

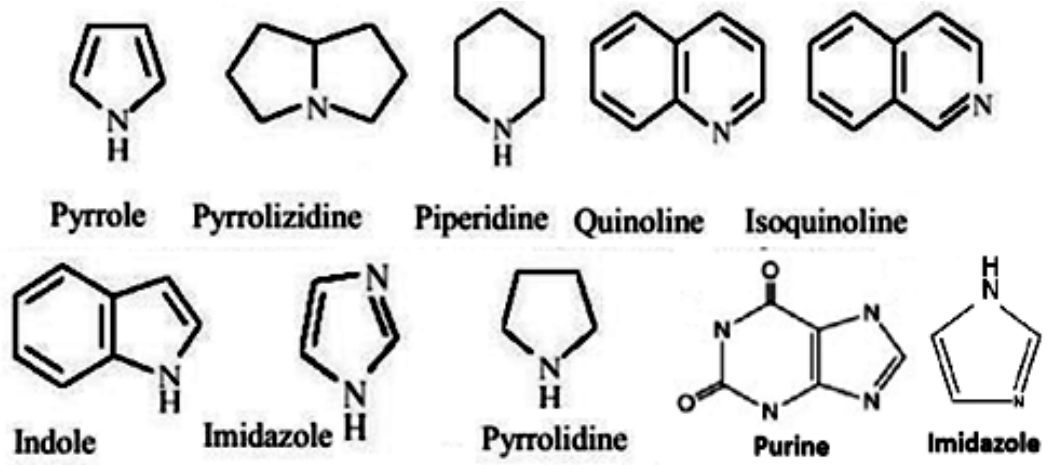


Fig. : Structural skeleton of different types of alkaloids

14.5.3 Biosynthesis of Alkaloids

Presence of nitrogen atom defines alkaloids, and as such understanding of how nitrogen is channelled into alkaloid biosynthesis is vital. Many of the amine precursors of complex alkaloids are present in the majority of plant taxa. Modifications to the metabolism of these precursors can result in their accumulation and channelling into alkaloid biosynthesis. First steps in an alkaloid pathway are most crucial, because it acts as a gateway to a new chemical space. They are important metabolically, as they directly come from primary metabolism into the specialised metabolism. It is chemically and enzymatically significant as they involve the formation of a new molecular structure.

There are four steps that are typically present in the first steps of complex alkaloid biosynthesis: (i) accumulation of an amine precursor, (ii) accumulation of an aldehyde precursor, (iii) formation of an iminium cation and (iv) a Mannich-like reaction. This final step is often considered the "scaffold-forming" or first-committed step into a pathway. Since, biosynthesis of alkaloids is very complicated in nature, detailed outline is omitted here, but interested candidates can go through any text book of biochemistry for further detail.

14.5.4 Biological Activities of Alkaloids

Plant secondary metabolites are a diverse range of biologically active molecules having multiple pharmacological actions like antimicrobial, anthelmintic, antioxidant, stimulant, analgesic, anticoagulant, antiacne and others. Different synthetic compounds show

potential biological activity *in vitro* as well as *in vivo*, and various formulations of existing drugs are also developed to increase the safety profile.

- **Anti-hypertensive agent**: Among all indole alkaloids, reserpine from *Rauwolfia serpentina*, vinblastine and vincristine (antitumor lead) from *Catharanthus roseus*.
- **Anti-diabetic agent**: *Capsicum annuum, Curcuma longa, barberry Berberis vulgaris and Lepidium sativum* are among the most common therapeutic plants used for controlling diabetes due their alkaloids like berberine, capsaicin and trigonelline etc.
- **Anti-microbial / antiparasitic activity**: Reserpine showed potential antimycobacterial activity against *Mycobacterium tuberculosis*.
- **Anticancer activity**: Vallesiachotamine isolated from the leaves of *Palicourea rigida* possesses significant anticancer activity against human melanoma cells through apoptosis. Colchicine isolated from *Colchicum autumnale* is effective against chronic myelocytic leukaemia (and gout).
- **Anti-inflammatory activity**: Caulerpin isolated from *Caulerpa racemose* possesses analgesic and anti-inflammatory activity.
- **Anti-asthma agent**: Atropine is isolated from dried *Datura metal* of Solanaceae family, has a good action against nocturnal asthma.
- **Antispasmodic and antiallergic effects**: Hyoscyamine, atropine etc. contribute as antispasmodic and antiallergic agent by acting as a competitive antagonist at the muscarinic acetylcholine receptor site.
- **Anti- neurodegenerative agent**: Berberine is one of the important isoquinoline alkaloids of *Berberis vulgaris*. It is potentially effective against multineurodegenerative diseases such as Alzheimer, Parkinson, and Huntington diseases.
- **As stimulants**: Nicotine as example, stimulate central nervous system and directly work on the human brain.
- **As vasodilating agent**: Papaverine has smooth-muscle relaxant property, and can relax larger blood vessels including the coronary, systemic peripheral, and pulmonary arteries.
- **Anti-herbivoric agent**: Alkaloids have major role some of which are described above. However, it protects plants by acting as protecting agents against

herbivores due to its characteristic bitter flavour, causing disruption of protein activity after ingestion and metabolization and several other.

- **Deadly poisonous alkaloid**: Coniine is an alkaloid isolated from *Conium maculatum*, which is an active ingredient of poison hemlock.

14.6 Flavonoids

These are the largest group of phenolic secondary metabolites constituting a large group of hydroxylated phenolic compounds carrying a benzo-5ØþÞ-pyrone structure. They are virtually universal plant pigments and thus, found in almost all vegetables, fruit crops, flowers, and fruits. Flavonoids are primarily responsible for colour, fragrance, but are also employed in many pharmaceutical and cosmetic products. It is predominantly found in plants of Umbelliferae, Polygonaceae, Leguminosae, Compositae, and Rutaceae and many more. Some common examples of flavonoids are quercetin, cyanidin, delphinidin, and luteolin.

14.6.1 Classification of Flavonoids

Flavonoids are synthesized through the phenylpropanoid metabolic pathway and possess 15 carbon atoms arranged in three rings (C6-C3-C6) labelled A, B, and C as shown below. Flavonoids are classified into various types depending on their chemical structure, degree of unsaturation, oxidation of carbon ring (including flavones, flavanones, isoflavones, flavonols, chalcones, flavanols, and anthocyanins) and so on. Flavonoids are classified into *six major classes* based on modifications of their basic skeletons which include -

1) **Flavanones**: (e.g. hesperetin, isosakuratenin, naringenin)
2) **Flavones**: (e.g. apigenin, luteolin, chrysin)
3) **Isoflavones**: (e.g. daidzein, genistein, glycitein)
4) **Flavanols / dihydroflavones**: (e.g. catechin, epicatechin, gallocatechin)
5) **Flavonols**: (e.g. quercetin, kaempferol, myricetin),
6) **Anthocyanins** (e.g. cyanidin, delphinidin, petunidin) and others.

Above mentioned various classes of flavonoids differ in the level of oxidation and pattern of substitution of the C ring, while individual compounds within a class differ in the pattern of substitution of the A and B rings. The flavonoids occur as aglycones, glycosides, and methylated derivatives.

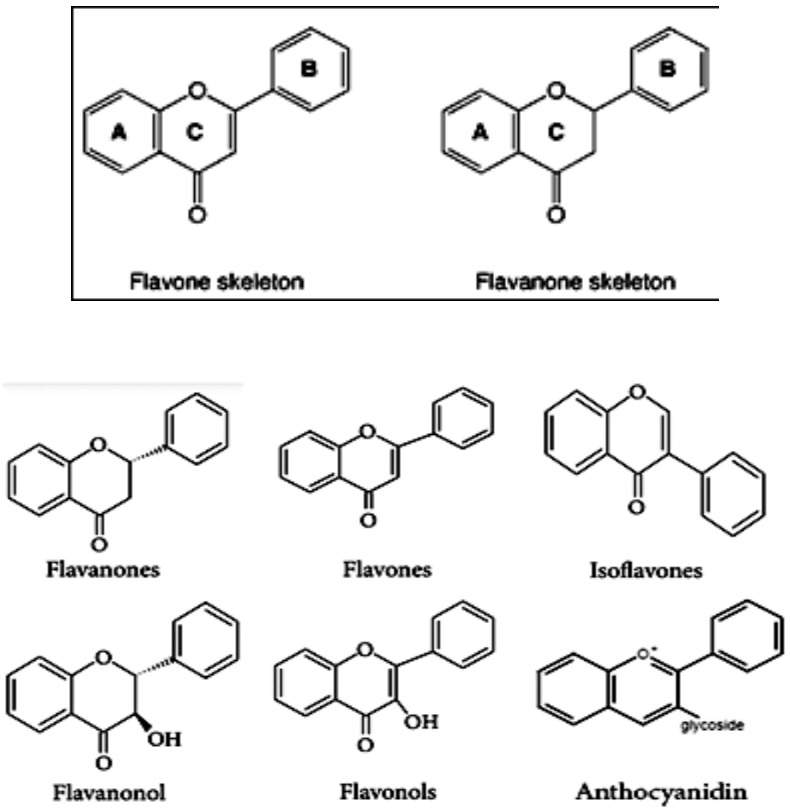


Fig. : General structures of different classes of flavonoids

14.6.2 Biosynthesis of Flavonoids

In plants, flavonoids are derived from two biosynthetic pathways – **1)** Phenylpropanoid pathway, which produces the phenylpropanoid skeleton (C_6-C_3), and **2)** Polyketide that produces blocks for polymeric C_2 units. Enzyme chalcone synthase catalyzes formation of 22 -hydroxychalcone back bone from *p*-coumaroyl CoA and malonyl CoA, which are then used in several enzymatic steps to produce other flavonoids.

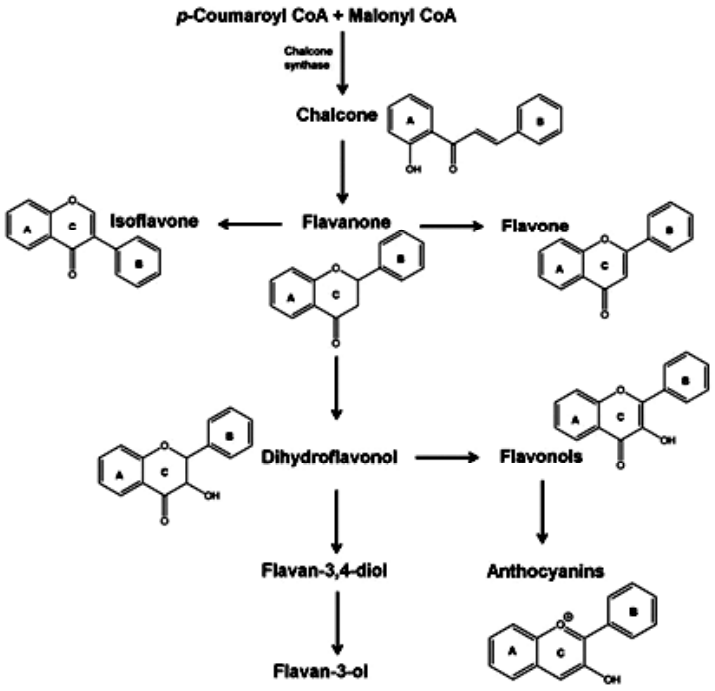


Fig. : Flavonoid biosynthesis (adopted from Dias et al., 2021)

14.6.3 Biological Activities of Flavonoids

Flavonoids are one of the most essential non-nitrogenous plant pigments. These are responsible for flower coloration by producing yellow or red / blue pigmentation in shoots, leaves, buds, petals, and fruits. Pigmentation helps the plant to attract pollinators. In some types of plants, flavonoids are involved in UV filtration, symbiotic nitrogen fixation and floral pigmentation.

Evidences have shown that ûavonoids are capable of inducing several health beneûts in humans. Now they are considered as an indispensable component in a variety of nutraceutical, pharmaceutical, medicinal, and cosmetic applications. Flavonoids have following biological activities:

- **Anti-oxidant activity**: Flavonoids are one of the best phytochemicals that act as antioxidants and thus, protect from several diseases. Flavonoids can scavenge ROS directly or by activating antioxidant defence or inhibit ROS formation through chelation of trace elements. For example, quercetin has iron-chelating

and iron-stabilizing properties. Glycosides, aglycones have potent antioxidant activities of which later have higher capacity.

- **Anti-inflammatory activity**: Inflammation is rapid and self-limiting, but in some cases, prolonged inflammation can contribute to the development of several chronic or degenerative disorders like cancer, diabetes, cardiovascular and neurodegenerative diseases, and obesity etc. Flavonoids can inhibit inflammation by regulating the immune system and acting as antioxidants (by scavenging ROS or reducing free radical accumulation). Some flavonoids, such as flavonols (e.g. rutin), flavanones (e.g. hesperidin), flavanols (e.g. catechin) etc. exhibit anti-inflammatory actions.
- **Anti-bacterial activity**: Flavonoids can inhibit membrane-bound enzymes to act as antimicrobial substances against a variety of bacteria. Plant extracts containing apigenin, galangin, flavone and flavonol glycosides, isoflavones, flavanones, and chalcones have been proved to possess potent antimicrobial activity. Most of them can destabilize the structure of bacterial cell membranes by disordering and disorientating the membrane lipids, leading to membrane leakage of bacteria.
- **Anti-fungal activity**: Flavonoids can cause disruption of plasma membrane, induction of several mitochondrial dysfunctions, inhibition of cell wall formation, cell division, RNA and protein synthesis in fungi. Glabridin hinder the synthesis of cell wall components β-glucans and chitin, while kaempferol, quercetin, luteolin, naringenin, and genistein repress synthesis of DNA, RNA, and protein in fungi effectively.
- **Anti-viral activity**: It has been proved that naturally occurring flavonoids exhibit a remarkable anti-viral activity. For example, quercetin, hesperetin, naringin etc. found to have anti-dengue activity.
- **Anti-cancer property**: Dietary flavonols significantly reduce the risk of gastric cancer in women and smokers. Flavonoids, anthocyanidins, tannins are reported to interfere with the initiation, promotion, and progression of cancer by modulating different enzymes and receptors in signal transduction pathways related to cellular proliferation, differentiation, apoptosis, inflammation, angiogenesis, metastasis and reversal of multidrug resistance. Kaempferol possesses antiproliferative and apoptosis activity in human osteosarcoma and breast, stomach, lung, cancer cells.

- **Cardioprotective**: Flavonols showed cardioprotective activities. Quercetin, naringenin, and hesperetin have distinct vasodilator properties, and naringenin reduces blood pressure and relaxation of vascular smooth muscles effectively. Anthocyanins diminishes the risk of myocardial infarction in humans, improve systolic blood pressure, decrease levels of triglycerides as well as total and LDL cholesterol.
- **Immune adjustment**: Flavonoids can modulate the immune system. For instance, sulfur-containing allicin present in garlic acts as immunity booster. Similarly, fisetin found in strawberries, grapes, onions, and cucumbers also exert positive effects on immune system.
- **Microbiota constitution**: Flavonoids improve gut health by reducing endotoxin production, increasing conversion of bile acids, maintain gut immune homeostasis. By changing the composition of gut microbiota.
- **Epithelial barriers**: Flavonoids can restore damaged epithelial barriers and helps to maintain a physical barrier against allergens and environmental insults. e.g. dietary flavonoids derived from *Citrus sp.* Genistein, a major soybean isoflavone, protects intercellular tight junction barrier against oxidative stress, acetaldehyde, enteric bacteria and inflammatory cytokines.

14.7 Summary

Plants are known to produce a vast array of biochemical compounds as a part of their metabolism and in response to environmental cues and threats. Primary metabolites are essential for growth, development, and reproduction, include carbohydrates, lipids, proteins, nucleic acids, etc. On the other hand, secondary metabolites are derived from primary metabolism. At this point it is worth mentioning that a number of primary metabolites, for example some phytohormones (GAs, ABA) are produced by so called secondary metabolism. Thus, the clubbing of metabolites of unknown function as "secondary" is probably indicative of our unfamiliarity. It is now established that secondary metabolites are essential components of cellular biology and metabolism; and depends on the primary metabolism for required enzymes, energy, substrates, and cellular machinery.

Terpenoids are the largest group of secondary metabolites, highly diverse in properties and chemical structure, and play a role in traditional herbal remedies. Some of the terpenoids take part in mediating interactions between plants and insects, acting as a

chemical defense mechanism against herbivores. Furthermore, they are largely associated with a wide range of biological activities, including antioxidant, antimicrobial, anti-inflammatory, antiallergic, anti-metastatic activities and several others. Terpenoids have also been widely exploited for their industrial applications, including in pharmaceutical, cosmetic, agricultural industries, and food industries.

Alkaloids belongs to nitrogen containing organic compound, comprising one of the important groups of phytochemicals. Besides having the same general name "alkaloids" they have an extreme variety of chemical structures. Alkaloids play significant role in the ecology of organisms which synthesize them. For thousands of years, extracts from plants containing alkaloids are being taken up as drugs. Alkaloids are well known as anaesthetics, cardioprotective, and anti-inflammatory agents. Popular alkaloids used in clinical settings include morphine, strychnine, quinine, ephedrine, and nicotine.

Flavonoids constitute a group of non-nitrogenous pigments found in fruits, leaves, vegetables and have many benefits for both plants and humans. These secondary metabolites are responsible for colouration, fragrance of flowers and fruits, and act as pollinator attractants. Besides that, prevention and cure of diseases by using flavonoids are not uncommon to us. Flavonoids are the sources of natural antioxidants of human diets. Flavonoids neutralize the harmful effects of free radicals in humans and thus, applied as antioxidants, anti-inflammatory, neuroprotective, cardioprotective agents and help in the prevention of many diseases.

14.8 Questions

1. Why secondary metabolites are dispensable for survival of plants?
2. Primary and secondary metabolism operates separately in plant cells. … Justify.
3. Why the term "secondary metabolites" is a misnomer?
4. Write the types of alkaloids based on number of isoprenoid units.
5. Mention any four health benefits of terpenes and terpenoids.
6. Write about the pathways through which terpenoids are synthesized in plants.
7. Distinguish between protoalkaloids and pseudoalkaloids. Give one example of each.
8. What is steroidal alkaloid? Write one example.
9. Write how flavonoids act as anti-inflammatory agent.
10. Mention the basis of anti-cancer activity of flavonoids.

11. Which of the following are nitrogen containing secondary metabolites?

a) Alkaloids, b) Triterpenes, c) Isoflavones, d) Glycosides

12. Which of the following is the best criterion for alkaloids?

a) Nitrogen containing phenol b) Heterocyclic ring with nitrogen c) Aliphatic compounds with nitrogen d) Highly water-soluble compounds

13. **Fill in the blanks :**

a) Flavonoids are group of compounds with two aromatic rings (A and B) connected by ……carbon bridge that usually forms ring C.

b) An example of a flavonoid compound involved in treatment of fungal infection is ……

c) …… is a pyrrolizidine alkaloid occurring as N-oxides.

14. **Write 'Yes' for the correct option:**

a) Terpenoids were first isolated from turpentine oil.

b) Terpenoids are always cyclic compounds without nitrogen.

c) Monoterpenes are isoprenoids having one isoprene units.

d) The C15 and C30 terpenoids are synthesized through MEP pathway.

15. Indicate two medicinal properties for each of the three major groups of secondary metabolites (alkaloids, terpenoids and flavonoids).

Alkaloids : (i)…… (ii) ……

Terpenoids : (i)…… (ii) ……

Flavonoids : (i)…… (ii) ……

14.9 Answers

1) See 14.1; **2)** 14.1; **3)** 14.1 and 14.7; **4)** 14.5.1.2; **5)** 14.4.3; **6)** 14.4.2; **7)** 14.5.1.1; 7) 14.5.1.2; **9)** 14.6.3; **10)** 14.6.3; **11)** Ans. a; **12)** Ans. b; **13)** Ans. a) Three, b) Glabridin, c) Senecionine; **14)** Ans. a) Yes, b) Yes, c) No, d) No; **15)** See 14.5.4, 14.4.3 and 14.6.3

14.10 References and further readings

- Bhatia M. (2015). Secondary Metabolites of Plants and their Role Overview. Current Trends in Biotechnology and Pharmacy. **9** (3): 293-304.

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