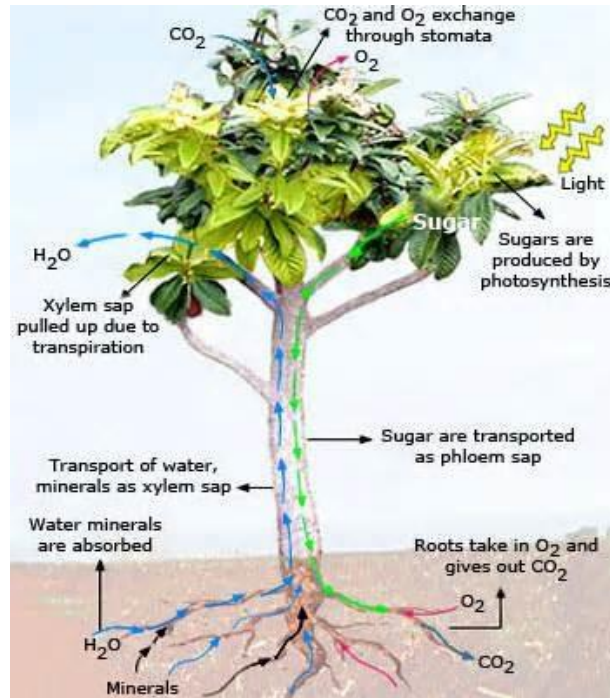


## Introduction

### PLANT:

Plants included those organisms that possess photosynthesis, cell walls, spores, and a more or less sedentary behavior. This contained a variety of microscopic organisms, all of the algae, and the more familiar plants that live on land.

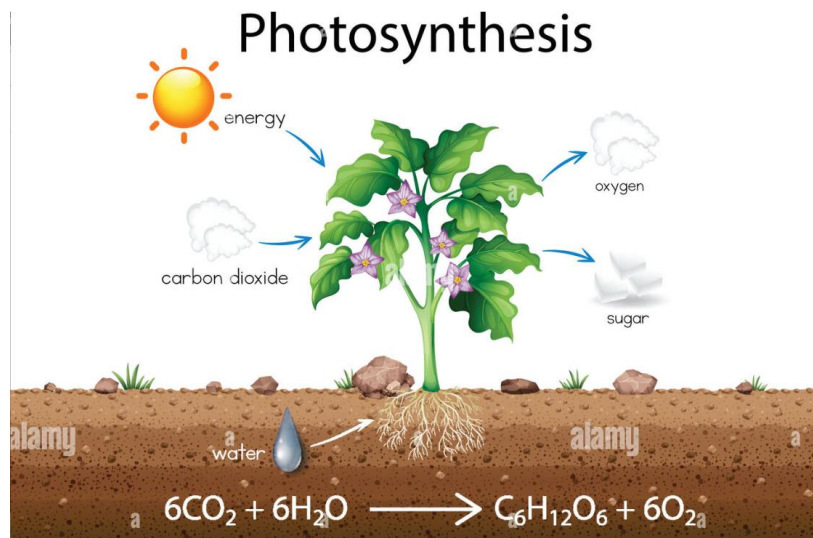


### WHY STUDY PLANTS?

The tremendous importance of plants cannot be overstated. *زیادہ روی*. Without them, we and most other species of animals (and many other groups of organisms) would not be here.

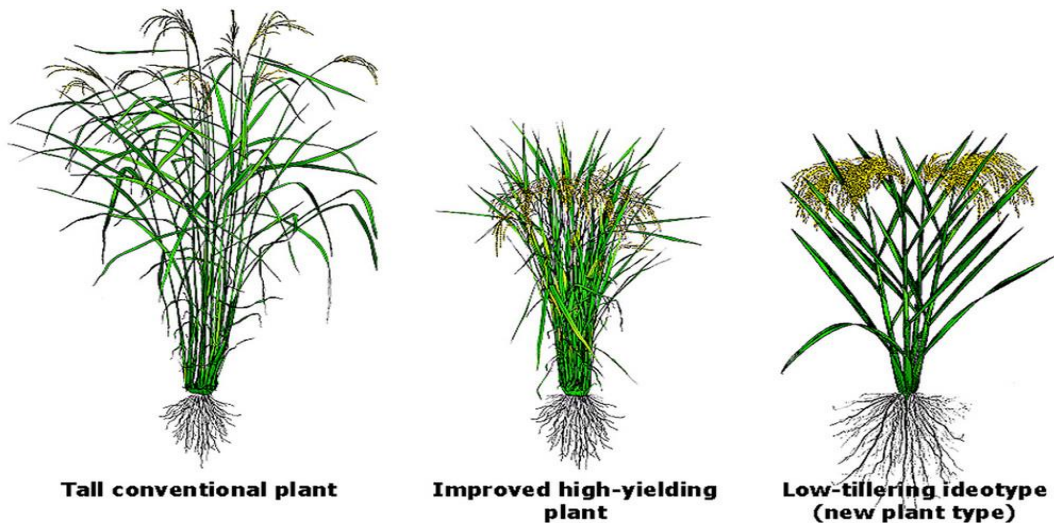
Photosynthesis in plants and the other photosynthetic organisms changed the earth in two major ways. First, the fixation of carbon dioxide and the release of molecular oxygen in photosynthesis directly altered the earth's atmosphere over billions of years. As a critical mass of oxygen accumulated in the atmosphere, selection for oxygen dependent respiration occurred, which may have been a necessary precursor in the evolution of many multicellular organisms, including all animals.

In addition, an oxygen-rich atmosphere permitted the establishment of an upper atmosphere ozone layer, which shielded life from excess UV radiation. This allowed organisms to inhabit more exposed niches that were previously inaccessible. Second, the compounds that photosynthetic species produce are utilized, directly or indirectly, by non-photosynthetic, heterotrophic organisms.

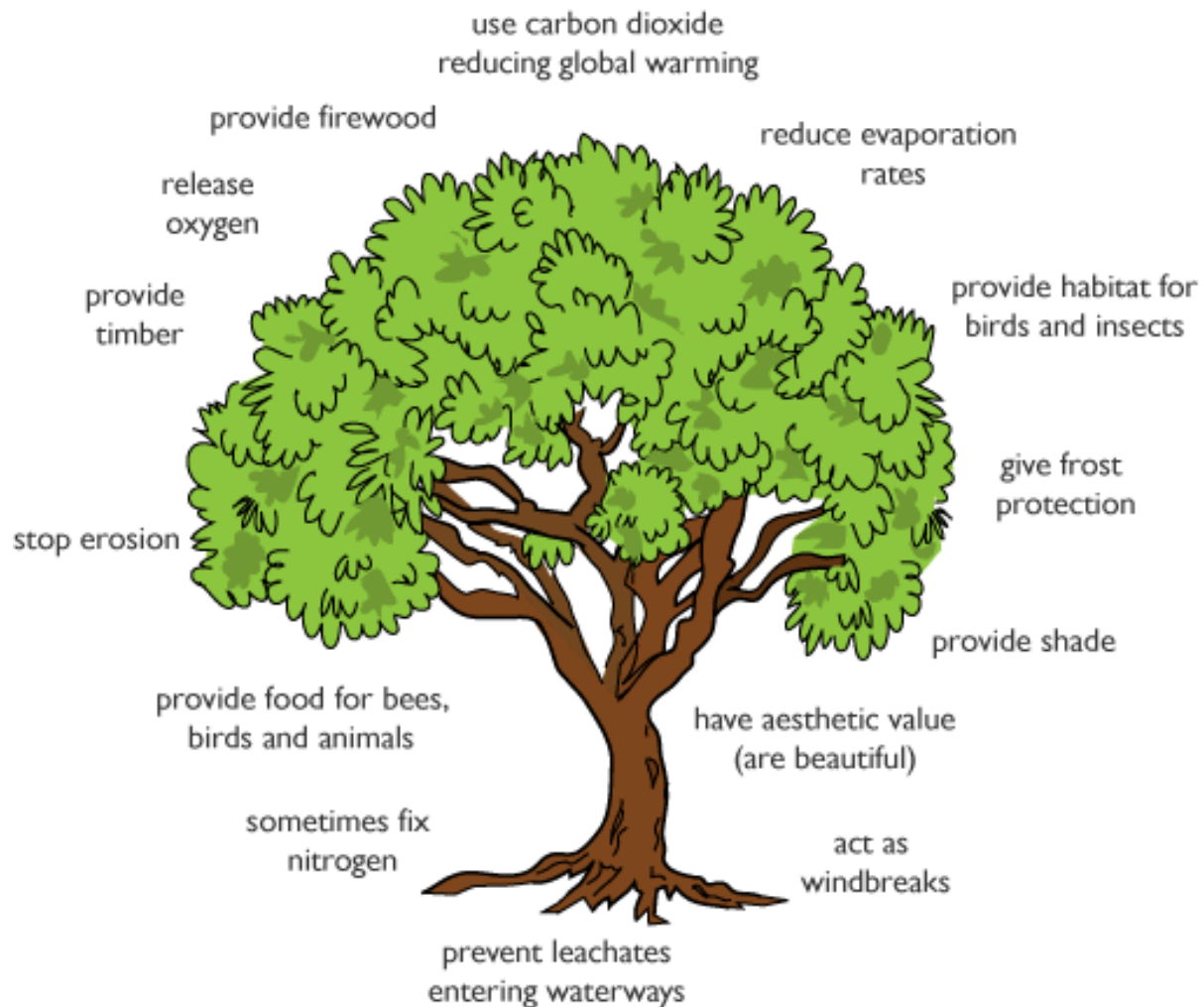


For virtually all land creatures and many aquatic ones as well, land plants make up the so-called primary producers in the food chain, the source of high-energy compounds such as carbohydrates, structural compounds such as certain amino acids, and other compounds essential to metabolism in some heterotrophs. Thus, most species on land today, including millions of species of animals, are absolutely dependent on plants for their survival. As primary producers, plants are the major components of many communities and ecosystems. The survival of plants is essential to maintaining the health of those ecosystems.

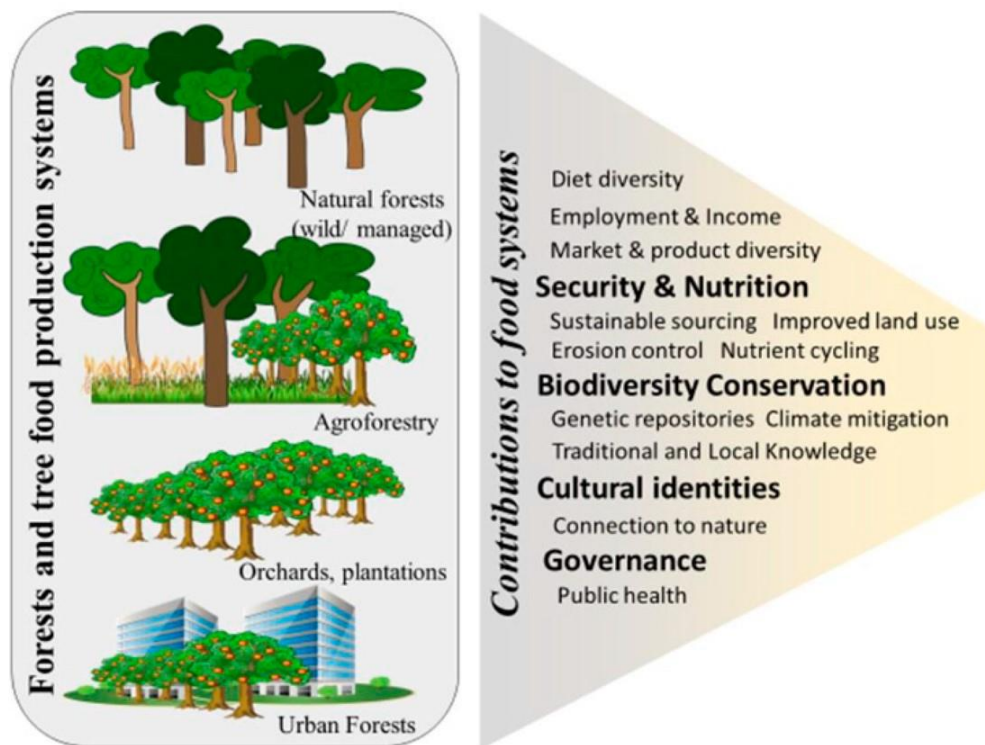
To humans, plants are also monumentally important in numerous, direct ways. Agricultural plants, most of which are flowering plants, are our major source of food. We utilize all plant parts as food products: roots (e.g., carrots; stems (e.g., potatoes; leaves (e.g., cabbage, celery, lettuce; flowers (e.g., broccoli; and fruits and seeds, including grains such as rice, wheat, corn, barley, and oats, legumes such as beans and peas, and a plethora of fruits such as bananas, tomatoes, peppers, pineapples, apples, cherries, peaches, melons, citrus, olives, and others too numerous to mention.



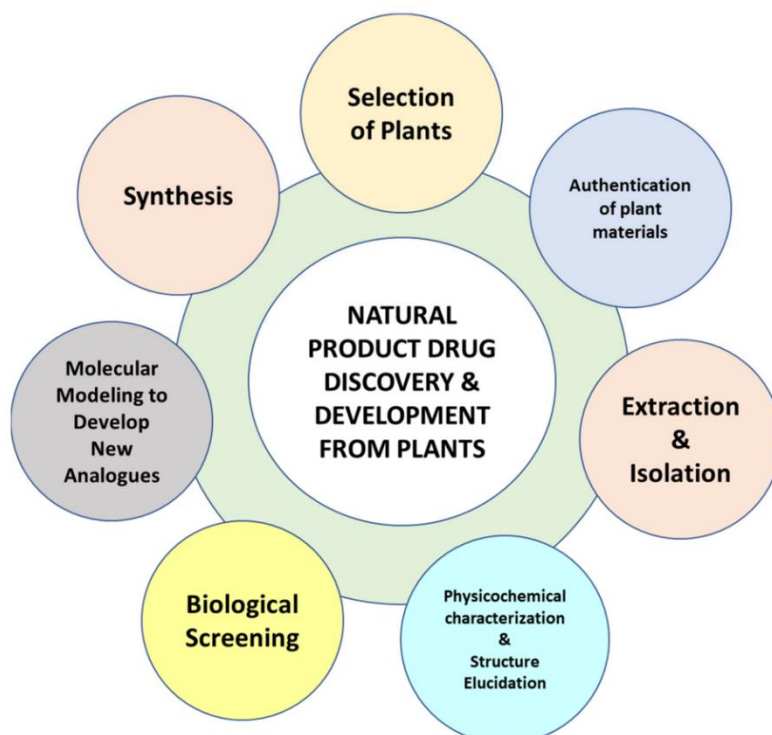
Other plants are used as flavoring agents, such as herbs and spices, as stimulating beverages, such as chocolate, coffee, and tea. Woody trees of both conifers and flowering plants are used structurally for lumber and for pulp products such as paper. In tropical regions, bamboos, palms, and a variety of other species serve in the construction of human dwellings. Plants are important for their aesthetic beauty, and the cultivation of plants as ornamentals is an important industry. Finally, plants have great medicinal significance, to treat a variety of illnesses or to maintain good health. Plant products are very important in the pharmaceutical industry; their compounds are extracted, use to synthesize new drugs.



Some of the fields in the plant sciences are very practically oriented. **Agriculture** and horticulture deal with improving the yield or disease resistance of food crops or cultivated ornamental plants, e.g., through breeding studies and identifying new cultivars. **Forestry** is concerned with the cultivation and harvesting of trees used for lumber and pulp.



**Pharmacognosy** deals with crude natural drugs, often of plant origin. But many aspects of the pure sciences also have important practical applications, either directly by applicable discovery or indirectly by providing the foundation of knowledge used in the more practical sciences.



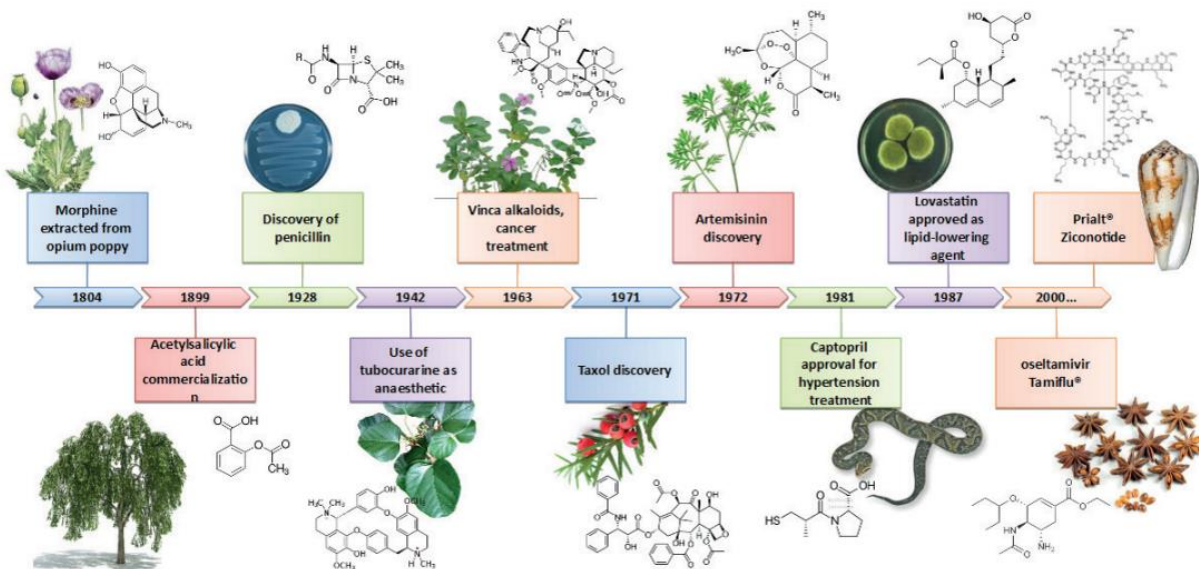
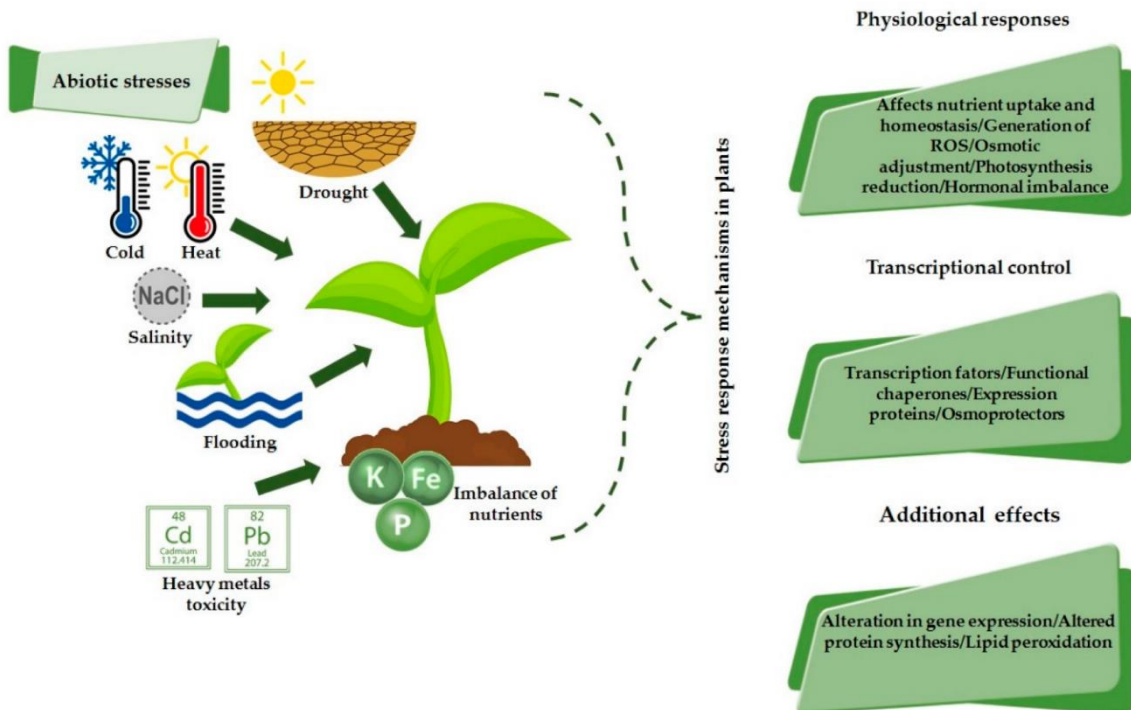


Figure 1 - A few natural products used as medicines identified in the last century.

Among these are plant anatomy, dealing with cell and tissue structure and development; **Plant chemistry and Physiology**, dealing with biochemical and biophysical processes and products; plant molecular biology, dealing with the structure and function of genetic material; plant ecology, dealing with interactions of plants with their environment; and, of course, plant systematics. A distinction should be made between botany and plant sciences.



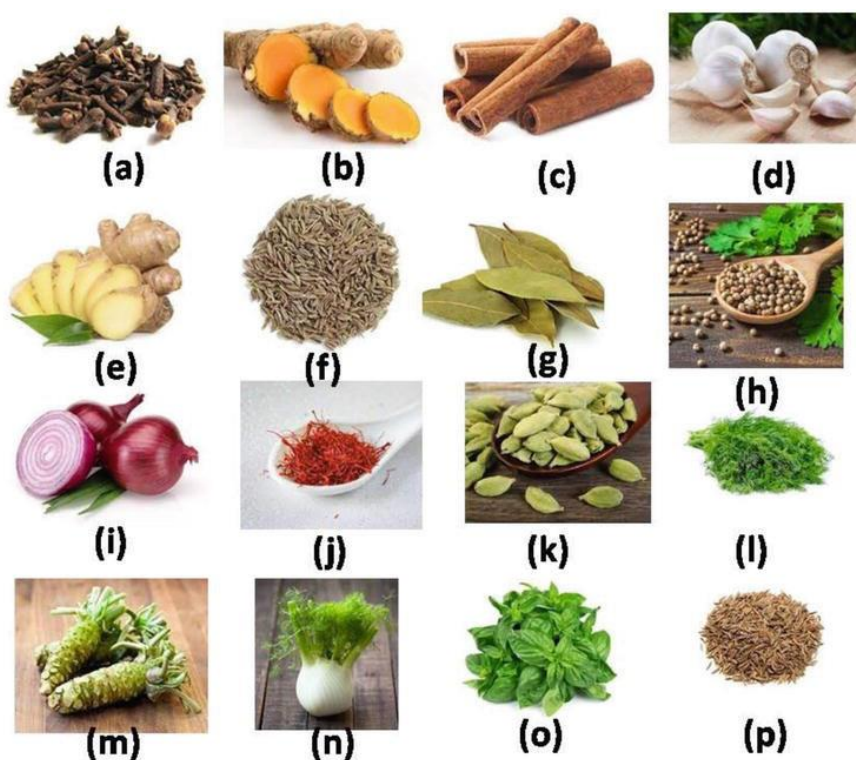


Figure 1. Some common spices in use; (a) clove (b) turmeric (c) cinnamon (d) garlic (e) ginger (f) cumin (g) bay leaf (h) coriander (i) onion (j) saffron (k) cardamom (l) dill (m) wasabi (n) fennel (o) basil (p) caraway.

Herbal medicine is often thought of as a phenomenon of the so-called New Age; in reality, much of it is older than human history. Every society has herbal cures and remedies, many of which have been incorporated into orthodox medicine. In fact, it is estimated that at least half of our modern drugs originated from natural plant sources. One attractive characteristic of these herbal sources for possible future use is their apparent wide safety margin in terms of toxicity compared with synthetic pharmaceuticals. Most natural herbals have been used for some time, yet there are few reports of adverse side effects in users. If natural drugs are safe for common use, future treatment protocols might involve the combination of herbal and synthetic pharmaceuticals, which would allow the usage of far-reduced doses of the medicines.

### **What is a medicinal plant?**

A medicinal plant is any plant which, in one or more of its organs, contains substances that can be used for therapeutic purposes or which are precursors for the synthesis of useful drugs. This description makes it possible to distinguish between medicinal plants whose therapeutic properties and constituents have been established scientifically, and plants that are regarded as medicinal but which have not yet been subjected to a thorough scientific study.

A number of plants have been used in traditional medicine for many years. Some do seem to work although there may not be sufficient scientific data (double-blind trials, for example) to confirm their efficacy. Such plants should qualify as medicinal plants. The term ‘crude drugs of natural or biological origin’ is used by pharmacists and pharmacologists to describe whole plants or parts of plants which have medicinal properties. A definition of medicinal plants for the purpose of this presentation should include the following:

- plants or plant parts used medicinally in galenical preparations (e.g. decoctions, infusions, etc.) e.g. Cascara bark;
- plants used for extraction of pure substances either for direct medicinal use or for the hemi-synthesis of medicinal compounds (e.g. hemi-synthesis of sex hormones from diosgenin obtained from *Dioscorea* yams);
- food, spice, and perfumery plants used medicinally, e.g. ginger;
- microscopic plants, e.g. fungi, actinomycetes, used for isolation of drugs, especially antibiotics. Examples are ergot (*Claviceps purpurea* growing on rye) or *Streptomyces griseus*; and
- fibre plants, e.g. cotton, flax, jute, used for the preparation of surgical dressings.

Plants have been one of the important sources of medicines even since the dawn of human civilization. In spite of tremendous developments in the field of allopathy during the 20th century, plants still remain one of the major sources of drugs in modern as well as traditional system of medicine throughout the world. Approximately one-third of all pharmaceuticals are of plant origin, wherein fungi and bacteria are also included. Over 60% of all pharmaceuticals are plant-based.

Plants may have bioactive constituents like alkaloids, glycosides, steroids, phenols, tannin, antioxidants and other groups of compounds which may have marked pharmaceutical actions as anti-cancerous, anti-malarial, anti-helminthic or anti-dysentric, etc. Many of the essential oils, dyes, latex and even vegetable oils are also widely used as medicines. Many substances that go into making up medicines are frequently products of living cells, although seemingly 'waste' or intermediate, metabolic compounds and not an integral part of the protoplasm and may have no obvious utility to the plants.

Out of nearly 450,000 species of higher plants available, only a small proportion have been investigated for medicinal properties and still a smaller number of plants yield well defined drugs. The same is the case with lower plants and with plants of the sea origin. Thus, the knowledge of plant constituents gained so far is still meager, considering the huge number of species available in the world. Approximately, only 10% of the organic constituents of plants are reported to be known and the remaining 90% are yet to be explored.

A very small proportion of Indian medicinal plants are lower plants like lichens, ferns, algae, etc. The majority of medicinal plants are higher plants. The major families in which medicinal plants occur are Fabaceae, Euphorbiaceae, Asteraceae, Poaceae, Rubiaceae, Cucurbitaceae, Apiaceae, Convolvulaceae, Malvaceae and Solanaceae.

Drugs are derived from trees, shrubs, herbs and even from primitive kinds of plants which do not fall into the above categories. They are made from fruits (Senna, *Solanum viarum*, Datura, etc.), flowers (*Butea monosperma*, *Bauhinia variegata*), leaves (Senna, Datura, Periwinkle, *Tylophora*, etc.), stems (Liquorice, Ginger, *Dioscorea*, Costus, Garlic), roots (*Rauvolfia*, Periwinkle, Ginseng, etc.), seeds (Isabgol, Abrus, *Nux vomica*) and even bark (*Cinchona*).

## Why People Use Herbal Medicine:

The earliest evidence of human's use of plants for healing dates back to the Neanderthal period. Herbal medicine is now being used by an increasing number of patients who typically do not report to their clinician concomitant use. There are multiple reasons for patients turning to herbal therapies. Often cited as a "sense of control, a mental comfort from taking action," which helps explain why many people taking herbs have diseases that are chronic or incurable viz. diabetes, cancer, arthritis, or AIDS. In such situations, they often believe that conventional medicine has failed them. When patients use home remedies for acute, often self-limiting conditions, such as cold, sore throat, or bee sting, it is often because professional care is not immediately available, too inconvenient, costly or time-consuming. In rural areas, there are additional cultural factors that encourage the use of botanicals, such as the environment and culture, a "man earth relationship." People believe that where an area gives rise to a particular disease, it will also support plants that can be used to cure it. In India vast sections of the rural population have no access to modern medicine. Hundred of primary health centers which are intended to serve rural areas, lack staffs, diagnostic facilities, and adequate supplies of drugs. The rural population is heavily dependent on traditional medical systems.

- Natural plant products are perceived to be healthier than manufactured medicine. Additionally, reports of adverse effects of conventional medications are found in the lay press at a much higher rate than reports of herbal toxicities, in part because mechanisms to track adverse effects exist for conventional medicines whereas such data for self-treatment is harder to ascertain. Even physicians often dismiss herbs as harmless placebos.

Plants with medicinal or aromatic properties that are used in pharmacy and/or perfumery are usually defined as medicinal and aromatic plants; however, medicinal, aromatic and cosmetic plants would be a better term as many medicinal and aromatic plants are also used in cosmetics. Aromatic plants are those that contain aromatic compounds – basically essential oils that are volatile at room temperature. These essential oils are odorous, volatile, hydrophobic and highly concentrated compounds. They can be obtained from flowers, buds, seeds, leaves, twigs, bark, wood, fruits and roots. Essential oils are complex mixtures of secondary metabolites comprised of low-boiling point phenylpropenes and terpenes. These oils usually consist of about tens-to-hundreds of low molecular weight terpenoids. Even unidentified trace constituents may be held responsible for altering the odour, flavour and the bioactivity of the oil to a considerable degree. Essential oils have characteristic flavor and fragrance properties, possess biological activities and are widely applied in aromatherapy and healthcare in addition to several industries such as cosmetics, flavoring and fragrance, spices, pesticides and repellents, as well as herbal beverages.

Antioxidant and antimicrobial activities of aromatic plants have been widely explored and found to have health applications in prevention and reducing risk of diseases such as inflammation, atherosclerosis, cardiovascular and cancer. Various plant families, particularly Lamiaceae, Apiaceae and Zingiberaceae have been investigated in depth for their medicinal value due to their significant antioxidant properties. The antioxidant activities of aromatic plants is influenced by various factors such as growing conditions, methods of processing/extraction and importantly constituents of the antioxidants; the methods involved in determination of antioxidant capacity as well as extraction therefore play a crucial role.



## **History of Herbal Medicine**

Plants had been used for medicinal purposes long before recorded history. Ancient Chinese and Egyptian papyrus writings describe medicinal uses for plants as early as 3,000 BC. Indigenous cultures (such as African and Native American) used herbs in their healing rituals, while others developed traditional medical systems (such as Siddha, Ayurveda, Unani and TCM) in which herbal therapies were used. The consumption of plant-based medicines and other botanicals in the West has increased manifold in recent years. About two centuries ago, our medicinal practices were largely dominated by plant-based medicines. However, the medicinal use of herbs went into a rapid decline in the West when more predictable synthetic drugs were made commonly available. In contrast, many developing nations continued to benefit from the rich knowledge of medical herbalism. For example, Siddha & Ayurveda medicines in India, Kampo Medicine in Japan, traditional Chinese medicine (TCM), and Unani medicine in the Middle East and South Asia are still used by a large majority of people.

## **The importance of plants**

Plants have been used by the mankind since prehistoric times for getting relief from sufferings and ailments. Primitive people, when injured in battle or when they had a fall or cut, instinctively resorted to materials available at the reach of hand for stopping the flow of blood or for relieving from pain and, by trial and error, they learnt that certain plants were more effective than others. Man has also gained such knowledge from his observation of birds and animals which use plants for curing their ailments. Even today, we find that the domestic dog and cat, when they suffer from indigestion or other ailments, run to the field, chew some grasses or herbs and vomit to get cured. The folk medicines of almost all the countries of the world abound in medicinal plants wealth, rely chiefly on herbal medicine, even today.

Today, chemical and pharmaceutical investigations have added a great deal of status to the use of medicinal plants by revealing the presence of the active principles and their actions on human and animal systems. Investigations in the field of pharmacognosy and pharmacology have provided valuable information on medicinal plants with regard to their availability, botanical properties, method of cultivation, collection, storage, commerce and therapeutic uses. All these have contributed towards their acceptance in modern medicine and their inclusion in the pharmacopoeias of civilized nations.

The practices of indigenous systems of medicine in India are based mainly on the use of plants. Charaka Samhita (1000 BC-100 AD) records the use of 2000 plants for remedies. Ancient medicine was not solely based on empiricism and this is evident from the fact that some medicinal plants which were used in ancient times still have their place in modern therapy. Thus for example, 'Ephedra' a plant used in China 4000 years ago is still mentioned in modern pharmacopoeias as the source of an important drug, ephedrine. The plant Sarpagandha (*Rauvolfia serpentina*) which was well known in India as a remedy for insanity is in existence today for curing mental ailments. Quinine, another important anti-malarial drug of modern medicine, was obtained from the cinchona tree.

The knowledge about the use of medicinal plants has been accrued through centuries and such plants are still valued even today, although synthetics, antibiotics, etc. have attained greater prominence in modern medicine. It is, however, a fact that these synthetics and antibiotics although they often show miraculous and

often instantaneous results, prove harmful in the long run and that is why many synthetics and antibiotics have now gone out of use or have been specified to be prescribed strictly under medical supervision. In the case of most medicinal plants, however, no such cumulative derogatory effect has been recorded and that is why many of the medicines obtained from plants are still widely used today.

It is also true that lately, in spite of the rapid progress and spread of modern medicine, the popularity of herbal medicines is gaining momentum.

Besides the above, the following are some of the reasons that make the large scale cultivation of medicinal plants inevitable.

1. In nature, there remains a wide variation among the plants with regard to their active principles. As only the best among them are used for cultivation, it enables us to obtain raw material of homogenous quality with high potency.
2. It is easy to grow and fulfill the commitment of large scale demand through cultivated sources rather than from natural sources, which mainly depend on nature for their regeneration and availability.
3. The increasing pressure of population and the development of roads into remote areas have resulted in deforestation and the eventual loss of natural plant resources.
4. In many cases, the important plant parts used are roots or the entire plant, results in destructive collection/ extractive methods, which results in the extinction of many species and ecotypes.
5. Despite the fact that our forests are the major resource base for medicinal plants as many of them appear in wild, the importance of conservation has not been clearly spelt out. Any long-term strategy includes the conservation of biodiversity and support to the communities which are solely dependent on forests for their livelihood.
6. The unauthorized collection of minor forest produce by persons who are led by the burgeoning demand for raw medicinal plant parts has led to the deprivation of the rights and opportunities of the forest-dwelling communities.
7. Since government of India provides policy support for promoting Indian system of medicine, the pharma industries look for organized supply of quality raw materials in larger quantities.

A comparative analysis of the prospects and constraints of the medicinal plant-based drug industry in our country reveals the following.

## **Prospects**

1. The World Health Organization (WHO) has emphasized the need for better utilization of the indigenous system of medicine, based on the locally available medicinal plants in the developing countries. In the USA and UK, plant-based drugs are being used in recent years on a considerable scale. The former USSR countries, East European countries and China have adopted an integrated system of allopathic, traditional and folk systems of medicine. During the last two decades, there has been a tremendous transformation of medical systems in the world. Owing to the realization of the toxicity associated with the use of antibiotics and synthetic drugs, Western countries are increasingly aware of the fact that drugs from natural sources are far more safer. Therefore, there is an upsurge in the use of plant derived products.

2. Medicinal plants and their derivatives will continue to play a major role in medical therapy in spite of advances in chemical technology and the appearance of cheap, synthesized, complex molecules from simple ones through highly specific reaction mechanisms. The reaction involved is either difficult or expensive to duplicate by classical chemical method. For example in Vitamin A, disogenin and solasodine of plants, where steric forms are possible, chemical synthesis yields a mixture of the isomers which may be difficult to separate. The product obtained by synthesis may therefore be toxic or have a different therapeutic effect than what is obtained in nature.
3. Drug development out of medicinal plants is less costlier than synthetic drug development. Reserpine is a good example of this. The synthesis of reserpine costs approximately Rs.1.25/g, whereas, commercial extraction from the plant costs only Rs.0.75 /g.
4. The vast range of agro climatic conditions in India, varying from alpine/mild temperate to tropical regions with abundant rains and sunshine make it an ideal place for the luxuriant growth of flora. India is endowed with incredible natural plant resources of pharmaceutical value. Despite comprising only 2% of the land mass, India is blessed with 25% of the biodiversity of the world. Over 7000 species of plants found in different ecosystems are said to be used for medicine in our country. The Indian pharmacopoeia records about 100 medicinal plants available in India and their preparations.. Out of these, quite a few are also recorded in the pharmacopoeias of other countries of the world and there is a growing demand for them in the international market.
5. There has been a tremendous upsurge in the demand for phytopharmaceutical raw medicinal herbs and vegetable drugs of Indian origin from the Western nations. There is also an increase in domestic demand for raw material used for perfumeries, pharmacies and biopesticidal units. The demand for traditional herbal drugs is also increasing rapidly mainly because of the harmful effects of synthetic chemical drugs and also because of an expansion of pharmacies manufacturing natural drug formulations.
6. Our country is the proud possessor of an impressive medical heritage which encompasses various systems of medicine, viz., Ayurveda, Siddha, Unani, folklore and grandma medicine. India has an invaluable treasure trove of various scriptures on diverse medical systems.
7. India is the source of cheap labor and skilled manpower which readily absorbs technological change and also adopts the same.
8. Being strategically located in the world map, India could become a potential supplier of phytopharmaceuticals, alkaloids and raw medicinal herbs for the emerging world market. At present, India is not self-sufficient in pharmaceutical products, and drugs worth millions of rupees have to be imported every year by the pharmaceutical industries in order to meet the national demand for drugs. Hence it is necessary to bestow utmost attention to check the import by producing the raw material and fine chemicals within the country.
9. In addition, these crops have many virtues like drought hardiness, capability to grow on marginal lands. They are relatively free from cattle damage and hence, can be profitably grown in areas where stray cattle or wild animals or pilferage is a major problem. As it is, medicinal plants are better earners than many of the field crops. Since they are new crops, there is an immense scope for further improvement in their productivity and adaptability, in order to obtain further increase in returns. They are suitable for incorporating into various systems of culture like intercropping, mixed cropping and multi tier cropping.

## Constraints (قيود)

10. Although India is a leading exporter of medicinal plants in the world, the rate of growth of these crops in relation to their economic prospects is not at all satisfactory. The reasons for this apparent backwardness are many and varied.
11. So far, there has been no organized research set-up to continually recharge scientific inputs in order to make their cultivation not only economically viable but also more profitable, so that they can claim their due share in the cropping systems of the country.
12. In spite of the thrust given by the government of India through the institutions like the Centre for Medicinal and Aromatic Plants (CIMAP): the Regional Research Laboratories (RRL), at Jammu, Bhubaneswar and Jorhat; Directorate of Medicinal & Aromatic Plants (DMAPR), National Botanical Gardens, Forest Research Institutes, state Cinchona Directorates in Tamil Nadu and West Bengal, the replenishment of renewable inputs like quality planting material of improved varieties, developing extension literature, organizing training and quality testing, are very limited because of the number of medicinal plants as well as their divergent uses.
13. The other major constraint is marketing of the cultivated raw material because of the quality considerations. Lack of testing facilities at the procurement and trading centres together with unscrupulous market handling, results in wide fluctuations in prices, often going down to uneconomic and unrealistic levels. Thus, speculative trade has been one of the most serious deterrent to the development of this enterprise.
14. The systematic cultivation of a few medicinal plants has been found to be a discouraging enterprise, mainly because of the uneconomical price they command. For example the sale price of *Phyllanthus amarus* is as low as Rs.10/kg, making it a commercially unviable proposal. There is a need for the user industry to come forward and ensure that the cultivated product is going to be homogeneous, in comparison to those collected from natural sources, where there is possibility for wide variation.
15. Although most of them are industry oriented crops, the pattern of land-holdings does not lend itself for commercial cultivation on an extensive scale. In case of a few plants, viz., aonla, asoka, arjun, bael, nutmeg, neem, the cultivation involves a long gestation period due to which many farmers are reluctant to grow them.
16. Unstable market conditions have also kept farmers away from taking up cultivation of these crops. The prices of certain crops like *Holostemma annulare* fluctuate greatly; the price of the crop/kg ranged from Rs. 70/kg in 1993 to Rs. 240/kg in 1990.
17. In the phytopharmaceutical industry, presently, no quality standards have been fixed, either for the raw material or the final product and, as such, one finds wide variation in the quality specifications.
18. Difficulty in proper identification of medicinal plants has led to the use of adulterants or mimics. Physical verification is also a difficult proposition, mainly because the plant part used in many cases like the barks, roots, etc, show close resemblance. The only way to check adulterants would be by chemical examination.
19. The package of practices for number of medicinal plants has not been standardized to suit different agro ecological conditions.

20. The supply of raw material for the phytopharmaceutical industry is virtually monopolized. It is found that supply and price patterns are often determined by the minor forest produce contractors/gatherers.

21. In a number of cases the produce has to be used fresh for which instant transportation is a must, and in many cases it cannot be stored for long periods as this would entail fumigation which at times, results in chemical contamination of the raw material and eventually the final product, because of its residual effect. Generally, the maximum period for which plant material should be stored is around 5-6 months and no more.

22. To overcome these constraints, it is necessary to organize the cultivation of medicinal crops on specific regional basis and organize their marketing on similar lines as that of other cash crops like coffee, tea cardamom, to maximise their production and returns. In fact, in some states like Tamil Nadu, there are some organized production systems like contractual farming, group farming which are exclusively engaged in the production, procurement and marketing of these crops.