Pharmacognosy

Eighth Edition

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Preface

Changes in the practice of pharmacy and, concurrently, in the educational preparation for such practice have continued at an unprecedented rate since the appearance of the previous edition of this textbook. It is now universally recognized by physicians, patients, and pharmacy practitioners themselves that the transmittal of information concerning the appropriate use of drugs is the principal role of the pharmacist. Basic and applied science courses, which provide students with this knowledge, and clinical practice courses, which teach them how and when to communicate this knowledge, thus comprise the essentials of the pharmacy curriculum.

Pharmacognosy, "pharmacy's specific and peculiar contribution to the cause of science," has not only retained its position of importance in pharmaceutic studies, but, as a result of the increasing interest shown by consumers in such topics as herbal medicine and megadose vitamin therapy, has actually increased in significance. Pharmacists are the only members of the health-care team who are accessible to the general public on a daily basis. As such, they must be able to advise on a wide variety of drug-related matters ranging from the side effects of the newest antibiotic to the desirability or undesirability of consuming certain herbal teas.

This edition of *Pharmacognosy* has been revised to reflect these changes in the needs of pharmacists. The previously extensive "General Introduction" has been abridged to render it not only more concise, but also, it is hoped, more interesting. Obsolete drugs and references to them have been deleted, and new drugs have been added in most chapters. Some information of marginal interest, e.g., coverage of certain flavoring agents in the "Volatile Oils" chapter, has been reduced to tabular form. Tabular presentation of other, more significant drugs has also been introduced to facilitate comprehension and comparison of related groups, such as the penicillins. Because the study of biosynthetic details no longer forms a major part of most undergraduate courses in pharmacognosy, many of the diagrams depicting biosynthetic pathways and the accompanying explanations have been deleted. A number of the structures of chemical constituents have been redrawn to show the steric configuration of the molecules.

One entire chapter, "Pesticides," has

been eliminated. This does not reflect any reduction in the significance and utility of insecticides, herbicides, and related products. Instead, it recognizes the tremendous increase in their number and in the complexity of federal and state regulations governing their use. A single chapter can no longer provide adequate coverage. Rather than devote more space to a topic of marginal pharmaceutic interest, we decided to omit the topic entirely.

Popular demand for critical, scientific information on herbs and so-called "health foods" prompted inclusion in this edition of a new chapter devoted to this increasingly popular specialty. As many of the older, natural drugs were replaced by newer, more potent pharmaceuticals, authoritative information on them ceased to be available. Yet, the drugs themselves continued to be readily available, primarily in nondrug outlets, where they were accompanied by an enormous selection of advocacy literature presenting much misinformation on their safety and efficacy. Numerous requests for information led us to conclude that pharmacists today require an accurate, concise reference source that would enable them to provide counsel to patients desiring to self-medicate with herbs and related natural products. This source has been provided in the new chapter "Herbs and 'Health Foods'," which covers most of the better-known remedies.

These, then, are the principal changes incorporated in the text of the eighth edition of *Pharmacognosy*. We are hopeful that it, like its predecessors, will prove of interest and value to all those seeking information on the materials of plant, animal, and microbial origin used in the prevention and cure of illness.

West Lafayette, Indiana — Varro E. Tyler
and — Lynn R. Brady
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Chapter 1

General Introduction

WHAT IS PHARMACOGNOSY?

Pharmacognosy, which literally means a knowledge of drugs or pharmaceuticals, has been a part of the healing arts and sciences since mankind first began to treat illnesses. It has developed from ancient civilizations that used parts of plants and animals to concoct various potions to eliminate pain, control suffering, and counteract disease. Pharmacognosy has risen from the mysterious incantations of voodoo tribes and has survived the unwritten secret recipes of medicine men. It has progressed from an era of empiricism to the present age of specific therapeutic agents. Today, pharmacognosy is a highly specialized science that represents one of the major disciplines of pharmaceutic education. A number of the drugs used by the ancients are still employed in much the same manner by today's medical practitioners. Although it is true that extraction, separation, isolation, and identification of the component constituents of plant and animal drugs have occurred in relatively recent years, nevertheless the purpose for which many of these medicinal substances are employed today parallels closely the use for which they were intended by our predecessors in the study of pharmacy and medicine.

Because of the interest it engenders in many of the scientists of today, pharmacognosy is a respected discipline which has no counterpart in the other professions. Perhaps because the lay public has heard little about the term "pharmacognosy," there is a lack of recognition and, further, a lack of association of the term with the specific subject matter it represents. However, an intuitive curiosity is inherent in the average person who reads or hears of opium, morphine, foxglove, insulin, reserpine, thyroid, penicillin, blood plasma, polio vaccine, and even the much maligned castor oil!

During the past few years, as a result of the intense concern with all aspects of ecology, there has been a renewed interest in so-called "natural" foods and drugs. The availability of an extremely wide variety of these products, ranging from foenugreek tea to ginseng chewing gum,

has stimulated the public to learn more about them. Consequently, a vast literature on natural drugs written by laymen and intended to inform other laymen has come into existence. Much of this literature is relatively inaccurate, consisting of beliefs and opinions substituted for facts. The pharmacist must, of course, be aware of the existence of such pseudopharmacognostic writings, primarily to be able to caution his patients concerning them and to correct any factual misinformation gained from reading them. Chapter 16 in this text provides accurate, up-to-date information on these so-called "health foods" and herbs.

In order to gain proper perspective about a science that deals with plant and animal drugs and their constituents, it is exceedingly helpful to survey past records and to recognize those who have contributed to the subject matter that comprised the field of pharmacognosy in its beginning. By trial and error, primitive man must have acquired biologic knowledge that was useful in determining which plants and animals possessed food value and which were to be avoided because they were unpalatable, poisonous, or dangerous. His observations were handed down from one generation to another and were added to by his progeny. The healing powers of certain herbs, roots, and juices were undoubtedly discovered by accident; but once these attributes were learned, they were too important to be forgotten. The Babylonians made clay models of the human body, and early writings indicate that they were aware of the medicinal effects of a number of plants. It is a well-known fact that the ancient Egyptians were adept at embalming the dead and that they possessed an understanding of the human anatomy as well as a knowledge of the medicinal uses of many plants and animals, according to the *Papyrus Ebers*. This famous document, written in 1550 B.C., was found in the tomb of a mummy and is now preserved at the University of Leipzig.

Dioscorides, a Greek physician who lived in the first century A.D., wrote his "De Materia Medica" in 78 A.D. in which he described about 600 plants that were known to have medicinal properties. Of these, a surprisingly large number are still important in modern medicine. Aloe, belladonna, colchicum, ergot, hyoscyamus, and opium are a few that were used then in much the same manner as they are used today. Galen (131–200 A.D.) was a Greek pharmacist-physician who lived in Rome and who described the method of preparing formulas containing plant and animal drugs. He devoted considerable time to compiling this knowledge which was distributed throughout 20 books. As a tribute to his accuracy in recording his observations, the term "galenical" pharmacy was originated.

From this humble beginning, medicine and pharmacy gradually emerged along separate paths: the physician diagnosed the ailment and prescribed the remedy, and the apothecary or pharmacist specialized in the collection, preparation, and compounding of the substance. Thus, the term **materia medica**, meaning medicinal materials, was synonymous with the substances and products derived from natural sources and was employed by the physicians of that era.

The term **pharmacognosy** was introduced by C. A. Seydler, a medical student in Halle/Saale, Germany, in 1815. This name is formed from two Greek words, *pharmakon*, drug, and *gnosis*, knowledge. The most comprehensive idea of the scope of pharmacognosy was presented by Flückiger who stated that pharmacognosy "is the simultaneous application of various scientific disciplines with the object of acquiring knowledge of drugs from every point of view."

Pharmacognosy may be defined as "an applied science that deals with the biologic, biochemical, and economic features of natural drugs and their con-

stituents." It is a study of drugs that originate in the plant and animal kingdoms. Modern aspects of the science include not only the crude drugs but also their natural derivatives. Digitalis leaf and its isolated glycoside, digitoxin; rauwolfia root and its purified alkaloid, reserpine; and thyroid gland with its extracted hormone, thyroxine, are all part of the subject matter of pharmacognosy.

In some instances drug constituents have been partially replaced in commerce by synthetic compounds of identical chemical structure and therapeutic properties; such **natural** and **synthetic substances** often can be distinguished by physical and chemical tests. For example, natural camphor is obtained from the camphor tree by steam distillation; it is dextrorotatory in its reaction to polarized light. In contrast, synthetic camphor may be manufactured by either of two methods: by *total synthesis* from vinyl chloride and cyclopentadiene (a completely synthetic process) or by *semisynthesis* from pinene derived from pine stumps (not entirely a synthetic process but a chemical modification of a natural product). Synthetic camphor is racemic and can be differentiated easily from the natural form.

Epinephrine, caffeine, codeine, ephedrine, menthol, penicillin, and other chemicals may also be obtained from either the natural source or by partial or total synthesis. They are considered a definite part of pharmacognosy.

In a broad sense, pharmacognosy embraces a knowledge of the history, distribution, cultivation, collection, selection, preparation, commerce, identification, evaluation, preservation, and use of drugs and economic substances that affect the health of man and other animals. Such economic substances extend beyond the category of crude drugs and their derivatives to include a variety of commercial and medicinal products often requiring complicated methods of preparation: allergens, allergenic extracts, antibiotics, immunizing biologics, flavoring agents, and condiments. In a restricted sense, the definition of pharmacognosy implies a particular knowledge of methods of identification and evaluation of drugs.

As a part of the pharmaceutic curriculum, pharmacognosy forms an important link between **pharmacology** and **medicinal chemistry** on one hand and between **pharmacy** and **clinical pharmacy** on the other.

Pharmacology, like pharmacognosy, is an outgrowth of materia medica, the ancient science which dealt with all aspects of medicinal agents. Now, in this more specialized era, pharmacognosy deals primarily with information on the sources and constituents of natural drugs, and pharmacology is concerned with their actions and effects.

Methods of procurement and preparation affect the price of drugs; thus, insofar as economics are concerned, pharmacognosy is intimately associated with the phases of pharmacy administration that deal with prescription pricing. The relationship of pharmacognosy to dispensing pharmacy and clinical pharmacy is obvious when one considers the number of naturally derived drugs that are handled by the pharmacist in this age of drug specialties. Because of his knowledge of drug constituents, the pharmacist is able to predict not only the chemical and physical incompatibilities encountered in compounding, but also the therapeutic incompatibilities that the patient may encounter when utilizing a drug concomitantly with other prescribed or self-selected medications.

When supplying both prescription and over-the-counter (OTC) medication to patients, the pharmacist also provides information required for the safe and effective use of such drugs. The pharmacist further serves as an information source on all aspects of drugs to his colleagues in the med-

ical, dental, and nursing professions. These advisory roles are made possible by the vast background of the pharmacist, the drug expert, in such fields as pharmacognosy, pharmacology, medicinal chemistry, and pharmaceutics.

Any treatise on plant and animal products encompasses a wide variety of uses inasmuch as natural substances are employed in almost every known industry. Although the pharmacist is mainly concerned with those substances having application to public health, he realizes that many of these therapeutic aids are also utilized as beverages, as spices and condiments, in confectioneries, and as technical products.

Coffee beans and tea leaves both yield caffeine, which has medicinal application, yet the original sources are mainstays in the diet of the American public. Wintergreen oil and ginger are used pharmaceutically, but a much greater quantity of each is utilized by the soft drink industry. Mustard seed and clove have definite therapeutic application, still they are in more demand in the spice and condiment trade. Cinnamon oil and peppermint oil are valuable carminatives; however, they enjoy an enviable reputation as popular flavoring agents in candies and chewing gums. Certain industries depend on large supplies of rosin, turpentine, linseed oil, acacia, pectin, and numerous other natural products that have a relatively limited application in the field of pharmacy.

CRUDE DRUGS

Crude drugs are vegetable or animal drugs that consist of natural substances that have undergone only the processes of collection and drying. The term, **"natural substances,"** refers to those substances found in nature that comprise whole plants and herbs and anatomic parts thereof; vegetable saps, extracts, secretions, and other constituents thereof; whole animals and anatomic parts thereof; glands or other animal organs, extracts, secretions, and other constituents thereof; and that have not had changes made in their molecular structure as found in nature. The term, **"crude,"** as used in relation to natural products, means any product that has not been advanced in value or improved in condition by shredding, grinding, chipping, crushing, distilling, evaporating, extracting, artificial mixing with other substances, or by any other process or treatment beyond that which is essential to its proper packing and to the prevention of decay or deterioration pending manufacture.

Crude drugs are used infrequently as therapeutic agents; more often, their chief principles are separated by various means and are employed in a more specific manner. These principles are known as **derivatives** or **extractives**. Regardless of whether the derivative or extractive is a single substance or a mixture of substances, it is considered as the **chief constituent** of the drug.

The process of drug extraction is a generally accepted method of obtaining these active principles. Extraction removes only those substances that can be dissolved in the liquid or liquid mixture referred to as the **solvent**, or, more specifically, as the **menstruum**. The undissolved portion of the drug that remains after the extraction process is completed is called the **marc**. The product of the extraction process is known as the **extractive** and is usually a mixture of substances. A large-scale drug extractor of the type currently used in the pharmaceutic industry is illustrated in Figure 1–1.

The **geographic source** and **habitat** are the region in which the plant or animal yielding the drug grows. Sometimes this term is applied erroneously to the drugs themselves. Drugs are collected in all parts of the world, though the tropics and sub-

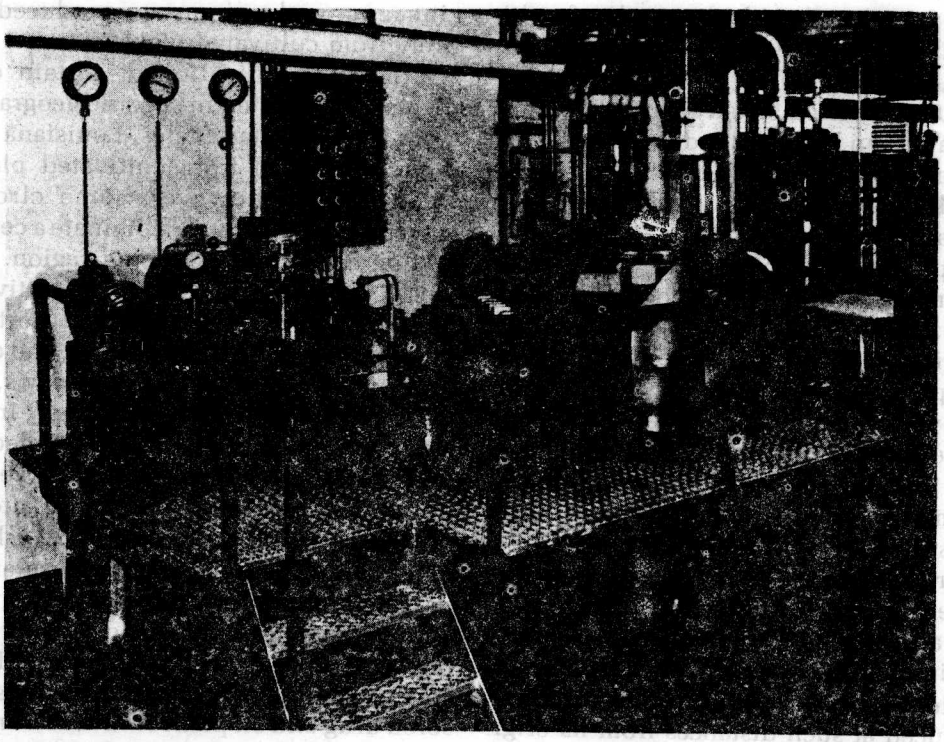

Fig. 1–1. A fully automatic industrial drug extractor. Its operating cycle, which involves pressures up to 2000 lbs per sq in and a centrifugal force of 1000 × g, can be programmed to meet process requirements. (Courtesy of Dr. Madis Laboratories, Inc.)

tropics, where plant species abound, yield more drugs than do the arctic and subarctic regions. The Mediterranean basin including Asia Minor yields more drugs than any other region of the world. However, India, the East Indies, central Europe, northern South America, Mexico, Central America, North America, and other regions yield numerous and valuable drugs.

Neither the **scientific name** of the plant nor the **commercial name** of the drug is necessarily an indication of the true habitat of drug plants. For example, the specific name of *Acacia senegal* seems to indicate that this plant, which yields gum arabic, is most abundant in Senegal. Actually, the bulk of the commercial gum now comes from trees cultivated in Sudan. In other cases, plants are common to a much larger territory than the specific name indicates, such as *Prunus virginiana*. Peru balsam, for example, does not come from Peru, but is produced in El Salvador, whereas most of the Spanish licorice now comes from Asia Minor.

Plants growing in their native countries are said to be **indigenous** to those regions, such as *Pinus palustris* in the southern United States, *Aconitum napellus* in the mountainous regions of Europe, and others. Plants are said to be **naturalized** when they grow in a foreign land or in a locality other than their native homes, such as *Datura stramonium*, which was introduced into the United States from Europe. Some of these plants may have

been introduced with the seeds of cultivated plants, some by birds or ocean currents, others by ballast of ships, and so on.

Drugs can be collected from wild plants, or plants can be cultivated for the production of drugs.

Cultivated medicinal plants have been propagated for centuries in China, India, Europe, and many other lands. Plant cultivation was known to the people of ancient civilizations inasmuch as sculptures and drawings depict hand pollination of the date palm by the Assyrians in 9000 B.C. and cultivation of rice and barley by the Chinese and Egyptians in 5000 B.C.

In Europe, medicinal plant gardens of the monasteries date back to the early Christian era. Since shortly after the discovery of America and continuing to the present, many countries have made definite attempts to cultivate drug and economic plants. Thus, vanilla, which is native to Mexico and Central America, is now produced at such distances from its original habitat as the islands of Réunion, Tahiti, and Mauritius. Cocoa, another native of Mexico, is now produced in large quantities in Nigeria and Ghana, in Sri Lanka, and in Indonesia.

Cinchona, native to the South American Andes, was developed as a crop in Indonesia. By 1900, the South American production was practically nil, owing to the wanton destruction of wild trees; thus, the Dutch in the Netherlands East Indies held a world monopoly on cinchona. A similar situation existed with coca, another South American plant transported to that area.

In many instances plants have been cultivated in their native habitats, either because of dwindling natural supply or to improve the quality of the drug. Before World War II, the Japanese had established large plantations of camphor trees in Formosa and held a virtual monopoly in natural camphor. Other drugs, such as Ceylon cinnamon and opium, are produced entirely from cultivated plants.

Extensive cultivation of certain drug plants is conducted in specific geographic areas of the United States. Louisiana produces castor oil from cultivated plants. Occasionally, however, some circumstances will completely eliminate a certain section as a drug-producing region. Formerly, mints were extensively cultivated in southwestern Michigan and northern Indiana. Peppermint, spearmint, and other mints were grown in mile-long rows, particularly near Mentha, Michigan. In the early 1950s, a fungus blight invaded the fields of that area and within a few years it was considered uneconomical to attempt further cultivation. At present, Washington and Oregon have assumed leadership in the production of mints and mint oils although both Michigan and Indiana have relocated their areas of cultivation. In recent years the state of California has sponsored drug and oil plant cultivation among the farms in the southern part of the state, and this section now produces several million dollars' worth of drugs and economic products annually, all from cultivated plants.

It is important to ascertain that plants cultivated in a certain geographic area will develop the desired type and amount of constituents. The differences in the relative amounts of volatile constituents often determine the character of the oil and, consequently, the demand for that particular oil. California orange oil is marketed at more than twice the price of Florida oils. The preference for Michigan peppermint oils over Washington and Oregon oils is owing to the types of constituents developed—the Michigan oils taste better.

COMMERCE IN DRUGS

The **commercial origin** of a drug refers to its production and its channels of trade.

Drugs frequently bear a geographic name indicating the country or region in which they are collected, the country or city from which they are shipped, or their variety. These names do not necessarily reflect the area where the plant grows. English hyoscyamus leaves are gathered from plants growing in England and are principally consumed in that country; Indian rhubarb is the product of plants growing in various parts of India; Spanish licorice is a botanic variety of *Glycyrrhiza glabra*, originally produced in Spain but now produced elsewhere; and Oregon grape root is a species of *Mahonia* and may or may not come from Oregon. The commercial origin may change in the course of time as with cinchona, vanilla, and coca previously mentioned.

Since World War II, most of the drug items have been shipped directly from the producing areas to New York City. Although many drug collectors and dealers conducted their business through a governmental agency in the past, little drug commerce now passes through such an agency. The exceptions are the communist countries and their European satellites where governmental agencies control all commerce.

PREPARATION OF DRUGS FOR THE COMMERCIAL MARKET

COLLECTION

Collection of drugs from cultivated plants always insures a true natural source and a reliable product. This may, or may not, be the case when drugs are collected from wild plants. Carelessness or ignorance on the part of the collector can result in complete or partial substitution. This is especially true when drugs are difficult to collect or the natural source is scarce. Many drugs are collected from wild plants, sometimes on a fairly extensive scale (tragacanth, senna) when collection is the vocation of the gatherer, and sometimes on a limited scale when collection is an avocation (podophyllum, hydrastis). Because drugs come from all over the world, collection areas are almost universal, and collectors may vary from uneducated natives to highly skilled botanists.

Certain areas of the United States are particularly noteworthy as collection areas. White pine, podophyllum, ginseng, and many other native American drugs are collected in the Blue Ridge Mountain region, of which Asheville, North Carolina, is one of the important collection areas. Native American drugs are usually collected by individuals, such as farm children and part-time agricultural laborers.

The proper time of harvesting or collecting is particularly important because the nature and quantity of constituents vary greatly in some species according to the season. The most advantageous collection time is when the part of the plant that constitutes the drug is highest in its content of active principles and when the material will dry to give the maximum quality and appearance.

HARVESTING

The mode of harvesting varies with each drug produced and with the pharmaceutic requirements of each drug. Some drugs may be collected by hand labor; however, when the cost of labor is an important factor, the use of mechanical devices is often more successful in economic production of the drug. With some drugs, where the skillful selection of plant parts is an important factor (digitalis), mechanical means cannot replace hand labor.

DRYING

By drying the plant material, one removes sufficient moisture to insure good

keeping qualities and to prevent molding, the action of enzymes, the action of bacteria, and chemical or other possible changes. Drying fixes the constituents, facilitates grinding and milling, and converts the drug into a more convenient form for commercial handling. Proper and successful drying involves two main principles: control of temperature and regulation of air flow. Control of the drying operation is determined by the nature of the material to be dried and by the desired appearance of the finished product. The plant material can be dried either by the sun or by the use of artificial heat.

With some natural products, such as vanilla, processes of fermentation or sweating are necessary to bring about changes in the constituents. Such drugs require special drying processes, usually called "curing."

GARBLING

Garbling is the final step in the preparation of a crude drug. Garbling consists of the removal of extraneous matter, such as other parts of the plant, dirt, and added adulterants. This step is done to some extent during collection, but should be carried out after the drug is dried and before the drug is baled or packaged. Although garbling may be done by mechanical means in some cases, it is usually a semiskilled operation.

PACKAGING, STORAGE, AND PRESERVATION

The packaging of drugs depends on their final disposition. In commerce, if transportation, storage, and ultimate use for manufacturing purposes are involved, it is customary to choose the type of packaging that provides ample protection to the drug and gives economy of space. Leaf and herb material is usually baled with power balers into a solid compact mass that is then sewn into a burlap cover. Bales that are shipped overseas weigh from 100 to 250 pounds. Senna leaves from India come in bales of 400 pounds; stramonium from Argentina in bales of 700 pounds. Drugs that are likely to deteriorate from absorbed moisture (digitalis, ergot) are packed in moisture-proof cans. Gums, resins, and extracts are shipped in barrels, boxes, or casks.

Packaging is often characteristic for certain drugs. The standard package for all grades of aloe is a 55-gallon steel drum, and this type of container is also employed for balsam of Peru. Matting-covered packages of cinnamon from the Far East, seroons (bales covered with cowhide) containing sarsaparilla from South America, lead flasks with oil of rose from Bulgaria, and many other odd forms of packaging are noted in the drug trade.

Proper storage and preservation are important factors in maintaining a high degree of quality of the drug. Hard-packed bales, barks, and resinous drugs usually reabsorb little moisture. But leaf, herb, and root drugs that are not well packed tend to absorb amounts of moisture that reach 10, 15, or even 30% of the weight of the drug. Excessive moisture not only increases the weight of the drug, thus reducing the percentage of active constituents, but also favors enzymatic activity and facilitates fungal growth.

Light adversely affects drugs that are highly colored, rendering them unattractive and possibly causing undesirable changes in constituents. The oxygen of the air increases oxidation of the constituents of drugs, especially when oxidases are present. Therefore, the warehouse should be cool, dark, and well ventilated with dry air.

The protection of drugs against **attacks by insects** must not be overlooked. The insects that infest vegetable drugs belong

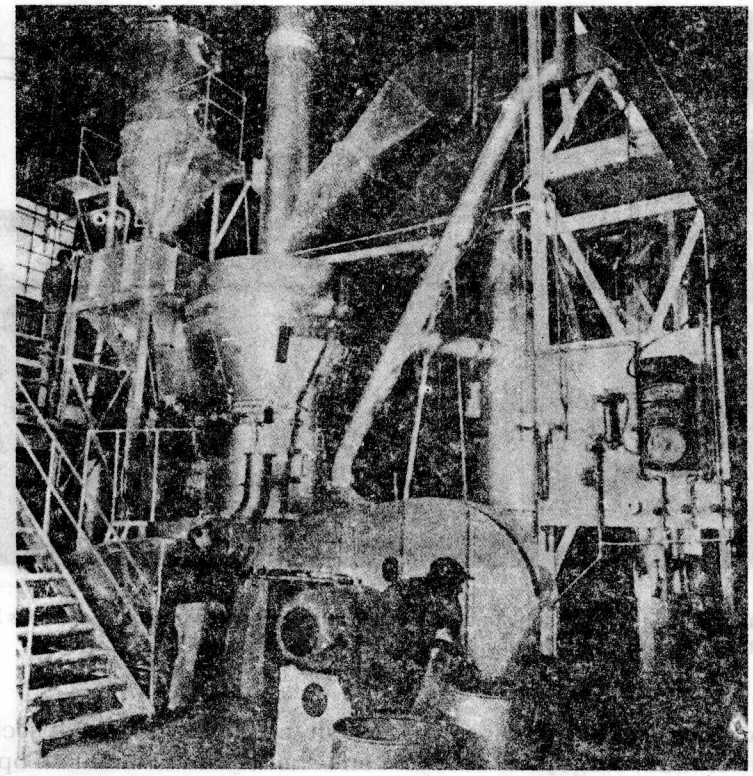

Fig. 1–2. A grinding mill used in large-scale commercial production of crude drugs. (Courtesy of S. B. Penick and Company.)

chiefly to the orders *Lepidoptera*, *Coleoptera*, and *Diptera*.

For destruction of insects and prevention of their attacks, a number of methods have been employed. The simplest method is to expose the drug to a temperature of 65°C. This method is probably the most efficient not only in preventing insect attacks, but in preventing many other forms of deterioration. For the fumigation of large lots of crude drugs, such as those stored in warehouses and manufacturing plants, the use of methyl bromide has met with considerable success.

Small lots of drugs may readily be stored in tight, light-resistant containers. Tin cans, covered metal bins, or amber glass containers are the most satisfactory. Drugs should not be stored in wooden boxes or in drawers and never in paper bags. Not only is deterioration hastened, but odors are communicated from one drug to another, attacks by insects are facilitated, and destruction by mice and rats may occur. If drugs in small quantities are stored in tight containers, insect attack can be controlled by adding to the container a few drops of chloroform or carbon tetrachloride from time to time. In the case of digitalis and ergot, whose low moisture content must be maintained at all times, the insertion of a suitable cartridge or device containing a nonliquefying, inert, dehydrating substance may be introduced into the tight container.

Because high temperatures accelerate all

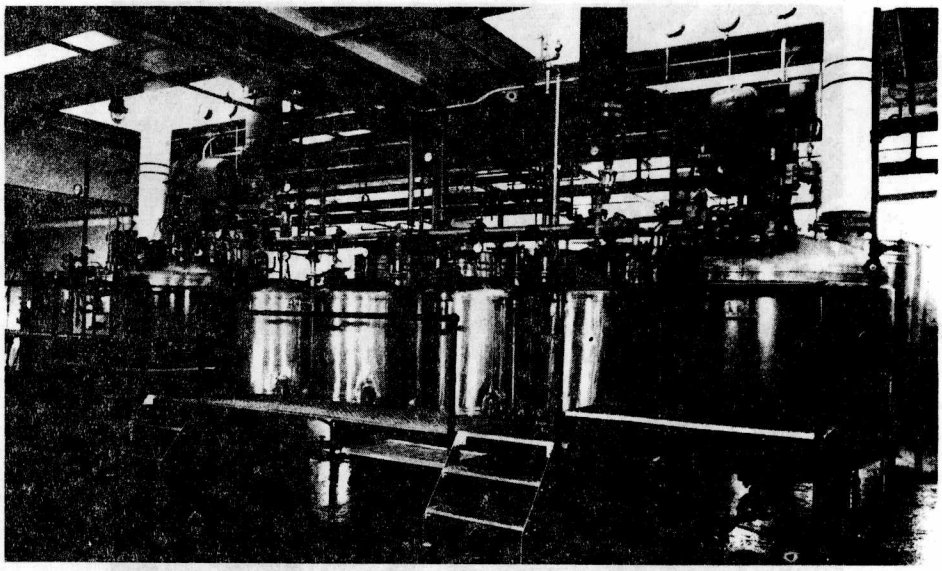

Fig. 1–3. Semiautomatic vacuum and atmospheric reflux reactors used to produce various kinds of resins, enzymes, and extracts. (Courtesy of Dr. Madis Laboratories, Inc.)

chemical reactions, including those involved in deterioration, drugs must always be stored at as low a temperature as possible. The ideal temperature is just above freezing, but since this is impractical in most cases, the warehouse or other storage place should be as cool as possible. Certain drugs, such as the biologics, must be stored at a temperature between 2° and 8°C.

ANIMAL DRUGS

Animal drugs are produced from wild or domesticated animals. Wild animals must be hunted (whale, musk deer) or fished for (cod and halibut), and thus, in a sense, their collection parallels the collection of vegetable drugs. Many animal drugs, however, are produced from domesticated animals and, therefore, correspond to the cultivated vegetable drugs. When drugs consist of insects, the drugs are either collected from wild insects (cantharides) or definite attempts are made to cultivate them, i.e., to furnish the insects with food and shelter and to maintain optimum conditions for their propagation (honeybee).

Drugs such as lanolin and milk products, as well as hormones, endocrine products, and some enzymes, are obtained from domesticated hogs, sheep, or cattle. The slaughterhouse is the usual source of glandular products and enzymes, and the larger packing establishments have departments for the recovery and refinement of these therapeutic agents and pharmaceuticals. Processing and purification of the animal drugs vary with the individual drug.

EVALUATION OF DRUGS

To evaluate a drug means to identify it and to determine its quality and purity.

The identity of a drug can be established by actual collection of the drug from a plant or animal that has been positively identified. Research investigators must be

absolutely certain of the origin of their samples; hence, "drug gardens" are frequently established by institutions engaged in pharmacognostic research. Another method of identification is the comparison of a representative unknown sample to a published description of the drug and to authentic drug samples.

Quality refers to the intrinsic value of the drug, i.e., the amount of medicinal principles or active constituents present. These constituents are classified into groups of nonprotoplasmic cell contents and can be found in the section of this chapter on "Classification of Drugs." These groups include: carbohydrates, glycosides, tannins, lipids, volatile oils, resins and resin-combinations, steroids, alkaloids, peptide hormones, enzymes and other proteins, vitamins, antibiotics, biologics, allergens, and others.

A high grade of quality in a drug is of primary importance, and effort should be made to obtain and maintain this high quality. The evaluation of a drug involves a number of methods that may be classified as follows: (1) organoleptic, (2) microscopic, (3) biologic, (4) chemical, (5) physical (Fig. 1–4).

Organoleptic (lit. "impression on the organs") refers to evaluation by means of the organs of sense and includes the macroscopic appearance of the drug, its odor and taste, occasionally the sound or "snap" of its fracture, and the "feel" of the drug to the touch.

The microscope is not only essential to the study of adulterants in powdered plant and animal drugs, but is indispensable in the identification of the pure powdered drug. Powdered drugs possess few macroscopic features of identification other than color, odor, and taste; hence, the microscopic characteristics are important.

The pharmacologic activity of certain drugs has been applied to their evaluation and standardization. Assays on living animals as well as on intact or excised organs often indicate the strength of the drug or its preparations. Because living organ-

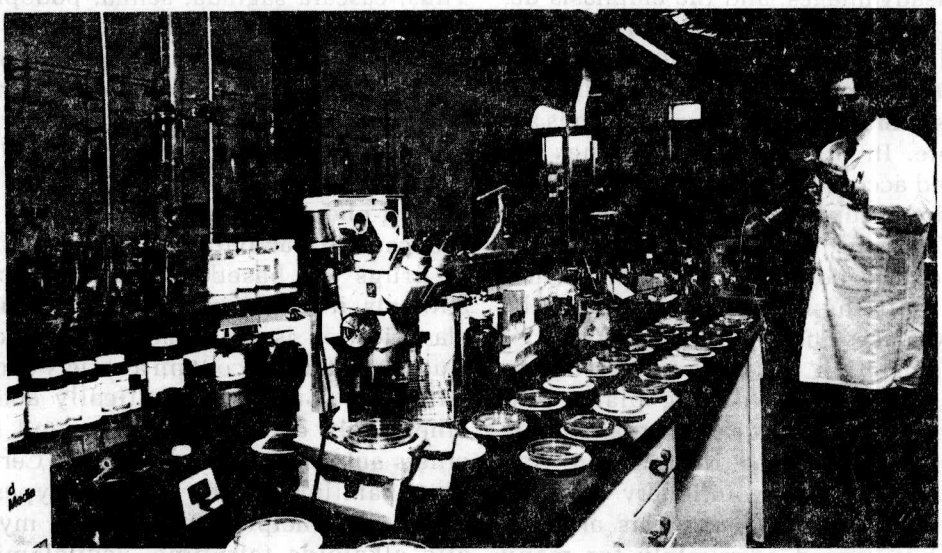

Fig. 1–4. A drug quality-control laboratory where chemical, physical, microbiologic, and pharmacognostic tests are carried out on natural drug products. (Courtesy of Dr. Madis Laboratories, Inc.)

isms are used, the assays are called biologic assays or bioassays.

Because the active constituents of many natural drugs have been determined, chemical methods of evaluating crude drugs and their products are useful and, consequently, are widely employed. For many drugs, the chemical assay represents the best method of determining the official potency.

The application of typical physical constants to crude drugs is rare. However, physical constants are extensively applied to the active principles of drugs, such as alkaloids, volatile oils, fixed oils, and others.

CLASSIFICATION OF DRUGS

In pharmacognosy, drugs may be classified according to (1) their morphology, (2) the taxonomy of the plants and animals from which they are obtained, (3) their therapeutic applications, and (4) their chemical constituents. Each of these methods of classification has advantages and disadvantages, and the emphasis depends on the ultimate goal of the individual. If a person is expected to identify specific drugs and to ascertain their adulterants, a **morphologic** classification is applicable. In this system, the drugs are grouped according to the part of the plant or animal represented, such as roots, leaves, organs, or glands. However, the form of the commercial article is not always distinguishable and cannot be readily placed in its proper category.

Consideration of the natural relationship or phylogeny among plants and among animals gives rise to a **taxonomic** classification. With the present-day knowledge of the evolutionary development of living organisms, this arrangement has served adequately for many years. A large number of plant families have certain distinguishing characteristics that permit drugs from these families to be studied at one time; thus, drugs consisting of cremocarp fruits (anise, fennel, caraway) are considered with other members of the Umbelliferae, drugs obtained from plants having alternate leaves, cymose flowers, and fruits that are capsules or berries (belladonna, hyoscyamus, stramonium) are considered with the Solanaceae, and drugs possessing square stems, opposite leaves, and bilabiate flowers (peppermint, spearmint, thyme) are considered with the Labiatae. This type of arrangement is sometimes called the botanic arrangement for plant drugs or the zoologic arrangement for animal drugs. In the latter case, all arthropods are grouped, as are all mammals, fish, and other natural phylogenetic types.

Inasmuch as drugs are employed medicinally because of their therapeutic effects, a third method of study is the **pharmacologic** or **therapeutic** classification. All of the cathartic drugs are associated with this classification regardless of morphology, taxonomy, or chemical relation. Thus, cascara sagrada, senna, podophyllum, and castor oil are considered at one time because of their action on the intestinal tract. Similarly, digitalis, strophanthus, and squill are grouped together because they affect cardiac muscle. This type of consideration forms the basis for the science of pharmacology.

Because the activity and therapeutic use of drugs are based on chemical constituents, it would appear that a **chemical** classification is the preferred method of study. Most drugs contain a variety of constituents, some therapeutically active, others only chemically active, and still others antagonistic to each other. Certain plant families exhibit definite types of chemical principles; for example, mydriatic alkaloids (atropine, scopolamine) characterize the Solanaceae, volatile oils represent the Umbelliferae, and oleoresins