

Chapter 2

Origin, Definition, Scope and Area, Subject Matter, Importance, and History of Development of Pharmacognosy

Abstract The term ‘pharmacognosy’ was derived by the merger of two Greek words (e.g., *pharmakon*—drug and *gnosis*—knowledge of) to mean the knowledge of drugs. It was introduced and used for the first time by J.A. Schmidt (1811) and C.A. Seydler (1815), respectively, to define the branch of medicine or commodity which deals with crude drugs. Studies on physical, chemical, biochemical, and biological properties of drugs, drug substances, or potential drugs or drug substances of natural origin as well as the search for new drugs from natural sources are now included in pharmacognosy. Pharmacognosy was developed as a descriptive botanical subject in early days (nineteenth and during the last half of the twentieth century), and currently, plant-based drugs are researched and formulated in modern framework of medicine rather than galenical preparations. Pharmacognosy has been playing a significant role in the discovery, characterization, production, and standardization of natural drugs. Therefore, the scope of pharmacognosy is broad and includes the scientific study of crude drugs, medicinal products (e.g., enzymes, vitamins, antibiotics, pesticides, allergens, and allergenic extracts), and excipients (e.g., coloring, flavoring, emulsifying and suspending agents, diluents, bulking or filler agents, disintegrants, anesthetic aids, sweeteners, binders, adhesives, solidifiers and also the research problems in the areas of phytochemistry, microbial chemistry, biosynthesis, biotransformation, chemotaxonomy, and other biological and chemical sciences. Studies on poisonous, hallucinogenic, and teratogenic plants; raw materials for the production of oral contraceptives, aphrodisiacs, etc., as well as spices, beverages, and condiments are included in the subject matters of pharmacognosy. The history of development of pharmacognosy is as old as that of human history as evidenced by the Neanderthals use of healing herbs such as yarrow, marshmallow before >60,000 years. The innovation of medicinal properties of plants at the beginning was accomplished through guesswork, observation, trial and error, accidental discovery, curiosity, and search for food and in many other ways. The ancient people acquired a considerable volume of knowledge about drugs by a combination of all these means and subsequently a group of people (medicine men) emerged in the society who acquired expertise in collecting, testing, and using medicinal plants for treating diseases. The ancient Egyptian, Babylonian or Assyrian, Indian, Chinese, Greek, and Roman were the forerunner of herbal medicine and contributed

enormously to the development of pharmacognosy. The knowledge developed on herbal medicine was once transferred to successors verbally by the use of signs and symbols, and the earliest written form was the Egyptian papyri. This was followed gradually by backed clay tablets, parchments, manuscript herbals, printed herbals, pharmacopoeias and recently by computerized information database systems.

Keywords Scope of pharmacognosy • Medicinal products • Excipients • History of pharmacognosy

2.1 Origin, Definition, Scope, and Avenue of Pharmacognosy

The term ‘pharmacognosy’ was coined for the first time by an Austrian physician J.A. Schmidt (1759–1809) in his hand-written manuscript ‘Lehrbuch der Materia Medica,’ published in 1811 after his death and C.A. Seydler used the term in his book on crude drugs ‘Analectica Pharmacognostica’ in 1815. Pharmacognosy has been derived by the merger of two Greek words: (a) ‘pharmakon’ means a drug, and (b) ‘gnosis’ means knowledge of or ‘gignosco’ means to acquire knowledge of. Pharmacognosy means knowledge of drugs or to acquire knowledge of drugs. During the nineteenth century and the beginning of the twentieth century pharmacognosy was used to define the branch of medicine or commodity which deals with drugs in their crude or unprepared form from natural sources. The American Society of Pharmacognosy describes ‘pharmacognosy’ as the study of physical, chemical, biochemical, and biological properties of drugs, drug substances, or potential drugs or drug substances of natural origin as well as the search for new drugs from natural sources (Photograph 2.1). Although most pharmacognostic studies focus on plants and medicines derived from plants, other types of organisms such as microbes (bacteria, fungi, etc.), marine organisms, and animals are also important in pharmacognosy. It is the science of nature-derived pharmaceuticals and includes studies on structural, physical, chemical, biological characters of crude drugs their therapeutic use, history, method of cultivation, collection, preparation, preservation, and commerce.

The scope of pharmacognosy is broad in the field of pharmacy. Pharmacognostical studies include natural product molecules, especially the secondary metabolites, which are useful for their medicinal, ecological, gustatory (that distinguishes sweet, sour, bitter, and salty taste properties in the mouth), or other functional properties. In early part of the nineteenth century, the term ‘Pharmacognosy’ was coined; during the last half of the twentieth century, pharmacognosy was evolved from being a descriptive botanical subject to one having a more chemical focus embracing a broad spectrum of disciplines including botany, zoology ethnobotany, marine biology, microbiology, herbal medicine, chemistry, biotechnology, phytochemistry, pharmacology, pharmaceuticals, clinical pharmacy, pharmacy practice, etc.; today, it is a highly interdisciplinary science. At the



Photograph 2.1 Research materials in the pharmacognosy laboratory: drugs from natural sources

beginning of the twenty-first century, pharmacognosy teaching in academic pharmacy institutions has been given new relevance as a result of the explosive growth in the use of herbal medicines. Pharmacognosy is now undergoing major change, and herbal drugs are researched and formulated in the modern framework of medicine instead of galenical preparations or conventional dosage. Pharmacognosy now embraces a wide range of diverse techniques, and the recent progress in extraction, chromatography, hyphenated techniques, screening of natural product, biotechnology, etc., has opened new avenues and lines for pharmacognosist to enhance natural product research. Herbs can be turned into products now, and pharmacognosy is playing active role in the discovery, characterization, production, and standardization of natural drugs.

Pharmacognosy is an important branch of pharmacy that includes the scientific study of structural, physical, chemical, biochemical, and biological properties of crude drugs and search for new drugs from plant, animal, and mineral sources. In addition, pharmacognosy studies of a variety of commercial and medicinal products such as vitamins, enzymes, pesticides, allergens as well as the study of history, distribution, cultivation, collection, preparation, identification, evaluation, preservation, and commerce of medicinal plants. Research problems in pharmacognosy include studies in the areas of phytochemistry, microbial chemistry, biosynthesis, biotransformation, chemotaxonomy, and other biological and chemical sciences.

2.2 Subject Matter of Pharmacognosy and Classification

Pharmacognosy is a branch of pharmaceutical science, and it is involved in the scientific study of crude drugs and active principles including their structural, physical, chemical and biochemical, therapeutic, and economic features.

- (i) Natural source and its drug principles are important subject matter of pharmacognosy. For example, creat (*Andrographis paniculata*) and its labdane diterpenoid and rographolide; purple foxglove (*Digitalis purpurea*) and its cardiac glycoside digitoxin, digoxin; periwinkle (*Catharanthus roseus*) and its anticancer agents, vinblastine and vincristine; St. John's Wort (*Stramonium*) and its chemical constituents tropane alkaloids, hyoscyne and hyoscyamine; Indian snakeroot (*Rauvolfia* root) and its alkaloids, ajmalicine, reserpine, and rescinnamine; fruits such as papaya (*Carica papaya*), kiwifruit (*Actinidia deliciosa* and other species), pineapple (*Ananas comosus*), figs (*Ficus carica*) and their proteases enzyme mixture; thyroid gland and its extracted hormone, thyroxine; pancreas and its peptide hormone, insulin, etc. are equally important as subject matters of pharmacognosy.
- (ii) Excipients (pharmaceutic necessities) such as the coloring (*Curma longa*, *Crocus sativus*, *Carthamus tinctorius*, *Calendula officinalis*) and flavoring agents (*Mentha arvensis*, *Cymbopogon flexuosus*, *C. martini*, *Cyperus scariosus*, *Eucalyptus globules*); emulsifying and suspending agents (*Plantago ovata*); diluents, bulking agents or filler (plant cellulose as well as lactose, sucrose, glucose, mannitol, sorbitol, calcium carbonate, and magnesium stearate), and disintegrants (carboxymethyl cellulose); anesthetic aids (*Cannabis sativus*, *Piper methysticum*); sweeteners (*Glycyrrhiza glabra*, *Stevia rebaudiana*); binders (non-starch polysaccharides—pectins, alginates—and proteins-gelatin); adhesives (guar gum, amylase, and karaya gum); solidifiers (beeswax, cocoa butter, or theobroma oil), etc., are studied as important subject matters of pharmacognosy. Natural excipients are used in the formulation and preparation of pharmaceutical products because they are highly stable, modifiable, compatible, biodegradable, inexpensive, easily available, safe, and non-toxic in contrast to their many synthetic counterparts (e.g., maltodextrin, povidone or polyvinylpyrrolidone (PVP), polyethylene glycol-3350), and thus, they have a major role to play in pharmaceutical industry. In addition, natural excipients (e.g., pectin, agar, gelatin, wax, fixed oils) function as carrier or vehicles to ensure safe and targeted delivery of the active drug constituents of tablets and capsules.
- (iii) The surgical dressings prepared from natural fibers, filtering agents such as diatomite, support media, and many areas of natural paramedics are now included in the subject.
- (iv) Beverages such as tea and coffee are also studied in pharmacognosy because of their caffeine content that has good medical applications as an analgesic and stimulant.

- (v) Pharmacognosy includes studies on poisonous (e.g., *Abrus precatorius*, *Atropa belladonna*, *Colchicum autumnale*), hallucinogenic or psychoactive (e.g., *Cannabis sativa*, *Datura stramonium*, *Ipomoea purpurea*, *Salvia divinorum*), and teratogenic (e.g., *Datura stramonium*, *Lupinus formosus*, *Nicotiana glauca*, *Conium maculatum*) plants.
- (vi) Raw materials for the production of oral contraceptives (*Dioscorea alata*, *D. villosa*), aphrodisiacs (*Epimedium*, *Glycyrrhiza glabra*, *Smilax ornata*, *Turnaria aphrodisiaca*, ginger, ginseng, *Ginkgo biloba*), allergens, enzymes, vitamins, antibiotics, herbicides, and insecticides.
- (vii) Studies of some spices and condiments are included in the subject matters of pharmacognosy as they possess definite medicinal and pharmaceutical properties. Bark of cinnamon (*Cinnamum zeylnicum*); cardamom (*Amomum aromaticum* and *A. subulatum*); fruit and various fruits of Apiaceae such as fennel (*Foeniculum vulgare*); coriander (*Coriandrum sativum*); cumin (*Cuminum cyminum*), anise (*Pimpinella anisum*); seeds of mustard (*Brassica alba*, *B. juncea*, *B. nigra*); flower bud of clove (*Syzygium aromaticum*); and rhizome of ginger (*Zingiber officinale*) are some typical examples of such articles.
- (viii) The subject also includes many other aspects of plant science such as history, distribution, methods of cultivation, collection, identification, structure, drug preparation, evaluation, preservation, use and commerce of medicinal plant and plant products as well as use of biotechnological method for the production of active drug principles.
- (ix) The pharmacognostical studies of crude drugs from plant and animal sources include botany, zoology, chemistry, and pharmacology as basic subjects. Botany and zoology include the identification (taxonomy), genetics, breeding, pathology, etc. Taxonomic identity is fundamental for pharmacopoeial and quality control purposes, and by applying broader biological knowledge, one can improve the cultivation and culture methods for both plants and animals of therapeutic importance. In the nineteenth and even at the beginning of the twentieth century, botany played role in pharmacognosy for botanical description and identity of the crude drugs in their whole state and in powder form for pharmacopoeial identification and quality control purposes. Chemical characterization includes isolation, identification, and quantification of constituents in plant and other animate materials. Pharmacology studies the biological effects that the chemicals in medicinal plants and other natural sources have on cell cultures, animals, and humans (including pharmaceuticals, clinical pharmacy). Chemistry, pharmacology, microbiology, and biochemistry play important role in pharmacognostical studies involved in isolation, identification, characterization, biotransformation, and discovery of lead compounds and new drugs from natural sources.
- (x) Pharmacognosy also includes ethnobotany (traditional use of plants for medicinal purposes plays important role in drug discovery); ethnopharmacology (pharmacological aspects of traditional medicinal substances);

phytotherapy (the medicinal use of plant extracts); phytochemistry (diversity of phytochemicals, identification of new drug candidates); zoopharmacognosy (animals self-medication by using plants, soils, and insects); biotechnology (synthesis of natural bioactive molecules using biotechnology); herbal interactions (interactions of herbs with other drugs and body); and marine pharmacognosy (use of and chemicals derived from marine organisms), analytical pharmacognosy, herbal formulations, nutraceuticals, cosmeceuticals, etc. Herbal formulation indicates composition product (single or multiple herbs) and dosage form (quantity) and provides other information regarding use (therapeutic, nutritional, cosmetic), benefits, and contradictions.

- (xi) Molecular biology, genomic science, biotechnology, and bio-informatic tools have a deep impact on drug discovery and development. Analytical pharmacognosy, by applying different analytical methods, determines different physical and chemical constants such as ash values, extractive values, moisture content and loss on drying (LOD), volatile oil content, bitterness value, microbial load, pesticides, heavy metals and radioactive contaminants, foreign matters in various herbal drugs. Determination of *R_f* value following chromatography and chemical tests is important for quality control of herbal drugs.
- (xii) Adulteration of crude drugs is detected by microscopic, physical, organoleptic, chemical, biological, and other methods of evaluation. Assessment of quality, stability, safety, and efficacy is essential for standard herbal formulation. Proper double-blind clinical trials are needed for the improvement of quality (identity, purity, consistency, etc.), efficacy (therapeutic indications, clinical studies, pharmacological investigations), safety (adverse reactions, drug interactions, contraindications, precautions) of the herbal products before recommendation for therapeutic use (Ernst 2007; Vickers 2007; Shinde et al. 2008; Blondeau et al. 2010). With the renaissance of pharmacognosy in the twenty-first century, the conventional botanical approach of pharmacognosy has been extended up to molecular informatic and metabolomic levels (Huang et al. 2009; Dhami 2013). Pharmacognosy considers all these as its subject matter.

2.3 Contribution of Pharmacognosy in Pharmacy and Pharmacology

- (i) Pharmacognosy, the science of crude drugs of natural origin, occupies an important place in pharmacy. Pharmacognosy provides information about a large group of drugs and excipients from natural sources useful for screening, discovery, and development of modern pharmaceutical drugs.

- (ii) Pharmacognosy supplies the general information about solubility, reactivity, stability, toxicity, dosage, availability, purity and yield, methods of isolation, purification, and identification of the chemicals of natural drugs to all practicing pharmacists. A thorough understanding of the active principles of natural drugs as chemicals is necessary for a successful practice of the pharmacists. Thus, pharmacognosy has become a discipline of increased significance in the curriculum of pharmaceutical education.

- (iii) Pharmacognostical information on identity, physical nature, and chemical constituents of the drug principles is essential for understanding their pharmacological activities.

Chemical nature and properties of a drug principle can be studied and understood, or it can be synthesized or its activity can be modified or improved by a pharmaceutical chemist having a good knowledge in pharmacognosy about its source, occurrence, method of isolation, and state of purity.

- (iv) Formulation and preparation of a pharmaceutical product, pharmaceuticals, are dependent on a number of properties, such as solubility, stability, reactivity of the ingredients. A pharmacist can earn this type of information on substances of natural origin from pharmacognosy.

- (v) Price of a pharmaceutical product from natural sources or containing substances of natural origin is influenced by different pharmacognostical criteria such as the number of constituents from plant or animal constituents, methods of collection, curing, drying, and assaying of the ingredients. Thus, pharmacognosy is intimately associated with the curriculum of pharmacy administration dealing with prescription and pricing.

The relationship of pharmacognosy with operative pharmacy and dispensing is very intimate.

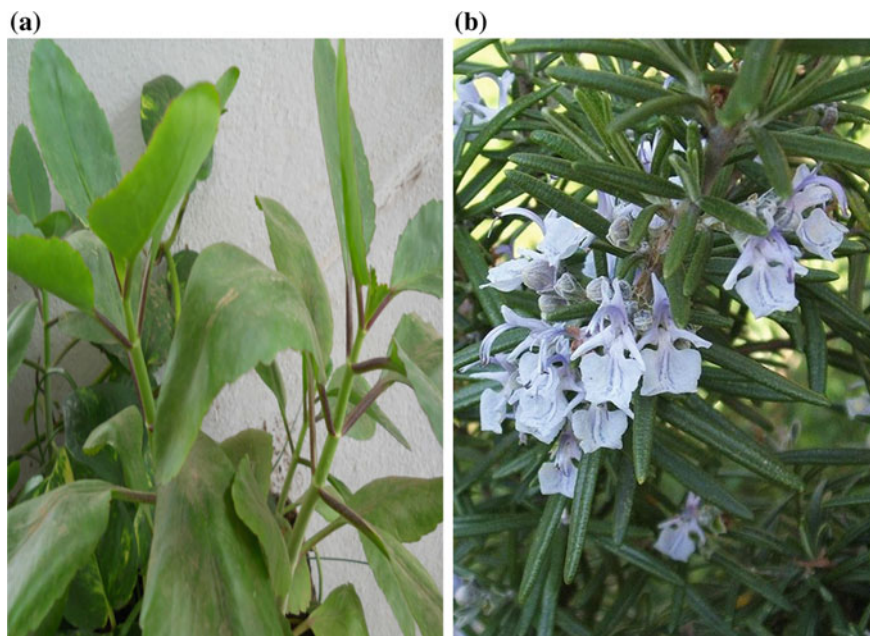
- (vi) Pharmacology, an important branch of pharmacy, deals with the research, discovery, development, and characterization of drugs, and therefore, it is intimately associated with the life cycle of any drug (e.g., discovery and research, development, regulatory review and approval, commercialization). Pharmacognostical studies provide most of the information about authenticity, purity, safety, chemical characteristics of the natural products required for pharmacological works leading to drug discovery and development.

- (vii) Because its multidisciplinary characteristics, pharmacognosy is closely related to botany and phytochemistry and shares some grounds with biochemistry, physiology, enzymology, food technology, taxonomy, anatomy, morphology, phytochemistry, cultivation, and conservation of medicinal plants. Pharmacy is related to the majority of pure and applied science disciplines including some of these subjects.

2.4 History of Development of Pharmacognosy

The history of development of pharmacognosy is the history of gradual advancement in use of plants and other products of natural resources for therapeutic purposes. From antiquity until the availability of medicaments as pure chemicals and synthetic drugs in nineteenth century, people were completely dependent on crude drugs from medicinal herbs and other natural sources for prevention and treatment of their ailments. Many herbs and spices were historically used by humans to season food and to combat food-borne pathogens, and therefore, the history of herbalism overlaps with food history (Billing and Sherman 1998; Lai and Roy 2004; Tapsell et al. 2006). Pharmacognosy began in ancient times with the search for the natural medicaments including plants, animals, and minerals from the surrounding environment, and so it was linked with the healthcare activities of the most primitive human race of the remote past. Healing herbs and other natural elements existed long before the existence of people on earth, and they had only discovered their curative power. There are historic sites in Iraq that show Neanderthals used yarrow, marshmallow, groundsel, centaury, ephedra, muscary, etc., herbs more than 60,000 years ago. The people of early days tried to alleviate their sufferings or illness by using plants as medicaments plants that were growing in the surroundings, and their innovation of medicinal properties of plants was not based on any scientific method or on the knowledge of chemical constituents of plants. The ancient people exploration of medicinal properties of plants throughout the ages discovered crude drugs and acquired knowledge of pharmacognosy in many ways including trial-and-error guesswork, observation, accidental discovery, curiosity, search for food, etc. (Photographs 2.2, 2.3, 2.4, 2.5, 2.6).

- i. Trial-and-error guesswork: Trial-and-error guesswork means that try and then discard the object until it serves the purpose. This method helped ancient people to distinguish between the beneficial and poisonous plants. This was a rough and time-consuming method of identifying herbs; people used this method when they were nomad and lived on hunting wild animals and gathering plants from the wild. There would be a long and flat learning curve, and they might had innumerable mistakes and problems to identify toxic, edible, and curative fruits, seeds, tuber, etc., gathered from the wild. Ancient people led by instinct, taste, experience, and wisdom used plants for healing. They dug, dried, chewed, pounded, rubbed, and brewed many of the plants surrounding them and tried to discover herbal effects through trial-and-error guesswork. They discovered that some plants were good for food, some were poisonous, and some produced bodily changes such as increased perspiration, bowel movement, urination, relief of pain, hallucination, and healing. Development of a number of innovative techniques, computer-based technology, and biomathematical models in the recent years has replaced the inefficient age-old trial-and-error guesswork method of drug discovery.



Photograph 2.2 **a** *Kalanchoe pinnata* (*Bryophyllum pinnatum*, Pathorcuchi); an age-old drug for diabetic patient, **b** Rosemary (*Rosmarinus officinalis*) used for medicinal purposes by prehistoric peoples

- ii. While searching for food: Many of the herbs and spices used by humans were identified, while they were searching for food plants, and as time went by, they discovered the therapeutic benefits of herbs and spices. Food such as meats was stored with the help of herbs in the prehistoric households, and today, the same plants are used as culinary spices. Herbs or medicinal plants and spices are used to produce natural conservatives. Some of the commonly used herbs and species used today for food preservation are: cinnamon, clove, ginger, oregano, pepper, rosemary, sage, thyme, turmeric, etc. Recently, scientists from Aarhus University, Denmark, in collaboration with the Danish Meat Research Institute produced a new method of preserving meat with herbs and berries like aronia (chokeberry), sage, savory, sloe (blackthorn), lingo berry, wild garlic (ramsons), red currant, and horseradish (Benson 2012). Spices and herbs have been used for thousands of centuries by many cultures to enhance the flavor and aroma of foods. Early cultures also recognized the value of using spices and herbs in preserving foods and for their medicinal value. Since the late nineteenth century, scientific experiments have documented the antimicrobial properties of many spices, herbs, and their components (Shelef 1983; Zaika 1988). The ancient people were not aware of this quality of their collected herbs and spices, but they discovered the properties through repeated use.

(a)



(b)



Photograph 2.3 a Apple and tomato as food items are rich source vitamins, minerals, and antioxidants; b thyme herbs; and c spices such as parsley, basil, oregano, garlic, turmeric, pepper possess antimicrobial properties

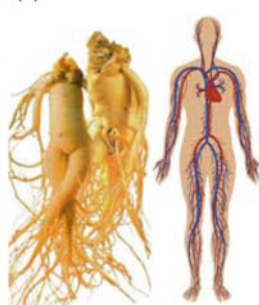
(a)



(b)

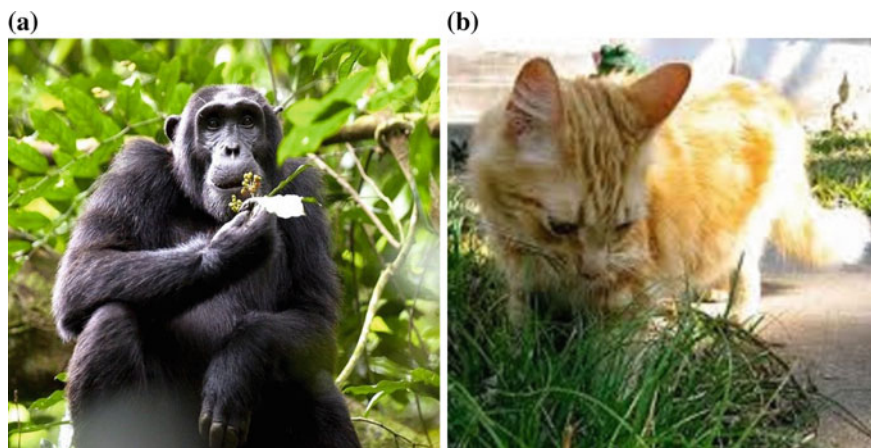


(c)



Photograph 2.4 Prehistoric signature plants: a horsetail, b ginkgo (leaves and fruits), and c ginseng roots show resemblance with human anatomy

- iii. Signature of nature: Many naturally growing plants or their parts show some superficial resemblances with human anatomy. The ancient people might have put emphasis on definite ‘signatures’ resemblance between plant and ill organ,



Photograph 2.5 **a** Common chimpanzee (*Pan troglodytes*) taking *Aspilia* sp. to fight intestinal parasite; **b** a cat eating grass—these are examples of zoopharmacognosy. Source [iStockphoto.com](https://www.iStockphoto.com)

while they were searching and selecting plants for therapeutic use. Such superficial structural similarities were the selection criteria for curative use. horsetail, ginkgo, ginseng, etc., are ancient signature plants.

Belief in this concept was developed independently among different cultures in ancient times. Later on, it became popular as ‘Doctrine of Signature.’ The Doctrine of Signatures has probably existed as long as people have looked at plants. Configuration and structure of a plant guided early man to its use in the treatment of different diseases, e.g., horsetail mimics cartilage, and was thought to support the connective tissue, leaves; the cross section of the fruit of the *Ginkgo biloba* resembles a brain and, today, *Ginkgo* is used for memory loss; ginseng root resembles human body and has been used for thousands of years as a tonic for the entire body.

- iv. Animal’s instinctive discrimination between toxic and palatable plants. Animals survive in a highly complex, dynamic, and unpredictable habitat, and they can instinctively discrimination between toxic and palatable plants. Ancient people after a closer look on animal’s behavior found that sick animals were using certain herbs that they normally ignore. Intimate and careful observation of such instinctive behavior of animals was helpful for ancient people in choosing the beneficial plants from medicinal point of view. Later, they were incorporated into prehistoric shamanism and then into medicine. Growing scientific evidence supports the view that wild animals have knowledge for self-medication, e.g., chimpanzees eating *Aspilia* shrub and pith of *Veronia* plant to remove parasitic worms from the intestinal lining. Many other animals including birds, bees, cat, deer, dog, elephants, elk, lizards, and various carnivores are known to consume medicinal plants for self-medication (zoopharmacognosy). Scientists of the present time also use this method to isolate active compounds from medicinal plants.



Photograph 2.6 **a** *Terminalia arjuna*. (a) Tree trunk with split bark, (b) bark separated from the tree trunk, (c) bark in powder form (the drug in usable form) **b** *Cinchona pubescens* (Quinine) tree (left) and dry bark (right) (BioWeb Home, AGE Fotostock)

- v. By accidental discovery or fortuitous accidents. The use of plants for medicinal purposes began in ancient times, and it is believed that some of these plants were accidentally discovered (unexpected discoveries by accident). The discovery of antimalarial drug (quinine) by a South American from *Cinchona* bark (known as quina-quina to indigenous people) and antibiotic penicillin from *Penicillium* mold happened accidentally. The accidental discoveries are referred to as drug serendipity (finding of one thing while looking for something else). There are many examples of serendipitous discoveries of medicinal plants and their constituents. Discovery of psychotropic medicine such as potassium bromide, chloral hydrate, lithium was serendipitous. The medicinal use of *Cannabis* is as old as about 5000 years or more, but the discovery of its medicinal applications of *Cannabis sativa* was accidental. It was a source of nutritious seeds for the ancient people, but later they noticed the dizzying side effects due to accidental intake of flower parts with the edible seeds. From accidental consumption, purposeful use developed and the earliest form of pharmacology began. *Cannabis* is a powerful medicinal plant famous for its psychotropic properties. Some of the most important modern discoveries in medicine, e.g., smallpox vaccine, insulin and its use in diabetes treatment, X-rays, Viagra, are serendipitous or accidental discovery.

In course of time, ancient people through their health-related and other activities acquired a considerable volume of knowledge about drug and drug application. Subsequently, a group of people emerged in each ancient community who acquired expertise in collecting, testing, and treating diseases. These people were the pre-historic or early 'Medicine Men.' They monopolized the knowledge of drugs and hide that knowledge in some mysterious incantations. They transferred this secret knowledge only to their trusted successors of the successive generations, who gradually increased the volume of knowledge about drugs and their uses. Initially, the transfer of the acquired knowledge from generation to generation was done verbally by the use of signs and symbols. As civilization progressed, transfer and recording of the knowledge were done in writing, e.g., clay tablets, papyrus. Throughout the Mesopotamian tablets and the Egyptian papyri, references are made to the medicinal use of cannabis as a remedy for acute pain, fever, trench foot/gout/sore feet, inflammation, gynecological disorders, colorectal illness, serosity, bacteria (Photograph 2.7).

The history of the use of medicinal plants for therapeutic purposes, i.e., the history of development of herbalism and pharmacognosy, passed different historical periods such as (i) prehistory, (ii) ancient history (Mesopotamia, Ancient Egypt, India, China, Ancient Greece and Rome), (iii) middle ages, (iv) early modern era (sixteenth to nineteenth century), and (v) modern era (from twentieth century onward). Historically, herbal medicine or herbalism belongs to four basic systems such as (i) traditional Chinese herbalism, (ii) Ayurvedic herbalism, (iii) Western herbalism (originated in Greece and Rome and spread to other parts of Europe and then to America), and (vi) Arab traditional medicine (Unani system of medicine).



Photograph 2.7 Sumerian medical tablet (2400 BC) listed 15 prescriptions (Library of Ashurbanipal) (left); Papyrus Ebers (1550 BC) (Antique Cannabis Book) (right). (<https://rootsnwingz.com/tag/education/>)

In addition to these, other forms of herbalism also exist in many parts of the world (e.g., Kampo medicine in Japan).

(i) Prehistory

Early records on medicine of natural origin from plants, animal parts, and minerals have been discovered from the ancient Babylonian, Egyptian, Indian, Chinese, North Africans, Greek, Roman, and Celtic cultures. All early cultures had left valuable evidences in their past activities on therapeutic use of their plant resources. Prehistoric physical evidence of the use of herbal remedies of the remote past (60,000 years old) was found in a burial site of a Neanderthal man in 1960 in northern Iraq (Solecki 1975). An analysis of the soil around the human bones revealed extraordinary quantities of plant pollen of eight species including yarrow (*Achillea*), marshmallow (*Althaea*), groundsel (*Senecio*), cornflower or centaury (*Centaurea*), Ma Huang (*Ephedra*), and tassel (*Muscary*). Seven of these were medicinal plants which are still in use throughout the herbal world (Bensky and Gamble 1993). Shanidar IV flowers, due to their considerable medical activity, would be a purposeful selection of the Middle Paleolithic Shanidar Neanderthals (Lietava 1992). However, the purposeful inclusion medicinal plant along with corpse in the Shanidar cemetery has now been disputed seriously (Sommer 1999;

Pettitt 2002). The body of Otzi, the Iceman, frozen in the Otzal Alps for more than 5300 years, contained medicinal herbs. These herbs appear to have been used to treat the parasites found in his intestines. The analysis of coprolites (desiccated fecal remains) of prehistoric man for undigested remains (macroremains and pollen) is a widely used method to get prehistoric information about the dietary and medicinal usage of plants (Bryant 1974; Reinhard et al. 1991). Analytical results of the 40 coprolites for pollen content of Caldwell Cave demonstrated the prehistoric people used medicinal plants such as *Ephedra*, *Prosopis*, and *Larrea* as pollen tea to combat diarrheal disease (Holloway 1983).

(ii) Ancient history

Plants have been the mainstream material source for shelter, food, and medicine for the people of all ages. They identified their nourishing value and healing power. In course of time, people entered from Paleolithic to Neolithic period and during the new stone age (8000–5000 BC), the lake dwellers gathered hundreds of plants and initiated cultivation of many crop species including several with significant medicinal value (e.g., *Papaver*, *Sambucus*, *Fumaria*). The practice of early mind–body medicine was followed by the rise of Egyptians (2500 BC) rational medicine. After the discovery of formal writing systems, the ancient prehistoric people began documenting the history of use of medicinal plants. Thus, they entered into the historic time several thousand years ago. Development of trade routes enhanced the exchange of views and practices regarding the use of herbal medicine among the ancient cultures of different regions.

The Sumerian civilization in southern Mesopotamia began by 3500 BC, and the characteristic cuneiform writing developed around 3100 BC. Mesopotamian medical knowledge compiled as ‘Treatise of medical diagnosis and prognoses,’ written in cuneiform, was preserved in clay tablets for several hundred years in the library of Assurbanipal. The Sumerians created clay tablets with lists of hundreds of medicinal plants including myrrh, opium. The Babylonians were aware of the use of about 250 medicinal plants at about 3000 BC. The Babylonian medicine developed in Mesopotamia from 3000 BC to 1648 BC. Babylonians had two types of medical practitioners: the asipu (whose cures were said to be magical based on prayers, chants, and rituals to propitiate the angry gods) and the asu (whose cure were basically medical). The Babylonian society at that time believed in fearsome gods who used illness to punish people for their sins (sin was the cause of a patient’s illness). Babylonian provides the earliest known record of practice of the art of apothecary (2600 BC), and the practitioners were three in one (priest, pharmacist, and physician). They described in clay tablets the symptoms, prescriptions, directions of compounding, and finally prayer to God. The Babylonian physicians utilized an extensive repertory of herbal medicines (e.g., cassia cinnamon, turmeric, garlic, myrtle, thyme, willow, pear, fir, fig, dates), salt as an antiseptic and saltpeter as astringent as well as animal products (e.g., milk, snake skin, turtle shell). The Babylonian Materia medica on a clay tablets is one of the oldest known medical treatises in existence, dated back from 2200 to 2100 BC. ‘An infection without a

doctor is like hunger without food' is an old Babylonian proverb which signifies their habitual dependence on doctors to suit their needs just as peoples' dependence on food to suit hunger. They also used polished diorite in medical writings, e.g., the 'Law Code of Hammurabi (1700 BC), a medical document that demonstrates the skill of Mesopotamian physicians in the use of different herbal drugs including sesame oil, belladonna, henbane, licorice, mandrake, sinna, mint, poppy.

Like Mesopotamian, many ancient documents revealed that plants were used medicinally in China, India, Egypt, Greece and Rome, America, Australia, New Zealand, etc., long before the beginning of Christian era. In China, medicinal plants had been in use since 5000 BC. The Chinese pharmacopoeia, the 'Pen T'sao' written by Shen nung (3000 BC), appears to be the oldest pharmacopoeia on earth. It described 365 drugs (120 emperor, 120 minister, and 125 servant drugs) including the use of Chalmogra (*Hydnocarpus kurzii*) seed oil against leprosy. Other medicinal plants included in this authoritative treatise were aconite (*Aconitum* spp.), ephedra (*Ephedra sinica*), hemp (*Cannabis sativa*), opium (*Papaver somniferum*), rhubarb (*Rheum rhabarbarum*), *Podophyllum*, ginseng (*Panax* spp.), stramonium (*Datura stramonium*), cinnamon bark (*Cinnamomum* spp.), etc., and these are still recognized in pharmacy. The ancient Chinese doctors are now regarded as pioneer in the use of herbal preparations. The other earliest medical treatises of China include inscription on oracle bones from the Shang dynasty (1766–1122 BC) and medical treatises on silk banner and bamboo slips. The 'Shang Hang Lun' (treatise on the treatment of acute diseases caused by cold) of Chang Chung Ching (142–220 AD) along with 'Chin Kuei Yao Lueh' (prescription from the golden chamber) comprises the basis of Chinese and Japanese herbalism (Kampo). Tao Hong Jing (456–536 AD) compiled 'Pen T'sao Jing Ji Zhu' (commentaries on the herbal classic) which contained 730 herbs of six categories such as minerals, grasses and trees, insects and animals, fruits and vegetables, grains. During Sui dynasty (589–618 AD), specialized books ('Sui Shu Jing JiZhi'—bibliography of the history of Sui) on herbal medicine include their cultivation ('Zhong Zhi Yue Fa'—how to cultivate herbs?) and collection from the wild ('Ru Cai Yue Fa'—how to collect herbs in the forest?). Pharmaceutical system was established in China during Sung dynasty (960–1276 AD). Li Shi Zhen (1518–1593 AD) compiled and completed 'Pen T'sao Kan Mu' (herbal with commentary) in 1578 during dynasty. This book listed 1892 drugs and over 11,000 prescriptions.

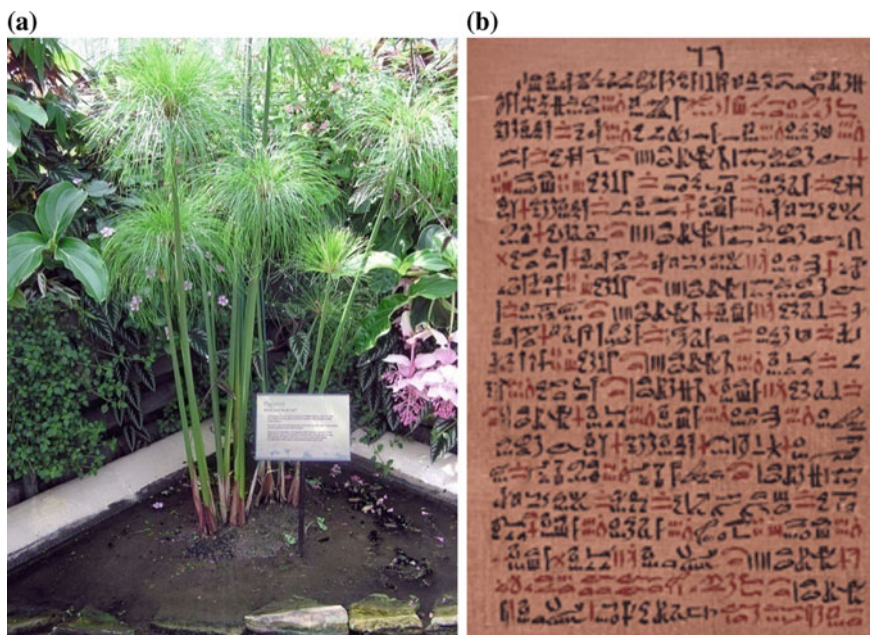
Among the ancient civilizations, Indian subcontinent has been known to be rich repository of medicinal plants. About 8000 herbal remedies have been codified in Ayurveda (Ayur means life, veda means the study of, i.e., life, knowledge), the medicine of classical antiquity. Ayurveda developed significantly during the Vedic period based on four Vedas (e.g., the Rig, the Sama, the Yajur, and the Atharva Vedas) of Hinduism compiled/written in Sanskrit ancient time between 6000 and 4000 BC. Out of them, the Rig Veda (the oldest written book preserved in the library) and Atharva Veda represent some of the earliest available written documents about the medical knowledge and practices that formed the basis of the Ayurveda system. The Rig Veda contained description of 67 species of medicinal plants, Yajur Veda 81 species and Atharva Vaveda 290 species. Charak Samhita

and Sushrut Samhita had described properties and uses of 1100 and 1270 species, respectively. The Charaka Samhita, the Sushruta Samhita, and the Astanga Sangraha are the greater triad and constitute important text in Ayurveda written by the three great authors—Charaka, Sushruta, and Vagbhata, respectively. Many herbs (700), minerals (64), and animal preparations (57) used in Ayurveda were later described in Sushruta Samhita.

A holistic approach is followed during diagnosis and therapy, and it is fundamental to Ayurveda. The earliest plant medicines used in the Ayurvedic system were described around 1200 BC, and these are still in use in the classical formulations. By the medieval period, Ayurvedic practitioners developed a number of medicinal preparations and surgical procedures for the treatment of various ailments. Practices that are derived from Ayurvedic medicine are regarded as part of complementary and alternative medicine. At present, Ayurveda is well integrated into the Indian national healthcare system following the establishment of state hospitals for Ayurveda in different parts of the country.

The ancient Egyptians left their medical procedures and practices as written document on papyrus. Papyrus is a thick type of paper made from the pith of the papyrus plant (*Cyperus papyrus*), and its use as a writing material goes back to antiquity (Photograph 2.8). The papyri texts described in detail the medical procedures and practices including herbal remedies, surgery, and a mixture of magic and religious spell. So far nine principal medical papyri are known, and they were named after their original owners (Edwin Smith, Chester Beatty, Carlsberg), the site of their discovery (Kahun, Ramesseum), the towns where they were kept (Leyden, London, Berlin) or their editor (Ebers).

The Ebers Papyrus or Papyrus Ebers (1550 BC) named after Georg Ebers, a German Egyptologist, that includes medicine, obstetrics, gynecology, and surgery; Edwin Smith papyrus or Edwin Smith Surgical Papyrus (1600 BC)—the oldest known surgical treatise on trauma; Kahun medical papyrus (1900 BC) that includes medicine, obstetrics, gynecology, pediatrics, and veterinary medicine, are some of the oldest and most important medical papyri of ancient Egypt. It is believed that these papyri have been copied from earlier texts, perhaps dating as far back as 3400 BC. They represent the Egyptian oldest medical document. The Ebers papyrus, discovered in 1862, contains around 876 prescriptions made up of more than 500 different substances. It is a collection of diverse medical texts that offers the most complete record of Egyptian medicine. The scroll addressed ailments ranging from crocodile bites to toenail pains contains a ‘treatise on the heart,’ chapters on contraception, diagnosis of pregnancy, birth control and other gynecological matters, intestinal disease and parasites, helminthiasis, hookworm, filariasis, ophthalmology, dermatology, obstetrics, dentistry and the surgical treatment of abscesses and tumors, bonesetting and burns, diabetes mellitus, trachoma, arthritis, and a short section on psychiatry as well as despondency. It also includes an accurate description of the circulatory system, noting the existence of blood vessels throughout the body, and the hearts function as a center of the blood supply. The Edwin Smith papyrus contains surgical instructions and formulae for cosmetics. The Kahun Gynecological papyrus narrates about the health of women and birth



Photograph 2.8 a Papyrus plant (*Cyperus papyrus*) at Kew Gardens, London (<https://en.wikipedia.org/wiki/Papyrus#/media/File:Kew.gardens.papyrus.plant arp.jpg>); b The Ebers papyrus suggests treatment for asthma: a mixture of herbs heated on a brick to produce fumes for inhalation (https://en.wikipedia.org/wiki/Ebers_Papyrus)

instructions. Ramesseum medical papyri (1800 BC) include medicine, gynecology, ophthalmology, rheumatology, and pediatrics; Hearst papyrus (2000 BC) includes urology, medicine, and bites; London medical papyrus (1300) includes skin complaints, eye complaints, bleeding, miscarriage, and burns; Brugsch medical papyrus (1350–1200 BC) and Carlsberg papyri include obstetrics and gynecology, medicine, pediatrics, and ophthalmology; Chester Beatty medical papyrus (1200) includes headache and anorectal disorders, etc., are some other worthy mentionable papyri.

The Egyptian papyri listed ailments and their treatments, ranging from disease of the limbs to diseases of the skin and recorded names and properties of hundreds of medicinal plants including alkanet (*Alkanna tinctoria*), aloe (*Aloe vera*), ammi (*Ammi majus*), bayberry (*Myrica gale*), elderberry (*Sambucus nigra*), cannabis (*Cannabis sativa*), caraway (*Carum carvi*), cassia gum (*Cassia obtusifolia*), cedar (*Cedrus libani*), coriander (*Coriandrum sativum*), cumin (*Cuminum cyminum*), cyperus (*Cyperus rotundus*), fennel (*Foeniculum vulgare*), flax (*Linum usitatissimum*), hemlock (*Conium maculatum*), juniper (*Juniperus* spp.), lotus (*Nelumbo nucifera*), mandrake (*Mandragora officinarum*), myrrh (*Commiphora myrrha*), nasturtium (*Nasturtium officinale*), onion (*Allium cepa*), garlic (*Allium sativum*), oak gall or oak apple, opium (*Papaver somniferum*), papyrus (*Cyperus papyrus*),

peppermint (*Mentha × piperita*), pomegranate (*Punica granatum*), ricinusbean (*Ricinus communis*), saffron (*Crocus sativus*), senna (*Senna alexandrina*), turpentine, thyme (*Thymus vulgaris*), henbane (*Hyoscyamus niger*), wheat (*Triticum aestivum*), wild lettuce (*Lactuca virosa*), ziziphus (*Ziziphus jujube*), many essential oils, bile, lard.

A diet rich in radish, garlic, and onion was preferred for workers in Egypt, and modern scientific research showed these items are rich in powerful natural antibiotics such as raphanin, allicin, and allistatin, respectively. They used honey as excellent antiseptic, willow in toothache, mint in gastric ailments, pomegranate against parasitic worms—‘snakes’ of the digestive system—moldy bread as antibiotic, etc., and left huge information about the use of medicines and herbs. Ancient Egyptian physicians earned expertise in performing eye surgery, to suture wound, wound healing, stimulation of blood production, curing night-blindness by feeding the patient vitamin A rich powdered liver, and they adopted an ethical code centuries before the Hippocratic Oath. It is thought that the Egyptian herbals were enriched from the translation of ancient texts, and trade and politics carried the Egyptian tradition to other regions of the world. So far, the level of medical knowledge and sophistication is concerned; the physician of ancient Egyptian outstripped both the Roman and Greek physicians and they were unparalleled until the golden age of Islam.

Medicinal knowledge about the ancient Greek mostly comes from Homer (Photograph 2.9a) and his epicpoems. Homer in his epics ‘the Iliad and the Odyssey,’ written in about 800 BC, served as textual sources of Greek medicine before the time of Hippocrates (470–410 BC) when there was no published medical text. While narrating the medical care of warriors, Homer, in his poems cast light on the ancient Greek medical knowledge and practices, descriptions of injury, disease treatment, and human anatomy at that time. Homer described a few warriors (e.g., Machaon) who were specialists in the art of healing with the use of herbal remedies, bandages, and wine. The ancient Greeks regarded illness as a divine punishment and healing as a gift from the gods, and by the 500 BC, they tried to acknowledge the material causes for illnesses and moved toward scientific enquiry leading to the exploration of connection between causes and effects, symptoms of illness, and success or failure of various treatments. From this simple initiative, Greek medicine rapidly developed over the course of the next several centuries.

Ancient Greece as well as Rome and Egypt played significant role in medical history. The Greek borrowed much of their medical knowledge from the ancient Egypt, and they also developed their own skills that definitely influenced the history of Western medicine. Many of the founders of the ancient Greek schools of medicine earned their knowledge in medicine from Egyptian priest doctors. The practice of medicine using medicinal plants flourished most during the Greek civilization. Some of the early Greek naturalists, scientists, and physicians who contributed enormously to the development of human knowledge about medicinal plants are Hippocrates (460–370 BC), Aristotle (384–322 BC), Theophrastus (370–287 BC), Dioscorides (first century AD), Pliny the Elder (23–70 AD), and others. The Unani (Greco-Arabic) system of medicine, improved by the Arabs, owes its



Photograph 2.9 **a** Homer (https://commons.wikimedia.org/wiki/File:Bust_Homer_BM_1825.jpg). 2.87" × 2.12". **b** Hippocrates Bust (Public Domain) <https://explorable.com/ancient-medicine> 2.88" × 218"

origin to Greece. The theoretical framework of *Unani* medicine was based on the teachings of Hippocrates (460–377 BC). Hippocrates of Kos, the father of medicine, freed medicine from superstition and philosophic speculation, elevated it to a level of science by putting emphasis objective observation and critical deductive reasoning (Fig. 6.9b). Thus, he laid down the scientific basis of drug use from the abuse of prejudice. The Hippocratic Corpus serves as a collection of texts including medical teaching, recipes, and remedies, but some of its authorship is disputed. Hippocrates was taught under Egyptian priest-doctors, and the treasure of the ancient Greek school of medicine was enriched by the knowledge he borrowed from the Egyptians. He wrote a treatise of about 300–400 medicinal plants including mint (*Mentha spicata*), opium (*Papaver somniferum*), rosemary (*Rosmarinus officinalis*), sage (*Salvia officinalis*), and verbena (*Verbena officinalis*). Ancient Greek medicine was centered on the humor theory, and Hippocrates believed in four bodily humors (blood, yellow bile, black bile, and phlegm) and in the causes of disease from their imbalance. He, however, believed in the glandular secretory origin humors and their imbalance due to outside factors and put emphasis on appropriate diet and hygienic measures for disease improvement. Greek herbal medicines were mostly based around restoring the balance of humors, and this belief continued in European thought until middle Ages. Greek medicine up held the concept ‘*Medicatrix Naturae*,’ i.e., ‘Mother Nature is a healing goddess and remedies of all diseases are to be found in the biosphere.’ Ecology supports the

view, and the animal kingdom and all sentient beings depend on nature (the plant) for food, medicine, and fresh air. Hippocrates used herbs in treatment, and his teaching was 'Let your food be your medicine and your medicine your food.' Hippocrates used both local and imported herbs from Arabia.

Aristotle, a philosopher, recorded the properties of more than 500 plants of medicinal importance. Theophrastus (370–285 BC), the father of botany, wrote *De Historia Plantarum* (Plant History) and *De Causis Plantarum* (Plant Etiology) with many kinds of plants (>500) including cinnamon, iris rhizome, false hellebore, mint, pomegranate, cardamom, fragrant hellebore, monskhood, and their medicinal use as well as culture. 'Historia Plantarum,' the first systematization of the botanical world, was remaining equally important for herbalists and botanists for centuries after Theophrastus. Krateus (~100 BC) is a Greek herbalist who produced an illustrated work on medicinal plants (a pharmacological book for medicinal plants). His influence is felt in the *De Materia Medica* of Dioscorides and in other works. Dioscorides, the father of pharmacognosy, was a military physician and pharmacognosist of Roman army, and he studied medicinal plants wherever he travelled with the army. He published five volumes of a book on pharmacopeia, entitled 'De Materia Medica' in 78 AD. This encyclopedic work described more than 600 medicinal plants including their name and synonym with picture, habitats, botanical description, drug properties, medicinal use, collection and storage instructions, adulteration and methods of detection, veterinary uses. Like Eber papyrus, this work also contained a number of recipes and prescriptions for ailments and among, and there were 80% plant, about 10% minerals, and 10% animal medicines. It was a significant herbal designed for practical purposes and was used widely utilized throughout the ancient period for over 1600 years. *De Materia Medica* was considered to be the authoritative source of pharmacological information (pharmacopeia) until the late middle Ages and the Renaissance.

Diocles of Carystus, a new pupil of Aristotle, wrote extensively on herbalism and treatment, and because of his high prestige, he would be referred to as 'the second Hippocrates.' His original texts no longer exist, but many medical scholars such as Galen, Celsus, Soranus, and others quoted Diocles extensively. Pliny the Elder (23–79 AD), a contemporary of Dioscorides, wrote 'Historia naturalis' (Natural History)—an encyclopedic text, a comprehensive guide to nature, and the largest compilation on medicinally valuable plants (>1000) from the Roman period. The Greeks had developed expertise in surgery, and the equipment they used includes forceps, scalpels, tooth-extraction forceps, catheters, and syringes for drawing pus from wounds. These are also recognizable today. They acquired the art of splinting and treating bone fractures and adding compresses to prevent infection. The Greeks together with the Egyptians lay at the root of the modern history of medicine, understanding the value of cleanliness, medicines, and the finer arts of surgery. Their knowledge passed down to the Romans, who preserved the medical skills and refined them.

The Roman contributed a lot to the development of medicine, especially the preventative medicine. They recognized the role of dirt and poor hygiene in spreading disease, and their engineering skill ensured clean water and installed

elaborate sewage systems. The Roman military surgeons developed into fine practitioners of their art, and under their treatment, the Roman soldiers had a much lower chance of dying from infection than those in other armies. Galen (131–200 AD), a Greek physician, surgeon, and philosopher who worked in Rome, is the most illustrious name in the history of Roman medicine. Galen wrote many texts regarding herbs and their properties, and the most notable one was ‘Works of Therapeutics’ aimed to combine all branches within medicine to restore health and prevent disease. While the subject of therapeutics encompasses a wide array of topics, Galen’s extensive work in the humors and four basic qualities helped pharmacists to better calibrate their remedies for the individual person and their unique symptoms. He practiced and taught both pharmacy and medicine and wrote many texts (~600 treatises) on many aspects of medicine, including herbs and their properties, physiology and anatomy, pharmacy, hygiene, etiology, semeiotics as well as therapeutics, and described hundreds of recipes and formulations containing ingredients of medicinal plants and animal origin. His principle of preparing and compounding medicines, ‘Galencial pharmacy,’ dominated the western world for over 1500 years. The idea of Galen formed the basis of both allopathic and homeopathic systems of medicine practiced today (Sofowora 1982). Pharmacognosy progressed gradually and formed the basis and beginning of both pharmacy and medicine.

(iii) Middle Ages

The long period between ancient Greek and Roman cultures and the Renaissance may be designated as middle ages. During this period, several schools of medicine were developed that ensured the progression of herbalism. There were three major sources of information on medicine and medical practices such as (i) Arabian School, (ii) Anglo-Saxon Leechcraft, and (iii) Salerno. The Spanish Muslim botanists (e.g., Al-Ghafiqi, Ibn Al-Awwan, and others) made the greatest contribution in botany, advanced botany beyond Dioscorides, and augmented herbology by addition of 2000 plants and botany reached its zenith in Spain of medieval times. They established botanical gardens in Cordova, Baghdad, Cairo, and Fez for teaching and experimental purposes. Ibn-Al-Baytar (1148–1197 AD) was a great botanist and pharmacognosist of Spain of medieval times and ranked with Dioscorides in that respect. He described >1400 drugs and wrote two medicinal compendium, e.g., *Al Mughani-fial Adwiyah al-Mufradah* and *Al-Jami Ji al Adwiyah al Mufrada* where he arranged plants collected mostly from Spain and North Africa in alphabetic order and gave instructions regarding preparation of the drug, administration, purpose, and dosage for each plant.

The two great Persian Muslim physicians Al-Razi (850–925 AD) and Ibn Sina (980–1037 AD) constructed an imposing edifice in the Islamic era. These two scientists by enriching the original Greek system of medicine laid down the foundation stone of modern Western medicine. Al-Razi and Ibn Sina are ever remembered for their famous books ‘*Kitab al-Mansuri*’ and ‘*Al-Kanun*,’ respectively, and they were used as important textbooks throughout Europe until the



Photograph 2.10 Dioscorides' *Materia Medica*, copy in Arabic, describes medicinal features of cumin and dill. Source https://en.wikipedia.org/wiki/File:Arabicherbalmedicine_guidebook.jpeg

sixteenth–seventeenth centuries. The *Al-Kanun* of Ibn Sina was known for its systematic experimentation, physiological study, discovery of infectious and sexually transmitted diseases, quarantine method to limit the spread of infectious diseases, experimental medicine, clinical trials, and method of diagnosis of diseases. It includes descriptions of some 760 medicinal plants and their related medicine. Ibn Altabari (770–850 AD), Al Zahrawi (930–1013), Ibn Al Haitham (960–1040), Ibn al-Nafis (1213–1288), Ibn Khaldun (1332–1395), and many other Arabs were famous for their contribution toward the development of herbal medicine in the middle ages. The Arab physicians used aloe, anise, basil, camphor, cinnamon, cloves, coffee, coriander, cucuma, deadly nightshade, fennel, ginger, henbane, licorice, myrrh, nutmeg, syrups, juleps, oregano, pepper, rheum, rosemary, senna, strychnos, saffron, thyme, and many other. They replaced drugs with strong action by drugs with mild action (e.g., *Sennae folium*, a mild laxative, was used to replace *Helleborus odoratus*). Based on the Greek system, the ancient Arab physicians contributed enormously to the development of modern medicine (Photograph 2.10). The Muslims were the first to establish hospitals, dispensaries, pharmacopoeia, and medical schools in the world.

'Herbarium Apuleius' is a famous manuscript of Anglo-Saxon medicine (480–1050 AD). It contains recipes and uses of >100 herbs. Leech means medical practitioner, and 'The Leech Book of Bald' (925 AD), the oldest surviving herbal of the West, contains many formulae and herbal remedies, but over shadowed by superstitious notations. Wood-Betoney, Vervain, Mugwort, Plantain, Yarrow, etc., were the most used herbs of the Saxon times. 'Physicians of Myddvai' (1250) contains the artful herbal practice of the family Myddvai.

Salerno, a famous school of health science and medicine in Italy, was founded by Charles the Great (742 AD–814). Constantine the African, a student of the school, epitomized (i.e., abridged) the Western medicine with Arab medicine, and in fact, he introduced Arabian medicine into Europe. 'Experiments of Cohpon' and 'Regimen Sanitatis Salerni' were two famous books. During the early middle ages, the Western knowledge of pharmacy and medicine was preserved in the monasteries. The monastic works were mainly translation and carbon copy of the ancient Greco-Roman and Arabic works. The monks gathered herbs from the wild or raised them in their own herb gardens (including sage, sea onion, iris, mint, common centaury, poppy, marsh mallow). Sage (*Salvia officinalis* L.) was a mandatory plant in all Catholic monasteries and prepared medicine according to the art of apothecary for the sick and injured persons. Following renaissance in Europe when new political independence was achieved from the church, many great herbals were written, compiled, and printed (e.g., Herbals of Brunfels, Bock, Fuchs, Mattioli).

Brunfels (1488–1534 AD) in his original work in botany arranged herbs in alphabetic order with illustrations. Bock (1498–1554 AD) continued the work of Brunfels in a very scientific way classified for the first time into herbs, shrubs, and trees and laid the foundation of Linnaeus. He clearly described the plants in his herbal and thus developed the prototype of phytography. Fuchs (1501–1577 AD) added to his herbal at least 100 new plants that were not mentioned earlier in the works of Dioscorides, Pliny, and Galen. Mattioli (1500–1577 AD) was a famous herbalist of the sixteenth century and incorporated many New World plants in his herbals.

Paracelsus (1493–1541), a well-known German alchemist and herbalist of the medieval age, presented the idea of the 'Doctrine of Signatures,' and it had been an idea of herbalists for centuries. The 'Doctrine of Signatures' in simple terms is the idea that God has created everything with a sign (signature) and the sign was an indication of the purpose for the creation of the item. By observation, one can determine from the color of the flowers or roots, the shape of the leaves, the place of growing, or other signatures, what the plant's purpose was in God's plan. According to this doctrine, symptoms of diseases or diseased organs reveal close resemblance with the herbal resources. For example, ginseng (*Panax ginseng*) root was suggested as tonic for good health as it resembled human figure, blue cohosh (*Caulophyllum thalictroides*) for muscular spasm treatment as its branches resembled limbs in spasm, blood red (*Sanguinaria canadensis*) root sap for blood purification, stomach-shaped flower of lobelia (*Lobelia inflata*) for emetic purpose, yellow-green juice of the root of golden seal (*Hydrastis canadensis*) for jaundice

treatment, walnuts for brain disorders, three-lobed liver shaped leaf of hepatica (*Hepatica acutiloba*) (liver leaf) liver ailments.

Paracleus idea was very much influential, and as a professor of medicine at the University of Basel, he refused to accept the classical medical books of Theophrastus, Galen, Dioscorides, Avicenna, and all others except Hippocrates. The 'Doctrine of Signatures' was highly developed during the European Renaissance, and it expounded in medical texts from the middle of the sixteen century right up to the end of the nineteenth century. Idea of the 'Doctrine of Signatures' by Paracleus was obviously wrong. Long before Paracleus, signature plants were probably first recognized in ancient China, where there was a classification that correlated plant features to human organs, e.g., yellow and sweet = spleen, red and bitter = heart, green and sour = liver, and black and salty = lungs.

Many vernacular names of temperate plants tell us how plants were once used to cure human ailments. Flowers shaped like a butterfly became cures for insect bites; liverwort relieves liver trouble, snakeroot, antidote for snake venom; adder's tongue cures wounds and inflammation from snake bite; lungwort cures pulmonary diseases; bloodroot cures blood disorders; toothwort relieves toothache; gravel wort dissolves stones in the urinary tract; wormwood expels intestinal parasites; pilewort cures hemorrhoids; mandrake promotes sexual passion in females; black-eye root removes bruise discoloration; maidenhair fern cures baldness. Long-lived plants were used to lengthen a person's life, and plants with rough stems and leaves were believed effective to heal diseases that destroy the smoothness of the skin, and roots with jointed appearance were the antidote for scorpion bites. Some of these were proved to be useful, and it was followed in Europe for long time (Murray 1995).

The medieval world (fifth to fifteenth century BC) was characterized by the expansion book culture. Translation is well-documented, began in Baghdad as early as eighth century, and expanded throughout European Mediterranean centers by the eleventh and twelfth centuries (Hoffman 2012). It was a collaborative effort, provided numerous versions and compilations of individual manuscript from diverse sources, and contributed great to science in the middle ages. The monastic works were mainly translation and hand copying of the ancient Greco-Roman and Arabic herbal literature and preserved these works in the monasteries; thus, they grew as local centers of medical knowledge. The monasteries were well known for their translation works from the ancient Greco-Roman and Arabic herbal literature. They developed in-depth herbal knowledge, grew the useful herbs in the monastic gardens, and treated various human ailments. Folk medicine at that time was practiced by herbalists, 'wise-women,' and 'wise men,' along with spells, enchantments, divination, advice, etc. Unfortunately, they often became the targets of the witch hysteria during the Dark Ages in Europe. Hildegard of Bingen, a twelfth-century Benedictine nun and famous women in the herbal tradition, wrote a medical text 'Causae et Curae' (Ramos-e-Silva 1999; Truitt 2009). The beginning of modern medical education could be linked with monastic works of middle ages (Krebs 2004).

(iv) Early modern era (sixteenth to nineteenth century)

The early modern era is extended from sixteenth to nineteenth centuries. The sixteenth and seventeenth centuries were the great age of herbals, and many of the books became available for the first time in English and other languages rather than Latin or Greek. During the eighteenth and nineteenth centuries, more plant America were incorporated and notable advancement of modern medicine began.

‘The Grete Herball’ appeared to be the first published herbal in English in 1526, and ‘General History of Plants’ (1597) and ‘The English Physician Enlarged’ (1653) of John Gerard and Nicholas Culpeper, respectively, were other two books. The best two herbals in English (e.g., The Herball, Gerard’s text) were pirated translation. The blend of traditional medicine with astrology, magic, and folklore by Culpepper was ridiculous. Exploration and the Columbian Exchange introduced new medicinal plants to Europe. ‘The Badianus Manuscript,’ written in Nahuatl and Latin, was an illustrated Mexican herbal of sixteenth century (Gimmel 2008).

The second millennium, however, also saw the beginning of a slow erosion of the pre-eminent position of herbal agents as sources of therapeutic effects began to decline slowly in next century, and later on, Paracelsus introduced the use of chemical drugs such as arsenic, copper sulfate, iron, mercury, sulfur minerals. During the eighteenth century, Swedish botanist, taxonomist Linnaeus wrote numerous theses including *Medicamenta graveolentia* (Drugs with a strong smell), *Sapor medicamentorum* (The taste of drugs), *De methodo investigandi vires medicamentorum chemica* (regarding the chemical method to investigate the virtues of drugs), and *Ineberiantia* (Intoxicants). Linnaeus published *Materia Medica* in 1749, where he combined botany with medicine with an intension to explore the medical potential of nature.

In eighteenth century, herbal knowledge in the Americas was based on books including almanacs, Dodoens’ New Herbal, Edinburgh New Dispensatory, Buchan’s Domestic Medicine, etc., and the Native Americans shared some of their knowledge with colonists. In nineteenth century, formalization of pharmacology took place and people began to understand the specific drug action. Samuel Thompson and Thompsonians were very influential at that time.

A vast body of Greco-Roman knowledge of herbs was preserved and enlarged upon by the Arabs. This knowledge, much of which had been lost to Europe in the Dark Ages, was reintroduced to Europe when the Crusaders returned from the Middle East. In India too, traditional medicine incorporated a large number of herbal remedies; the Indian *Materia Medica*, published in 1908, listed 2982 medicinal plants. The knowledge developed on herbal medicine was transmitted at one time orally, and the earliest written form was the Egyptian papyri (1600 BC). This was followed gradually by clay tablets, parchments, manuscript herbals, printed herbals, pharmacopoeias, and books on the method of preparation of herbal medicine and recently by computerized information database systems. *De Materia Medica* (78 AD) is a pharcompoeia, an authoritative book on botanical medicine and pioneer of all modern pharcompoeias. It contained information of about 600 medicinal plants.

The use of medicinal plants by the people of other continents, especially the South America and Australian aborigines, enriched the world herbal knowledge. In fourteenth and fifteenth centuries, the medicinal plants like coca (*Erythroxylum* sp.) and tobacco (*Nicotiana tabacum*) were in common use in Latin American countries. European immigrants to North America during eighteenth to nineteenth centuries discovered that the indigenous Red Indian population was skilled at using the native plants as medicines and they began to incorporate them into their own remedies. Many of these new herbal remedies from the Americas were also brought back to Europe.

Greek civilization witnessed a highly developed system of medicine which used medicinal plants and minerals. Arab Muslims further enriched this system and developed the Greco-Arabic or Unani system, which formed the basis of modern Allopathic system of medicine. In the nineteenth century, the term 'materia medica' was used for the subject pharmacognosy.

J.A. Schmidt (1759–1809) of Austria introduced 'pharmacognosy' for the first time in a manuscript published posthumously in 1811, and C.A. Seydler of German used the term in his book in 1815 to include drugs of plant origin. The progress achieved during eighteenth and nineteenth century in the field of botanical sciences had a direct influence in pharmacognosy. The modern era after the nineteenth century was dominated by the single-component synthetic drugs pushing the herbal remedies at bay.

The sixteenth to eighteenth centuries were the era of European exploration of pharmacognosy. Johann Adam (1759–1809), a surgeon and ophthalmologist, published his 'Lehrbuch der Materia Medica' in 1811, which was a work on medicinal plants and their properties. At the end of the eighteenth century, crude drugs were still being used as powders, simple extracts, or tinctures. In 1803, a new era in the history of medicine began—the era of pure compound isolation, when morphine was isolated from opium. Subsequently other compounds such as strychnine (1817); quinine and caffeine (1820); nicotine (1828); atropine (1833); cocaine (1855) were isolated from different plant sources. During the nineteenth century, pharmacognosy was the most important pharmaceutical discipline and the chemical structures of many of the isolated compounds were determined. The first signs for a new era took new dimension with the introduction of a very successful synthetic drug aspirin using nature as lead for a new synthetic drug (Viktorin 1999). In the nineteenth century, microscopy was introduced in pharmacognosy for the quality control of crude drugs, and for many years, pharmacognosy remained confined with the microscope-based methods.

In the twentieth century, the discovery of important drugs from the animal kingdom and microorganisms, particularly hormones and vitamins, have become a very important source of drugs. In the 2nd half of the twentieth century, thin layer chromatography (TLC), gas chromatography (GC), high-pressure liquid chromatography (HPLC), spectrometric methods (MS, NMR) were introduced in pharmacognostical analysis and search for new biologically active compounds in plants. *In vitro* system bioassay was added at end of the twentieth century, and

during this period (1983–1994), a large number of antibiotic and antitumor principles from natural sources were discovered (Cragg et al. 1997).

(v) Modern era (from twentieth century onward)

Since inception in 1811, pharmacognosy has evolved considerably during the past two hundred years. In recent years, it has gained much importance because of the worldwide development of interest in natural products as lead molecules for new drugs as well as the increased use of complementary medicinal products in industrialized countries. At the beginning of the twenty-first century, emphasis has been put on (i) analysis, (ii) biological testing, and (iii) collaboration of pharmacognostical research. In pharmacognostical, high-throughput-based hyphenated computer-aided analytical techniques have been adopted to aid the traditionally used macroscopical, microscopical, and chemical methods of analysis parameters to optimize guarantees of quality, safety, and efficacy. The introduction of in vitro bioassays (back up by in vivo studies) has been the most important change in pharmacognostical research enabled bioassay-guided fractionation for the identification of the active compounds in plant or other extracts. In pharmacognostical research, the high-throughput-based bioprospecting program using robotic technology has been introduced to screen thousands of samples per day for new bioactive compounds in recent time.

Taxonomic identity of a species or taxon is fundamental to pharmacognostical research. Introduction of DNA barcoding as taxon identifier in pharmacognostical analysis in the twenty-first century is valuable, where DNA barcoding is an effective tool for identifying species, authenticating the herbals, and discriminating the adulterants of medicinal herbs. It may be helpful for identifying the closely related medicinal herbs used in substitution and adulteration purposes. The novel technique of identifying biological specimens using short DNA sequences from either nuclear or organelle genome is called DNA barcoding. As in plants no single-locus barcode exists, multilocus barcodes were suggested, and after evaluation of seven chloroplast genomic regions across the plant kingdom, the Consortium for the Barcode of Life Plant Working Group (CBOL) proposed a combination of *matK* and *rbcL* as plant barcodes. Because of its low discriminating ability in closely related species, the China Plant BOL Group proposed the addition of nuclear ITS (Internal Transcribed Spacer) to the *matK+rbcL* combination for enhancing the identification rates.

Pharmacognosy as an interdisciplinary subject admits collaborative research between scientists of different disciplines and pharmacognosist can be a valuable bridge between specialists and has much to offer to help pharmaceutical knowledge of phytomedicines to advance. Since nineteenth century, synthetic drugs have been replacing gradually plant-derived drugs (except antibiotics and antitumor drugs). Due to the development of experimentation with molecules and progress in biotechnology, biochemistry, molecular biology, and research on metabolism, new perspectives appear for natural products that renewed interest in natural resources leading to the high-level development of the subject. The multidisciplinary

characteristics of pharmacognosy are becoming more and more prominent as many new areas of research and study such as molecular pharmacognosy, neuropharmacognosy, industrial pharmacognosy are emerging in modern pharmacognosy with time.

In the modern era, the traditional herbalism has been officially regarded as a method of alternative medicine in many parts of the world, especially in some developed countries (e.g., USA, UK). The Traditional Chinese Medicine has been in use Chinese in hospitals. The World Health Organization estimated that 80% of people worldwide rely on herbal medicines for some part of their primary health care. In Germany, about 600–700 plant-based medicines are available and are prescribed by some 70% of German physicians. Many alternative physicians in the twenty-first century incorporate herbalism in modern medicine due to the diverse abilities plants have and their low number of side effects.

2.5 Drug Literature, Publication, and the Related Technical Words

2.5.1 Drug Literature and Publication

The knowledge developed on herbal medicine was transmitted at one time orally, and the earliest written form was the Egyptian papyri. This was followed gradually by clay tablets, parchments, manuscript herbals, printed herbals, pharmacopoeias and recently by computerized information database systems. The worldwide renaissance of herbal medicine in the recent years has created an urge for intensive studies in the field of pharmacognosy, and consequently, there appeared a large volume of literature and publications in different regions of the globe on all aspects of pharmacognosy. Drug literature and publication contain different information about drugs, their sources, therapeutic use, purity, adulteration, efficacy, etc., as well as many technical terms for convenience and brevity in describing the subject matters.

Depending on the originality and proximity to the origin, there may be three categories of information resources, e.g., primary, secondary, and tertiary. Primary sources are the original materials on which the research is based, e.g., scientific journals and articles reporting experimental research results, proceedings of meetings, conferences and symposia, technical reports, dissertations, patents, communications on e-mail and news groups. Once published, the primary source information serves as the basis for secondary sources. Review articles, literature review, textbook, Medline database search, works of criticism and interpretations, indexing and abstracting services, or otherwise ‘add value’ to the new information reported in the primary literature. Tertiary sources are a compilation of primary and secondary sources and tend to be factual in nature. The following list of works (textbooks and reference works) may provide some useful information about the gradual progress of the subject pharmacognosy.

a. Printed publication:

- (i) Wallis TE. 1967. Text book of Pharmacognosy, 5th edn. London, Churchill Livingstone.
- (ii) Wagner H and Horhammer L. (Ed.). 1971. Pharmacognosy and phytochemistry. Springer-Verlag, 175 Fifth Ave., New York, NY 10010.
- (iii) Trease GE and Evans WC. 1972. Pharmacognosy, 10th edn. London, BilliereTindall.
- (iv) Ross MSF and Brain KR. 1977. An introduction to Phytopharmacy. Tunbridge Wells, Pitman Medical.
- (v) Takatori J. 1980. Color Atlas of Medicinal Plants of Japan, 2nd edn. Tokyo, HirokawaPub. Company.
- (vi) Mossa JS, Al-Yahya MA, And Al-Meshal IA. 1987. Medicinal Plants of Saudi Arabia. Riyadh, King Saud University.
- (vii) Evans WC. 1989. Pharmacognosy, 13th edn. Second print 1994. London, BilliereTindall.
- (viii) Ali M. 1994. Text book of Pharmacognosy, CBS Publishers, Delhi, India.
- (ix) Joshi SG. 2000. Medicinal Plants. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi, Calcutta.
- (x) Lyle E. Craker and James E. Simon (Ed.). 2002. Herbs, Spices and Medicinal Plants, Recent Advances in Botany, Horticulture and Pharmacology, Vol. 1. Haworth Press, Inc., U.S.A., First Indian Reprint, 2002. CBS Publishers and Distributors, 4596/1A, 11 Darya Ganj, New Delhi, 110002 (India).
- (xi) Ashutosh Kar. 2003. Pharmacognosy and Pharmacobiotechnology. New Age International (P) Ltd., Publishers, 4835/23 Ansari Road, Darya Ganj, New Delhi, 110002 (India).
- (xii) Ghani M. 2003. Medicinal Plants of Bangladesh with Chemical Constituents and Uses, 3rd edn. Asiatic Society of Bangladesh, 5 Old Secretariat Road, Ramna, Dhaka 1000.
- (xiii) Wagner H. 2004. Revival of pharmacognosy. Classical Botanical Pharmacognosy. Satellite Symposium: Annual Meeting of the American Society of Pharmacognosy, Phoenix, AZ.
- (xiv) Ghani M. 2005. Textbook of Pharmacognosy. Institute of Medical Technology, House-68, Road-4, Block-B, Mirpur 12, Dhaka.
- (xv) Khare CP (Ed.). 2007. Indian Medicinal Plants: An Illustrated Dictionary, Springer.
- (xvi) Evans WC. 2005. Trease and Evans' Pharmacognosy, 15th Edition, Elsevier, Reed Elsevier India Pvt. Ltd., 17-A/1, Main Ring Road, Lajpat Nagar-IV, New Delhi-110 024, India.
- (xvii) Evans WC. 2009. Trease and Evans' Pharmacognosy, 16th Edition, Elsevier.
- (xviii) Roy Upton, Alison Graff, Georgina Jolliffe, Reinhard Länger, Elizabeth Williamson (Ed.) 2011. American Herbal Pharmacopoeia: Botanical

- Pharmacognosy—Microscopic characterization of Botanical Medicines, CRC Press, Taylor & Francis Group. Boca Raton, London, New York.
- (xix) Michael Heinrich, Joanne Barnes, Simon Gibbons, Elizabeth M. Williamson. 2012. Fundamentals of Pharmacognosy and Phytotherapy. 2nd Edn., Elsevier Publishing company.
 - (xx) Lu-qi Huang (Ed.). 2013. Molecular Pharmacognosy, Pub. Springer Netherlands.
 - (xxi) Abstracting Journals such as Chemical and Biological Abstracts, Journal of Biological Sciences, Journal of Pharmacognosy and Phytochemistry, Journals of Ethnobotany, Ethnopharmacology, Natural Products frequently contain research articles and review papers on medicinal plants, chemical constituents as well as therapeutic use of medicinal plants.
 - (xxii) The World Health Organization (WHO) encouraged the safe use of herbal medicine and published 117 herbal monographs in several volumes (I-IV+I). Other publications of WHO include the following:
 - (xxiii) WHO. 1998a. Quality Control Methods for Medicinal Plant Materials, World Health Organization, Geneva.
 - (xxiv) WHO. 1998b. Guidelines for the Appropriate Use of Herbal Medicines. WHO Regional Publications, Western Pacific Series. WHO Regional office for the Western Pacific, Manila. 3.
 - (xxv) WHO. 1998c. Basic Tests for Drugs, Pharmaceutical Substances, Medicinal Plant Materials and Dosage Forms. World Health Organization, Geneva.
 - (xxvi) WHO. 2002. General Guidelines for Methodologies on Research and Evaluation of Traditional Medicine. World Health Organization, Geneva.
 - (xxvii) The National Medicinal Plants Board (NMPB) and Central Council for Research in Ayurvedic Science (CCRAS), under Department of AYUSH, Government of India developed a database (www.nmpb-mpdb.nic.in/). This will help the scientific community (students, teachers, practitioners) to keep themselves updated with the research and development work being carried out for a particular medicinal plant. Other databases are: Medicinal Plants Found in India, 7263 Medicinal plants of India Master list sourced from FRLHT, Bangalore—www.nmpb.nic.in/index1; Medicinal Plants of India; Ayurveda Encyclopedia of Indian Medicinal Plants/Herbs mainly using in Ayurveda—www.indianmedicinalplants.info/; Indian Medicinal Plants Database, www.medicinalplants.in/.

b. Online publications:

World Health Organization (WHO)

- (i) WHO drug information—www.who.int/medicinedocs/index/assoc/s14162e/s14162e.pdf
- (ii) WHO Regional Offices (African Region, Region of the Americas, South-East Asia Region, European Region, Eastern Mediterranean Region, Western Pacific Region): <http://www.paho.org>

- (iii) American Herbal Pharmacopoeia (AHP) Sample Monograph: <http://www.herbal-ahp.org/documents/sample/valerian.pdf>
- (iv) Med herb—<http://www.medherb.com>—Very comprehensive herbal information, folk lore, safety, and more.
- (v) Herb world—Therapeutic herbal monographs written by David Hoffmann <http://www.healthy.net/scr/MMList.aspx?MTId=1>
- (vi) European Medicines Agency (EMA) Committee on Herbal Medicinal Products (HMPC) Community Herbal Monographs: <http://www.emea.europa.eu/htms/human/hmpc/hmpcmonographs.htm>
- (vii) James Duke Data base—<http://www.ars-grin.gov/duke/>
- (viii) Natural Health Products Directorate's (NHPD) Health Canada Compendium of Monographs: http://www.hc-sc.gc.ca/dhp-mps/prodnatur/applications/licen-prod/monograph/mono_list_e.html
- (ix) World Health Organization (WHO) Monographs on Selected Medicinal Plants, Volume 1: <http://whqlibdoc.who.int/publications/1999/9241545178.pdf>
- (x) World Health Organization (WHO) Monographs on Selected Medicinal Plants, Volume 2: <http://whqlibdoc.who.int/publications/2002/9241545372.pdf>.

2.5.2 Related Technical Words

Some of the technical words commonly used in drug literature and publication for convenience and brevity are described in the following paragraphs:

(i) Drug and crude drugs

The term drug includes any substance, natural or synthetic, having therapeutic properties and used in the diagnosis, treatment, cure or prevention of diseases of man and animals (without any addiction). Crude drugs are substances having therapeutic properties and pharmacological action, derived from natural sources such as plants, animals, or minerals and have undergone no further treatment to advance medicinal value except collection and drying for preservation, packing or marketing. Crude drugs include whole plant (tree, shrub, or herb), its morphological or anatomical parts, sap, extract, secretion, and other constituents; whole animal, its anatomical parts, extract, secretion, and other constituents. Inconsistency with dosing is a major drawback of crude drug. Triphala (three fruits), consisting of equal parts of three myrobalans taken without seed such as Amalaki (*Embolica officinalis*), Bohera (*Terminalia bellirica*) and Haritaki (*Terminalia chebula*), is an example of Ayurvedic crude drug.

(ii) Official, unofficial, and non-official drugs

Any drug included in the current issue of the pharmacopoeia of a country and officially used for therapeutic purposes is known as official drug. On the other hand, an unofficial drug is one which was previously included in pharmacopoeia, but not in current issue of the pharmacopoeia or any drug literature. Any substance possessing some medicinal properties and used for therapeutic purpose, but has never been included in pharmacopoeia or any drug literature of any country, is called non-official drug.

(iii) Herbal medicine, traditional medicine, natural substances, and formularies

The medicinal preparations that made from one or more plants, plant parts or organs and are used in the treatment, mitigation, management, etc., of various physical, mental ailments and injuries (both external and internal) on man or animal are considered as herbal medicine. They maybe in the form of powder, paste, infusion, decoction, distillate, or other naturally produced products of medicinal plants. In addition to active drug components, herbal medicine may contain inactive ingredient, which may serve the purpose of various pharmaceutical necessities (excipients) or may show synergistic and catalytic effects to enhance the therapeutic efficacy of the herbal medicine.

Medicines that are prepared by natural ingredients derived from plants, animals, and minerals or their mixture following the age-old method and wisdom are called traditional medicine. They may consist of whole or broken parts, powders, decoction, extract, or distillate of various medicinal plants, animals, and minerals or their combination in different proportion. The WHO defines traditional medicine as a system of medicine or treatment as the sum total of all knowledge and practices used in the diagnosis, prevention, and elimination of physical, mental, and social imbalance, relying exclusively on practical experience and observation transferred from generation to generation orally or in writing.

The products of natural origin, derived from plants, animals, and minerals or their products, which have not undergone any treatment to induce changes of natural molecular structure or configuration of any extent, are grouped as natural substances.

Formulary is a publication containing a list of patent medicines with their ingredients and brief notes on their pharmacological properties and therapeutic uses, published by the relevant authority of a country as a guide for the practitioners of medicine and pharmacy. Bangladesh National Formulary (BDNF), British National Formulary (BNF), American National Formulary (ANF), etc., are some the examples of national formularies. They publish their own formulary listing the medicines, which are manufactured, imported, sold, and used in the country.

(iv) Materia Medica, pharmacopoeia, and monographs

Materia Medica or materials of medicine include medicinal substances and products derived from natural sources. Pharmacopoeia is an official publication of a

country containing list of various drugs and therapeutic agents of current use with their monographs and specifies tests and standards for them. British pharmacopoeia (BP), Indian pharmacopoeia (IP), African pharmacopoeia (AP), International pharmacopoeia (IP), etc., are some examples. Pharmacopoeia includes monographs of various drugs and therapeutic agents, and description of a single item is regarded as monograph. In a monograph of a crude drug, an elaborate description is given on different heads such as official title, synonym, vernacular name, habit and distribution, collection, preparation, storage, identity test, test for adulteration, method of assay, chemical constituents, property and uses, doses, reaction, bibliography.

(v) Cell constituents, primary and secondary metabolites

Plant constituents are chemical substances present in the cells of plant or animal organs. These constituents may be active (active principle) when they exert physiological or pharmacological action on living organisms. Primary metabolites including carbohydrates, proteins, lipids, nucleic acids, etc., are synthesized in plants through primary metabolic pathways (e.g., photosynthesis, respiration, carbohydrate, protein, and nucleic acid synthetic pathways). The primary metabolites fulfill the basic needs of the life activities of plants and so they are present in all plants. Secondary metabolites such as alkaloids, terpenoids, phenolics are synthesized in plants (with the use of primary metabolites) through secondary metabolic pathways (e.g., shikimic acid pathway, mevalonic acid pathway). They are present in some selected taxonomic group of plants (not universally in all plants); apparently, they have no primary function and mostly serve the defensive (also attract pollinating agents) function in plants. Many of them are physiologically active and are used as therapeutic agents.

(vi) Flora, indigenous, naturalized, exotic and endemic plants

Plant population (or animal population) of a particular geographic area or a country represents flora (fauna) of the area or country. Bacteria and fungi living in the gut or on skin are often referred to as gut flora or skin flora, respectively. Flora, fauna, and other forms of life (e.g., fungi) of an area or country constitute biota of the area. Plants (or animals) growing (or living) in the region of their origin are indigenous to that area (geographic qualifier). Plants that were found in America before European settlement are indigenous to America. Plants (or animals) growing (or living) comfortably and completing their life cycle by their own naturally over time without any external aid in the foreign region or country (other than their native land) are called naturalized plants (or animals). Naturalized plants tend to become aliens if they are well adapted to their surroundings and spread uncontrollably pushing out indigenous plants by consuming precious resources. Plants (or animals) introduced intentionally or accidentally from outside to a new place or habitat where they were not found are exotic plants (or animals). For example, plants from Europe are exotic in North America or Japan and vice versa. They very often require a lot of resources to keep healthy growth. Endemic plants are indigenous, but they are naturally found in a relatively small region. They grow best



Photograph 2.11 Weights and scales, mortar and pestle, jars and surgical instruments—the tools of the apothecary's trade

under the prevailing conditions, provide food for all kinds of creatures, and help maintain genetic diversity

(vii) Apothecary and apothecar

A person who prepared and sold drugs for medicinal purposes in the past was apothecary (Photograph 2.11). Apothecary was derived from the Greek word *apothēke* (a repository or storehouse) via Latin *apotheca* to eventually old French *apothecaire* and entered English in the fourteenth century. In all, *casesapothēca* means storehouse but it became a title for the person who was skilled in preparing medicines. Apothecary is a historical name for a medical professional who formulates and dispenses material medica to physician, surgeon, and patients. These are now served by two groups of people, the pharmacists and the physicians. In some languages (e.g., German, Dutch, Scandinavian languages) and regions (e.g.,

Germany, Austria, Switzerland, Philadelphia, and Boston of USA) of the world, the term ‘Apothecary’ or ‘Apotek’ is still in use to designate a pharmacist or in the name of business. The term ‘Apothecary’ is mentioned even in some creative literature of William Shakespeare (e.g., *Romeo and Juliet*, *King Lear*), William Faulkner (*A Rose for Emily*), and J.K. Rowling (*Harry Potter* series).

2.5.3 *Apothecary*

Apothecary shops existed during the middle ages in Baghdad and were also active in Islamic Spain (Harley and Woodward 1992; Hadzović 1997; Al-Ghazal 2004). In Germany and German speaking countries like Austria and Switzerland, pharmacies or chemist stores are still called apothecaries or in German Apotheken. The Apotheke (store) is legally obligated to be run at all times by at least one Apotheker (male) or Apothekerin (female), who actually has an academic degree as a pharmacist. Bulk Apothecary now supplies drugs or medication as well as quality and affordable essential oils, soap making, and natural ingredients. The medieval apothecary was the ancestor of the modern general practitioner (GP). Apothecary is a more synonymous to the present-day pharmacist.

In early days, the apothecary himself used to collect, identify, and process the collected drug for compounding and dispensing them to the patient in addition to his job of diagnosing the disease and prescribing the remedy. From the fifteenth century to the sixteenth century, the apothecary gained the status of a skilled practitioner. But as the volume of knowledge of disease, therapeutic uses of medicinal plants, and technology of preparation of medicaments increased gradually over the years, it became impossible for a single person to manage these two different aspects of health management and specialization of the people involved in health management profession started developing on two different aspects. As a result, medicine and pharmacy started emerging along two separate paths: One group of people became specialized in diagnosing the ailment and prescribing the remedy for the patient (physicians), and another group of people became specialized in collecting, compounding, and dispensing the medicament (pharmacists). By the end of the nineteenth century, this bifurcation of the medical professions took their current institutional form, with defined role for physicians and surgeons, and the role of the apothecary was more narrowly conceived as that of pharmacist.

(viii) **Pharmacognosy and pharmacognosist**

Pharmacognosy is one of the important disciplines of increased significance in the curriculum of pharmacy. People working in the field of pharmacognosy are known as pharmacognosists (Photograph 2.12). Identification of the drug sources; (ii) determination of the morphological character; (iii) determination of chemical constituents, chemical nature, uses, potency, and purity of crude drugs; (iv) planning and designing of the cultivation of medicinal plants; and (v) prescription of the



Photograph 2.12 Pharmacognosists at work (Web source)



Photograph 2.13 Pharmacology research laboratory

detail processes of collection, drying, and preservation are the major functions of a pharmacognosist.

(ix) **Pharmacology and pharmacologist**

Pharmacology is a major subject in the curriculum of pharmacy. Pharmacology studies properties and interaction of drugs with living systems (Photograph 2.13). It includes everything related to drug, e.g., drug composition and properties, synthesis and drug design, molecular and cellular mechanisms, organ or systems' mechanisms, signal transduction or cellular communication, molecular diagnostics, interactions, toxicology, chemical biology, therapy, and medical applications and antipathogenic capabilities. Attention is also given to the effects of various doses of each medicinal substance and to the different ways in which medicine can be introduced into the body. The effects of poisons and the means to overcome them (i.e., toxicology) are studied in pharmacology. Pharmacodynamics and pharmacokinetics are two main areas of pharmacology. Pharmacodynamics studies the effects of the drug on biological systems, and pharmacokinetics studies the time

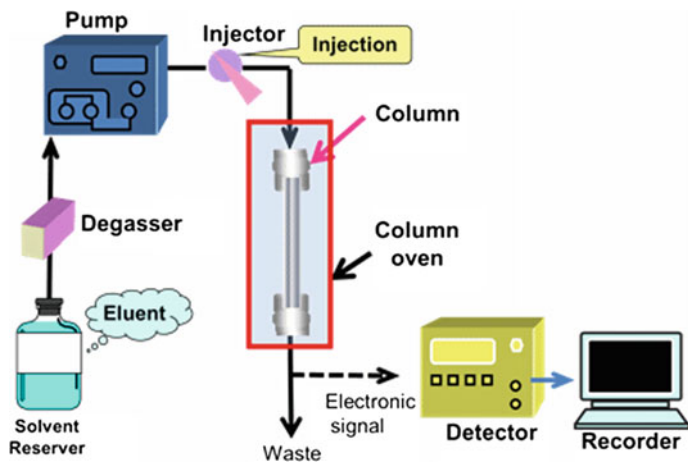
course of drug absorption, distribution, metabolism, and excretion from the biological systems. Pharmacology has adopted new technologies developed in other fields (e.g., bioinformatics, cheminformatics, computational chemistry, genetics, pharmacogenomics, proteomics) for drug discovery and drug design in the recent years. Pharmacology really makes sense of pharmaceutical studies.

Pharmacologists are biomedical scientists who research, develop, and test drugs and their effects on biological systems. Pharmacologists investigate the mechanisms underlying the effects of drugs and chemicals on living systems.

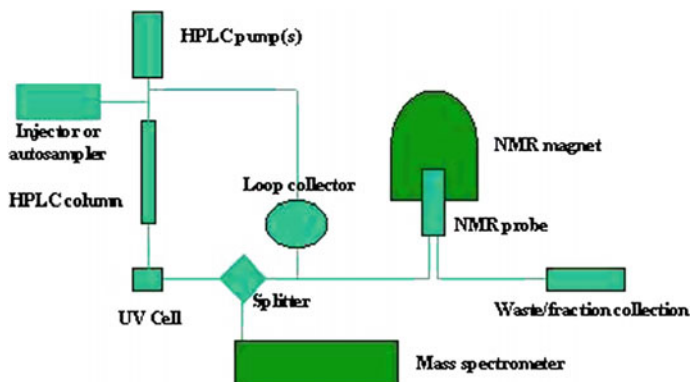
(x) Pharmacy and pharmacist

Pharmacy is a science and profession for safe and efficacious use of medication. It relates health science to chemical science. Subject pharmacy is divisible into several subdisciplines: (i) Pharmaceutics (convert medication and drugs to suitable drug dosage forms); (ii) pharmaceutical science (pharmaceutical chemistry, pharmacology, pharmacognosy, phytochemistry, etc.); (iii) pharmacy practice (dispensing medication and optimization of patients' care); and (iv) pharmaceutical analysis (analysis of pharmaceutical drug and its stability using various analytical techniques like GC-NMR, HPLC, etc.) are the main lines of pharmacy (Photographs 2.14, 2.15, 2.16, 2.17).

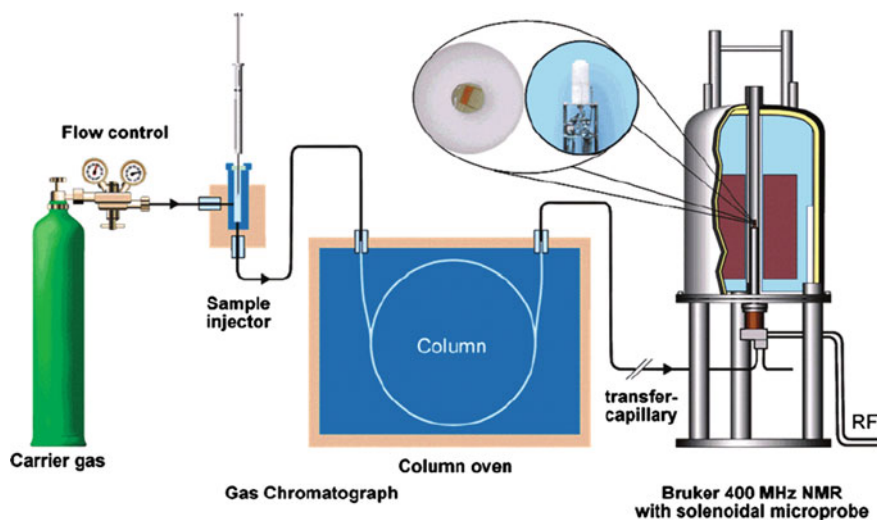
Pharmacy practice has been divided into hospital pharmacy and clinical pharmacy since the late twentieth century. Pharmacy curriculum at graduate and post-graduate levels emphasizes six basic courses including (i) pharmaceutical chemistry (application of chemical sciences to pharmacy); (ii) pharmacology (action of drugs in the body); (iii) pharmacognosy (sources of natural drugs obtained from plants or animals, either directly or indirectly); (iv) pharmacy administration (business management); (v) pharmacy practice; and (vi) the clinical component of the



Photograph 2.14 Components of HPLC (consisting of pump, injector, column, detector, recorder, degasser, column heater, or oven)



Photograph 2.15 Typical layout of a HPLC-NMR system (a hyphenated system)



Photograph 2.16 Hyphenation of gas chromatography to Microcoil ^1H Nuclear Magnetic Resonance Spectroscopy

pharmacy. In addition to these courses, four basic sciences such as mathematics, physics, chemistry, and biology are included in pharmacy curriculum.

2.5.4 Pharmacists

Pharmacists (chemists or druggists) are healthcare professionals who practice in pharmacy. Pharmacists undergo university-level education to understand the



Photograph 2.17 Pharmaceutical research and testing laboratories

biochemical mechanisms and actions of drugs, drug uses, therapeutic roles, side effects, drug interactions, etc. Pharmacists are educated in pharmacology, pharmacognosy, pharmaceutical chemistry, pharmacy practice, pharmaceuticals, pharmacy law, physiology, anatomy, pharmacokinetics, pharmacodynamics, drug delivery, pharmaceutical care, and compounding of medications along with mathematics, physics, chemistry, and biology. Additional curriculum may cover diagnosis with emphasis on laboratory tests, disease state management, therapeutics, and prescription medications. Pharmacists dispense prescription medications to patients and offer expertise in the safe use of prescriptions. Pharmacists interpret and communicate their specialized knowledge to patients, physicians, and other healthcare providers. The most common pharmacist positions are that of a community pharmacist (a retail pharmacist, first-line pharmacist, or dispensing chemist), or a hospital pharmacist, where they instruct and counsel on the proper use and adverse effects of medically prescribed drugs and medicines. Pharmacists may also practice in a variety of other settings, including industry, wholesaling, research, academia, military, and government.

Pharmacology is not synonymous with pharmacy, although the two terms are frequently confused. Pharmacology is a scientific field of study, and a pharmacologist studies the effects of drugs on the body of living organisms to produce a change in function, while pharmacy is a professional field and area of study, and a pharmacist (community or hospital pharmacist) studies weights and measures, solubilities, incompatibilities, qualities, drug reactions, the extraction of active principles, and the making of preparations suitable for the use in the practice of medicine. Pharmacology is a more specific science that may be studied either independently or as a part of pharmacy curriculum, and pharmacy also involves the study of sciences (e.g., pharmacology, pharmaceuticals, pharmacokinetics) and also more profession-based elements (e.g., counseling patients, checking and filling prescriptions, the manufacturing process of drugs) (Photograph 2.18).



Photograph 2.18 Compounding and dispensing pharmacy

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